A REVIEW OF THE USE OF HEPTACHLOR FOR THE CONTROL OF ARGENTINE ANTS AND TERMITES IN WESTERN AUSTRALIA

Environmental Protection Authority
Perth, Western Australia
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Preamble

In February 1988 the Government of Western Australia temporarily suspended the use of heptachlor for argentine ant control because of public concerns over human health and environmental contamination. Heptachlor, an organochlorine pesticide, is used to control argentine ants and termites because it is understood that a single application of this chemical remains effective against these insects in the soil for considerable periods. The Environmental Protection Authority was requested to review the use of heptachlor for the control of argentine ants, and to advise Government accordingly. In fulfilling this task the Authority released a discussion paper on the issue (EPA Bulletin 325) in March 1988 which sought public comment. After consultation with the Minister for Health, the Minister for the Environment extended the review to include the use of heptachlor for the control of termites. The Environmental Protection Authority does not have the expertise to determine the public health risks associated with the use of heptachlor.

This Bulletin contains the Environmental Protection Authority's findings on the environmental consequences of heptachlor use, and provides advice to Government for changes to the current patterns of use and administration of heptachlor. The paper also discusses issues relevant to the group of pesticide chemicals (cyclodienes) related to heptachlor.

Summary

The term organochlorine covers a group of chemicals which includes polychlorinated biphenyls (PCBs), chlorinated fluorocarbons (CFCs), cyclodiene insecticides (heptachlor, chlordane, dieldrin, aldrin) and other compounds. The organochlorine insecticide DDT is not a cyclodiene insecticide. This report uses the term cyclodiene to describe the insecticides chlordane, heptachlor, dieldrin and aldrin. The term organochlorine insecticides (OCs) refers to both DDT type insecticides and the cyclodienes.

Argentine ant control

Organochlorine insecticides and their breakdown products remain in the environment for considerable periods and are readily taken up by animals, where they remain in fatty tissues. Once in the food chain, cyclodiene insecticides have the ability to be passed to animals higher up the food chain. Long-term exposure of animals to cyclodiene insecticides at sub-lethal levels has the potential to disrupt behavioural and reproductive processes. The external spraying of heptachlor for argentine ant control disrupts both terrestrial and aquatic ecosystems by killing non-target invertebrate (and possibly vertebrate) animals.

Argentine ants disrupt native ant populations and adversely affect the environment. It is believed in South Africa that many rare endemic species of proteaceous plants will become extinct as a direct result of the argentine ant invasion. This loss is caused by predation of seed reserves by argentine ants. These seeds normally depend on co-evolved native ants for dispersal and burial.

The Western Australian environment with its wide range of endemic plant species which depend on co-evolved native ant communities will be adversely affected by invasions of argentine ants. The full impact of argentine ant invasion on the Western Australian environment will only become clear as native species are displaced and the interactions are studied. However, the EPA believes that there is a greater environmental risk associated with continued broad-scale external spraying for argentine ants than is likely from infestations of the argentine ant.

Western Australia is the only state in Australia where heptachlor is permitted to be sprayed externally, albeit under strict controls by trained Agriculture Protection Board staff. For the sake of the environment, the human population and agriculture, it is essential that argentine ants do not increase to those numbers experienced in the 1950s and 1960s. Argentine ants normally form large cooperating communities and invade homes in large numbers in search of food, causing considerable discomfort to residents. There have been reports from the 1950s of ants attacking the aged and infirm in their beds. The ants are capable of rapidly building up very high population densities in favourable conditions. They are easily spread by human activity and are extremely difficult to control. Alternative means of control are available, but these will not be as effective in treating infestations as organochlorine insecticides.

Possible alternative treatment options need to be evaluated in the Western Australian environment urgently, so as to ensure that some measure of effective, environmentally acceptable control is available as soon as possible. The biology of the ant (including its pathogens, predators and parasites in its original habitat), its distribution and its impact on the Western Australian environment should be assessed.

Accordingly, the EPA recommends that:

- *Broad-scale application of heptachlor for the control of argentine ants or any other pests should cease because of the environmental contamination and ecological disruption caused by external spraying.*

The EPA recommends that as a replacement for the external application of heptachlor:

- *The Agriculture Protection Board continue to monitor argentine ant populations and formulate a new argentine ant containment policy to the satisfaction of the EPA.*

The EPA considers that research into alternative argentine ant containment options which are environmentally acceptable should proceed as a priority. This should include the registration of new effective chemicals as soon as possible. Integrated pest management is the selection, integration, and implementation of pest control based on predicted economic, ecological and sociological consequences.

IPM seeks maximum use of naturally occurring pest controls, including weather, disease agents, predators, and parasites. In addition, IPM utilizes various biological, physical, and chemical controls and habitat modification techniques. Artificial controls are imposed only as required to keep a pest from surpassing intolerable population levels predetermined from accurate assessments of the pest damage potential and the ecological, sociological and economic costs of the control measures.

Accordingly the EPA recommends that:

. ***Integrated Pest Management (IPM) should be used to control argentine ants in Western Australia. Chemical baiting techniques, or if necessary, localized treatment with organophosphates or a synthetic pyrethroid, should prove environmentally more acceptable than the external spraying of heptachlor.***

The thrust of the IPM should be to achieve a high level of public awareness and responsibility for treatment of argentine ant infestations on private land.

There are a number of countries that require agricultural imports to be certified free of argentine ants. The EPA understands that there are a number of methods of achieving pest control prior to the export of products from Australia. These should be used to ensure that Western Australian agricultural produce is not contaminated by argentine ants when being sent to countries requiring insect-free certification.

If the above recommendations are accepted the Argentine Ant Act in its current form may no longer be necessary. The Argentine Ant Act may need to be revised following the development of a new argentine ant containment policy by the Agriculture Protection Board.

Termite control

The following section deals with the use of heptachlor for the control of termites. There appear to be no chemical alternatives which will offer the same effective life as the cyclodienes when correctly used as subsoil termiticides. Until environmentally appropriate alternatives become available, it is desirable that the cyclodienes continue to be registered for use as termiticides in this State.

Accordingly the EPA recommends that:

. ***The registration of heptachlor and other cyclodiene insecticides for termite control be continued.***

<u>However, this does not mean that the EPA supports the use of heptachlor and other cyclodiene insecticides.</u> Accordingly the EPA further recommends that:

. ***The use of cyclodiene insecticides should be <u>promoted as one option only</u> and that adequate information on the environmental risks should be widely available to consumers.***

There is clear evidence of over-servicing, of spraying sub-strength formulations, and of insecticide misapplication by sections of the pest control industry in Western Australia. Many Perth dwellings are being treated annually with cyclodiene insecticides even though it is clearly illegal to perform re-treatments at frequencies of less than five years. Since early 1988 the WA Health Department has suggested that pregnant and lactating women and very young children should avoid contact with cyclodienes. Appendix 1 describes levels of cyclodiene pesticides found in the breast milk of Perth women and indicates that the main source of human contamination is from the spraying of cyclodiene insecticides for the control of termites, as the levels of residue in foodstuffs are not high enough to account for currently observed human body burdens. This information shows that women have been in contact with cyclodiene insecticides in the past, and that this contact will continue unless current termite control operations are appropriately modified. Appendix 3 contains comparable data.

The data in Appendix 2 (Gerritse 1988) show that heptachlor may be more volatile in Perth's moist sandy soils than previously assumed. The data also show that heptachlor is strongly bound to soil organic matter, which suggests that volatilization rather than leaching may be responsible for observed heptachlor levels in groundwater.

The high volatility of heptachlor means that even when it is applied according to Australian standards (subsoil injection, trench and fill or pre-slab spraying) the chemical will vaporize and contaminate the air inside the treated house. Evidence presented in Appendix 1 shows that cyclodienes can be detected in the air of Perth houses that have been re-treated according to WA Health Department regulations. In the context of the frequency of re-treatments in Perth, this information may account for the high concentrations of cyclodiene insecticides and their metabolites in the breast milk of Perth women.

There is evidence that pre-slab treatments are not being carried out in accordance with WA Health Department regulations. Houses that have not been treated correctly have the potential to be attacked by termites so that re-treatments may be necessary years before they should be required, increasing the potential for environmental and human exposure.

The recommended rate at which heptachlor should be sprayed before slab laying is 62.5 ml/m^2 of concentrate (Heptachlor 400EC). This equates to a cost of chemical of between $80 -$100 for a typical 120 m^2 floor area house. There is evidence to suggest that pre-slab treatments are being carried out in Perth for less than the cost of the correctly applied chemical alone. Australian standard 2057 (1986) states that all sub-floor services should be in place prior to spraying. After spraying, the waterproof membrane should be placed over the treated area immediately and the slab poured as soon as possible. There should be a high level of compliance with this standard so as to minimize the potential for heptachlor contamination of the environment.

To ensure that pregnant and lactating women and very young children minimize contact with these chemicals, it is imperative that householders are aware of the spraying history of their dwellings. Householders should be supplied with a certificate which includes spraying details such as which chemicals were used, the formulated strength of chemicals and the quantity used. The certificate should also indicate how long such treatments are to remain effective. Independent inspectors should ensure that re-treatments are being carried out in accordance with WA Health Department regulations.

Increased monitoring is desirable to determine the level of exposure of householders to cyclodiene insecticides, even when they have been applied according to Australian standards. The average body burdens of susceptible groups within the community should be reduced as a direct result of the elimination of over-application and misapplication.

The Authority concludes that termite activity in external sheds, fences or timber piles does not constitute grounds for sub-floor cyclodiene re-treatments. Chlorpyrifos (or other suitable organophosphates), synthetic pyrethroids or other suitable alternatives should be used externally. It is highly desirable that pest control operators inspect premises on a regular basis to ensure that termite activity is detected and treated promptly.

Therefore the EPA recommends that:

. *A working party consisting of the WA Health Department, the Department of Occupational Health Safety and Welfare, and the Department of Agriculture jointly develop measures (including appropriate regulations) in consultation with the EPA, which ensure that minimal environmental and human contamination by organochlorine pesticides occurs.*

There is no reason, other than convention, to insist that buildings constructed without timber need cyclodiene soil barriers to prevent termite infestations. The most common form of housing construction in Perth is concrete raft slab supported by reinforced concrete footings, with double brick cavity walls and tile roofs. Softwoods are being used more frequently in the roofing timbers. Internal fittings are generally made from hardwoods. The possibility of termite attack in such dwellings is much lower than in the older style dwellings with timber floors suspended on timber piers. It should be permissible for people building or purchasing new dwellings with slab floor - double brick construction to obtain a contract stipulating regular termite inspections as an alternative to pre-slab treatment with cyclodiene insecticides.

The EPA therefore recommends that:

. *Structures built with termite-resistant materials need not have cyclodiene insecticide soil barriers established at the time of construction. The Local Government Building By-Laws (Uniform Building By-laws) should be amended accordingly.*

Contamination of urban and rural drainage water with cyclodiene insecticides suggests that improper disposal of waste chemicals is occurring.

Accordingly, the EPA recommends that:

. *The disposal of waste containers, tank washings and other waste cyclodiene pesticides be investigated with a view to finding measures of control. Disposal should take place only at sites approved by the EPA and the WA Health Department for that purpose.*

The EPA notes from its review of the published literature relating to heptachlor, and from various submissions to the Authority, that there is a deep division of expert opinion on the carcinogenicity of heptachlor and other cyclodiene insecticides to vertebrates, including humans. The EPA concludes however, that at the present time, there is insufficient evidence to decide on an acceptable level of public risk from the correct use of heptachlor or other cyclodiene insecticides for the prevention of termite attack in buildings. The EPA further concludes that cyclodienes are both persistent in the environment of south-western Western Australia, and more mobile in the environment than previously recognized.

Because it may not be possible to prevent some exposure of susceptible groups within the community to residual cyclodiene pesticides, the EPA recommends that:

- *A survey be undertaken by the WA Health Department, the Department of Occupational Health Safety and Welfare in consultation with the EPA, of the levels of cyclodiene residues found in the soil, air and in occupants of dwellings treated with cyclodienes according to Health Department regulations, and a thorough, comparative evaluation of the health risks associated with such levels made available to the public.*

In view of the above, the EPA further recommends that:

- *The use of cyclodiene insecticides for the control of termites in Western Australia should be reviewed after the health risks associated with the correct use of the cyclodienes to susceptible groups within the community have been established, and the frequency of re-treatments and the incidence of misapplications has been significantly reduced.*

1 Introduction

Since February 1988 the Government of Western Australia has temporarily suspended the use of the organochlorine pesticide heptachlor for the control of argentine ants because of public concerns over human health and environmental contamination. The Environmental Protection Authority was requested to review the use of heptachlor for the control of argentine ants and subsequently released a discussion paper (EPA Bulletin 325) which sought public comment on this issue. After consultation with the Minister for Health, the Minister for the Environment extended this review to include the use of heptachlor for the control of termites. This was because around 80% of the annual consumption of heptachlor in WA is for the control of termites, and concerns have been raised about this use. This paper summarizes issues raised by public submissions, and reviews the use of heptachlor for the control of both argentine ants and termites, and provides advice to Government.

The term organochlorine covers a broad group of chemicals which include polychlorinated biphenyls (PCBs), chlorinated fluorocarbons (CFCs), cyclodiene insecticides (heptachlor, chlordane, dieldrin, aldrin) and other compounds. The organochlorine insecticide DDT is not a cyclodiene insecticide. This report uses the term cyclodiene to describe the insecticides chlordane, heptachlor, dieldrin and aldrin. The term organochlorine insecticides (OCs) refers to both DDT and the cyclodienes. Relevant technical information is provided in Appendices 1, 2 and 3.

2 Control of argentine ants and termites in other Australian states

The policies of the other Australian states with regard to argentine ant control and termite treatment are summarized in Table 1. The policies of several states namely, Victoria and the ACT, are currently under review, and may be altered in the near future.

2.1 Argentine ants

Argentine ant infestations have been causing problems in Australia since the early 1900s when the ants were first introduced into this country. Argentine ants are aggressive competitors with native fauna because they form large cooperative colonies which disrupt native ant populations. Argentine ant colonies have established themselves throughout the southwest of WA where they cause considerable inconvenience to humans. The ants invade homes in large numbers in search of food and are extremely difficult to control.

Western Australia is the only state in Australia that currently allows the use of any cyclodiene pesticide for the control of argentine ants. There are currently no argentine ant infestations in South Australia, the ACT or in Queensland. New South Wales, Tasmania, the Northern Territory and Victoria do not allow the use of any cyclodiene pesticide for the external control of argentine ant infestations. These states rely on the organophosphate pesticides (chlorpyrifos) and synthetic pyrethroids (permethrin, deltamethrin) for the control of argentine ant infestations. No state outside Western Australia has a specific programme for the control of argentine ants, and states with argentine ant infestations place the responsibility and cost of treatments on individual landholders.

The New South Wales Department of Agriculture recently suspended its successful argentine ant eradication programme (based on the use of the cyclodiene chlordane) because of pending legal action initiated by residents of the Lane Cove area. The EPA was advised that environmental impact assessments may have become necessary for every proposed spraying programme.

In Victoria, the cyclodiene dieldrin is used as a soil barrier to ensure that wharves and other points of departure are free of argentine ant infestations.

Table 1 Summary of chemicals used in various Australian states for the control of argentine ants and subterranean termites.

State	Argentine ants	Termites re-treatment	Termites pre-slab
ACT	OP,SP	CI	CI
NSW	OP,SP	CI	CI
NT	OP,SP	OP,SP	CI
QLD	nil	CI	CI
SA	nil	CI	CI
Tas	OP,SP	nil	nil
Vic	OP,SP	CI[a]	CI[a]
WA	CI	CI	CI

nil = no infestations
CI = cyclodiene insecticides
OP,SP = organophosphate, synthetic pyrethroid insecticides.
CI[a] = not to be registered for termite treatment after July 1989

2.2 Termites

Queensland, Victoria, New South Wales, South Australia and the ACT currently permit the use of cyclodiene pesticides (heptachlor, chlordane, dieldrin, aldrin) for the control of subterranean termite infestations (Table 1). These chemicals are used by licensed pest controllers only. The Victorian Government has decided to deregister cyclodiene insecticides for all uses after the 30th of June 1989.

Tasmania does not have subterranean termites and banned cyclodienes for any use on the 1st of July 1988. The Northern Territory has totally banned the use of all cyclodiene pesticides for the control of termites other than for treatment beneath concrete pads prior to construction. Chlorpyrifos is used in the NT for sub-floor re-treatment. However at 2kg/ha of active ingredient, this chemical failed to effect control of *Mastotermes darwiniensis,* a particularly voracious species of giant termite found in the Northern Territory. The highly toxic organochlorine Mirex has been registered for use in termite baiting programmes in the Northern Territory. Mirex has also been tested recently in WA under closely controlled conditions.

Entomologists in the Northern Territory have expressed doubts as to the ability of organophosphate or pyrethroid insecticides to control other termites in the Territory, and research is currently being undertaken into biological control agents (a gut nematode worm, *Heterorabditis*) and new chemicals. These chemicals, chitin synthesis inhibitors and juvenile hormone analogues (which mimic natural insect growth hormones to effect control) are either available or under development. Biological control agents may require 5 - 10 years of evaluation before commercial production commences.

Australian standards state that it is permissible to spray the entire sub-floor area if the crawl space is less than 500mm. Termites have the ability to build aerial galleries from the ground up to the floor boards over small distances.

3 The control of argentine ants and termites in the United States of America.

3.1 Argentine ants

The EPA has received advice that cyclodiene insecticides have been withdrawn from use for the control of argentine ant infestations in southern California, which has a similar rainfall and temperature regime to the southwest of Western Australia. There is no specific programme for the control of argentine ants in California, and the responsibility for treatment lies with landholders and licensed pest control operators. Organophosphates, synthetic pyrethroid sprays and chemical baiting techniques are used in the control of the ants, but these forms of chemical control are mostly ineffective. Pest control operators report that around 40% of treatments are call-backs because of the failure of initial treatments to provide control. Home owners rank ants as the most serious indoor pests, ahead of fleas, flies, cockroaches, termites, moths and spiders. On the other hand, entomologists and pest control operators rank ants third after cockroaches and fleas. Outdoors, snails and slugs are considered more serious pests by the majority of home owners.

The EPA has received advice from research workers in California (Rust 1988 *pers comm*) suggesting that the explosive population increases that occur when argentine ants first move into a new area are only transitory, and that populations stabilize at much lower levels. It is possible that the plagues of ants found in WA in the 1950s may have been a transitory phenomenon. Officers of the Western Australian Agriculture Protection Board (APB) believe that the WA environment is more hospitable for these ants than comparable environments overseas and that the ants would quickly stabilize at the densities observed during the 1950s if the control programme's use of heptachlor was to cease.

Researchers at the University of California have found that experimental hydramethylnon baits provided *'outstanding control of argentine ants '* and these techniques permitted a marked reduction in the amount of active ingredient applied. It has been suggested that these techniques may prove effective in the control of argentine ant infestations in WA. The APB is currently attempting to obtain these baits for trial in WA.

3.2 Termites

There has been some conjecture as to the current status of the registration of the cyclodiene insecticides in the US. It had been reported to the Western Australian EPA that some states in the USA have re-registered cyclodiene insecticides for subsoil barriers under dwellings. Recent communications with the USEPA have established that the cyclodiene insecticides are currently not (or are not likely to be) registered for any use in the USA.

Alternative control methods such as chlorpyrifos, synthetic pyrethroids, and nematodes are currently being used in parts of the USA, but there are serious doubts as to the efficacy of these methods at controlling termites in Australia. The termites in Australia are of an entirely different genus to those in the USA.

4 The control of argentine ants and termites in WA

Prior to the Government suspending the use of heptachlor for the control of argentine ants, Western Australia was the only state in Australia which permitted the use of cyclodiene pesticides for external application. However, cyclodiene pesticides remain registered for termite control in WA as subsoil barriers both as pre-slab treatments and for re-treatments.

4.1 Argentine ants

There is no doubt that heptachlor effectively controls infestations of argentine ants. The reductions in ant populations achieved by the APB in the past have been spectacular. Many people living in WA today have not experienced the discomfort caused by infestations of argentine ants. It is highly desirable that ant populations do not build up to the densities experienced in the 1950s.

It is reported that argentine ants normally form large cooperating communities and invade homes in large numbers in search of food, causing considerable discomfort to residents. There have been reports from the 1950s of ants attacking the aged and infirm in their beds. The ants are capable of rapidly building up very high population densities in favourable conditions, are easily spread by human activity, and are extremely difficult to control.

Argentine ants will considerably disrupt native ant populations and adversely affect the environment. In South Africa it is believed that many rare endemic species of proteaceous plants will become extinct as a direct result of argentine ant invasion. This loss is caused by predation of seed reserves by argentine ants. These seeds are normally dispersed and buried by co-evolved native ants (Bond and Slingsby 1984). The Western Australian environment with its wide range of endemic plant and animal species, and co-evolved native ant communities, will be adversely affected by invasions of argentine ants. The full impact of argentine ant invasions on the Western Australian environment will become clear as native species are displaced and the interactions are studied. Officers of the APB believe that the potential damage from unchecked argentine ant infestations would be more environmentally consequential than the heptachlor spraying programme.

4.2 Termites

Dingle (1988) has described the current status of termite control in Western Australia in Appendix 1, and has presented evidence of breaches of Health Department regulations. There is evidence to show that re-treatment of homes for termites is occurring more frequently than the five yearly interval specified by Health Department regulations. A survey of 243 households revealed that 79% of the houses surveyed had been re-treated for termites at intervals of five years or less. Of these, 56% were re-treated at intervals of one year or less. It is of concern that many of these re-treatments would have used cyclodiene insecticides. Such activities constitute a clear breach of Health Department regulations.

The data presented by Gerritse (1988) in Appendix 2 show that heptachlor in particular is more volatile in moist soils than has been previously recognized. Annual treatment of dwellings for termite control even with sub-strength formulations of heptachlor would cause repeated contamination of the air inside re-treated dwellings. There is ample evidence that Health Department recommendations are not being followed and that pregnant and lactating women are not able to avoid contact with the cyclodiene insecticides (Dingle 1988). Levels of these chemicals in Perth women appear to be as high or higher than in women elsewhere in Australia or overseas (Table 7 in Appendix 1). Dingle also suggests that the most likely source of these chemicals is from their volatilization and inhalation after termite re-treatments.

5 Public response

Forty-four public submissions were received by the EPA in response to the request for submissions contained in EPA Bulletin 325, which related to the use of heptachlor to control argentine ants. There were 6 submissions from conservation groups, 2 from residents' action groups, 22 from private individuals, 8 from Government Departments (local, state and federal), 3 from professional bodies or research organizations, 2 from politicians and one from Velsicol Australia Limited, the distributor of heptachlor and chlordane. There were no submissions from the pest control industry even though copies of the discussion paper were sent to over 300 pest control firms.

In response to the terms of reference of this review being widened to include the use of heptachlor for termite control, the EPA convened a meeting with representatives of the pest control industry. Information gathered at that meeting is included in this report.

The quote cited below from one of the public submissions, best sums up the general feeling of the majority of respondents: '*The use of heptachlor cannot be justified on the basis of domestic inconvenience, the only substantiated result of argentine ant infestations* '. Most people making submissions suggested that a specific programme for the control of argentine ants should continue. It was generally believed that the APB should coordinate the programme based on a policy of containment of argentine ant infestations. The principles of integrated pest management or IPM (a combination of biological, physical and occasionally chemical techniques) should be used, and that enforcement of control measures is inappropriate. The use of the less persistent organophosphates and synthetic pyrethroid pesticides are suggested as appropriate in certain circumstances. However doubts have been raised about the ability of alternative methods to control ants. One submission suggested that control measures other than heptachlor '*would be as effective as a knapsack sprayer at the Ash Wednesday bushfires* '.

A number of submissions suggested that it may be inappropriate to assess the use of heptachlor for the control of argentine ant infestations in isolation from its wider use for subterranean termites, given that the use of this chemical for argentine ant control constitutes less than 20% of the annual consumption of heptachlor in WA. Several people suggested that a further discussion paper and public review period be initiated to address the other uses of heptachlor and other cyclodienes. Many people chose to include comments on the use of the cyclodienes for the control of termites in their submissions.

The first question posed by the discussion paper sought comment on whether there should be a specific programme for the control of argentine ants, and if so, whether the objective of this programme be containment or eradication. The majority of submissions suggested that a policy of argentine ant containment should continue.

	Yes	No	Containment	Eradication
Should the containment programme continue?	18	3	18	0

Question 2 sought comment on whether heptachlor is acceptable or not, and if so, under what circumstances and in which areas aught heptachlor be replaced with other control means. Alternatively, should heptachlor be seen as not acceptable, suggestions were sought for acceptable programmes.

	Yes	No
Is heptachlor acceptable?	7	35

Most respondents in favour of heptachlor did not differentiate between acceptable or unacceptable modes of use other than to specify that only trained operators should be responsible for pesticide application.

	IPM	OPs
What control measures are acceptable?	22	12

The majority of people suggested an integrated pest management (IPM) system as being the most appropriate for containment of argentine ant infestations, although many believed that the organophosphate family of pesticides alone should replace heptachlor. Question 2 also asked for a definition of an environmentally sensitive area in the context of argentine ant control. Responses to this question ranged from including all areas as being environmentally sensitive to suggesting that there are no sensitive areas in the context of argentine ant control. Other definitions of sensitive areas included wetlands, groundwater, residential backyards and farmlands.

The third question sought comment on what control options should be available to residents whose homes and properties are infested with argentine ants, and what information should be provided to them.

There was no response which suggested that heptachlor or other cyclodienes should be made available to the general public. This reflects changing community attitudes to pesticides, given the widespread use of DDT and dieldrin in home gardens in the recent past. Most people suggested that IPM procedures be made available along with a comprehensive public education programme. Suggestions as to what information should be made available to the public included a comprehensive listing of all possible management options and their potential hazards, and likely success rates. Information allowing the easy identification of argentine ants, details of the ants' biology and the potential hazards of argentine ant infestations should also be made available so that steps may be taken to reduce the possibility of argentine ant infestations and to reduce their potential spread. Question 3 also asked for comment on whether the control of argentine ant infestations should be made compulsory. Most submissions stated that compulsion should not play a part in argentine ant control, and that after a successful public education programme which outlined alternative control options, householders would be willing to undertake some form of pest management.

6 Cyclodiene residues in the local environment

6.1 Soils

Figure 1 is a schematic representation of the fate of pesticides once they have been applied as termite treatments and to agricultural soils. The submission by Velsicol Australia states that heptachlor breaks down to CO_2, H_2O and HCl within 2-4 weeks after application, and that there is no soil build-up after repeated sprayings of heptachlor. The APB has determined that the effective surface life of heptachlor is around three months when applied to the soil surface in our environment. Dutch researchers have shown that heptachlor metabolites persist in soils for up to 30 years after application (Doelman 1988). The breakdown of heptachlor in the environment is an extremely complex process which is influenced by many factors including the method of application, soil type, soil moisture, the presence and activity of soil microorganisms, sunlight, rainfall and temperature and whether or not the pesticide residues are attached to or incorporated within organic molecules. It is not surprising therefore that such a range of reported half lives for these chemicals exists in the literature. The data in Figure 2 shows that when heptachlor is sprayed externally onto vegetation, much of the chemical is lost to the atmosphere presumably by volatilization. The loss of heptachlor is almost as rapid as the loss of the organophosphate chlorpyrifos. The volatility of heptachlor in **moist** conditions is much higher than other cyclodiene insecticides and the data presented in Appendix 2 supports the observed field loss rates. This information suggests that much of the heptachlor would be lost to the atmosphere if housing pads were treated incorrectly. The waterproof membrane and concrete pad must be poured immediately after treatment to ensure adequate chemical remains in the soil as a termite barrier. The volatility of heptachlor is likely to be far less in dry conditions such as the soil beneath houses.

It has been established that cyclodiene pesticides persist in the environment for many years. The recent controversy over beef pesticide residues in WA revealed that some cattle had become contaminated with heptachlor as a result of the argentine ant spraying programme. This example serves to illustrate that heptachlor was taken up and accumulated in the tissues of animals that were kept off sprayed areas for some weeks after spraying. The persistence of heptachlor could also threaten wildlife that comes in contact with previously sprayed areas. The APB has responded to this information and now uses the less persistent organophosphate, chlorpyrifos, to control argentine ant infestations on grazing land.

Extensive sampling of paddocks by the Department of Agriculture has shown that there are areas which have high levels of organochlorine insecticide residues. Table 2 summarizes the residue levels in the Bunbury region, which are believed to be typical for much of the southwest of WA. A survey conducted in agricultural soils in the US (Harris *et al* 1977) showed average levels of cyclodiene insecticide residues found in soils used to grow vegetables and field crops to be 2.6 and 0.8 ppm. These average levels are above those found in the soils of the Bunbury region. Maximum values found in the US agricultural soils for chlordane, DDT, dieldrin and heptachlor were 13.3, 113, 1.85,and 0.34 ppm respectively (Crockett et al 1974). The maximum residue levels of dieldrin and heptachlor found in the soils of the Bunbury region are considerably higher than maximum levels found in the survey of US soils, but these extreme values make up a small proportion of the total. The paddocks sampled by the Department of Agriculture in WA were those that may have led to the contamination of beef cattle, and as such may not be representative of the pattern of agricultural soil contamination in WA.

6.2 Surface and groundwaters

Accumulations of pesticides found in the agricultural drainage waters and rivers of the South-west suggest that considerable OC pesticide loads are reaching estuaries and marine embayments. This is because of the large flow volumes in which the high OC concentrations were detected. Samples taken from the water column of some south-west estuaries show that at the beginning of the 1987 winter, 5 out of 8 estuaries sampled had OC levels which exceed the criteria for the maintenance of marine and estuarine ecosystems. This proportion fell to 4 out of 9 estuaries sampled in mid-winter. Concentrations of OCs in the sediments of these estuaries were generally low. There has been no attempt to investigate the rates of accumulation or the effect of these OC levels on aquatic invertebrates or animals at higher trophic levels in the South-west rivers or estuaries to date.

There have been a number of reports of cyclodiene pesticide concentrations exceeding criteria for the preservation of waterbodies in WA (Davis & Garland 1986, Thurlow *et al* 1986, McAlpine 1988). Heptachlor and DDT levels which exceed the criteria for the preservation of aquatic ecosystems have been found consistently in bores sampling the groundwater around the Perth metropolitan area (Gerritse 1988 *pers comm*). The levels of heptachlor in some bores exceed the WHO recommended maximum for potable water, but are considerably lower than the Australian standards. It is of concern that cyclodiene insecticides are being detected consistently in groundwater. The main mechanisms for movement of these compounds are unclear at present, but movement in the vapour phase has been implicated (Gerritse 1988). The cyclodienes are poorly soluble in water and are unlikely to be leached from soils by water movement (Gerritse 1988). Volatilization and movement in the gas phase or movement attached to fine soil fractions appear to be the most likely processes involved. Figure 1 shows some of the processes involved.

The pesticide cycle

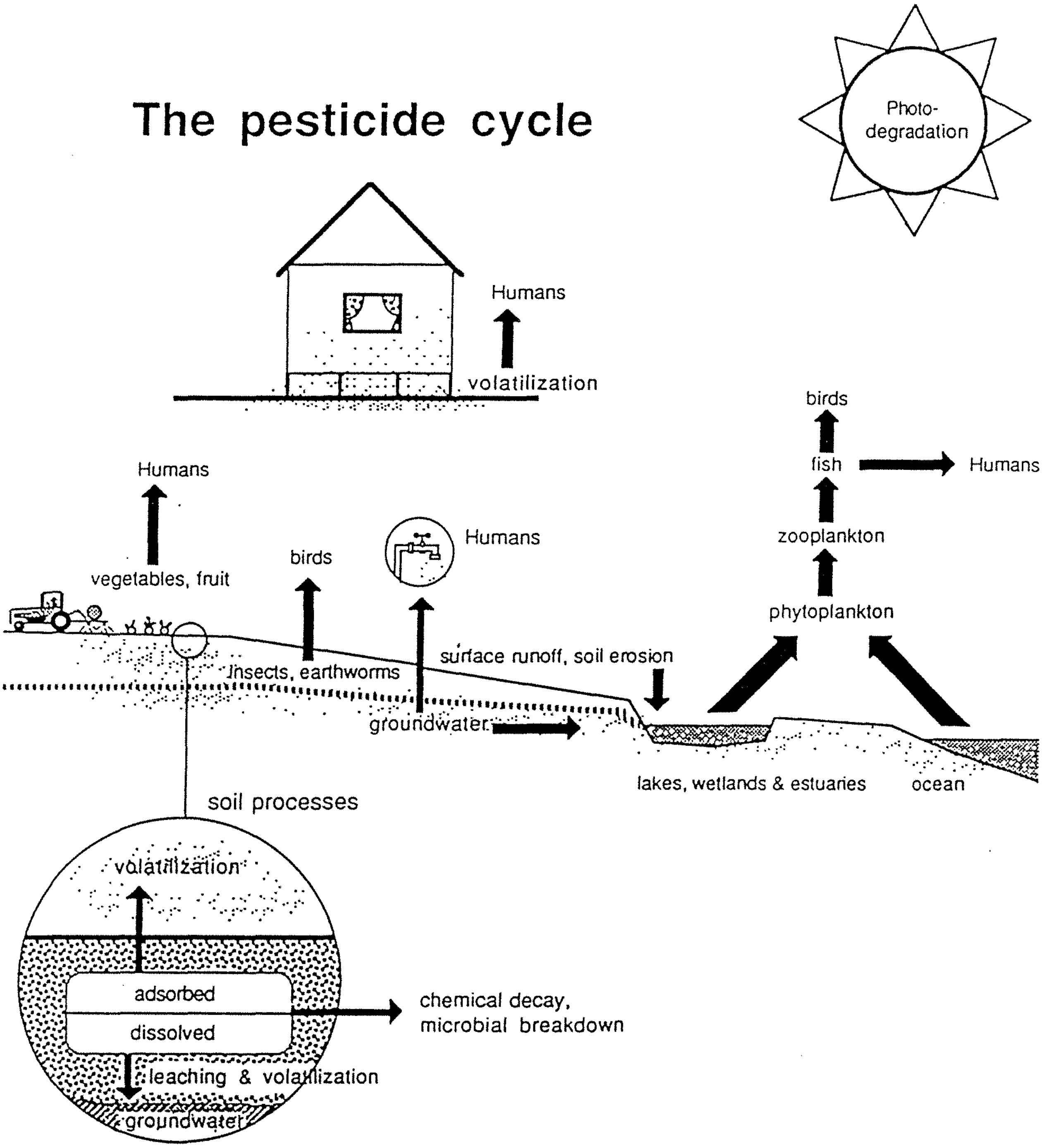

Figure 1 A schematic diagram showing the fate of cyclodiene insecticides after they have been applied to control pests in agricultural soils and termites beneath houses.

Table 2 Levels of organochlorine insecticides and their metabolites found in some soils of the Bunbury region

Concentration (ppm)	Chlordane	DDT	Dieldrin	Heptachlor
0-0.1	169	344	357	189
0.11-0.25	91	262	208	94
0.26-0.50	52	198	225	59
0.51-0.75	8	100	121	9
0.76-1.00	1	43	55	3
1.01-2.00	3	68	54	1
>2.0	0	15	12	2
Highest value	1.95	4.2	4.8	2.6

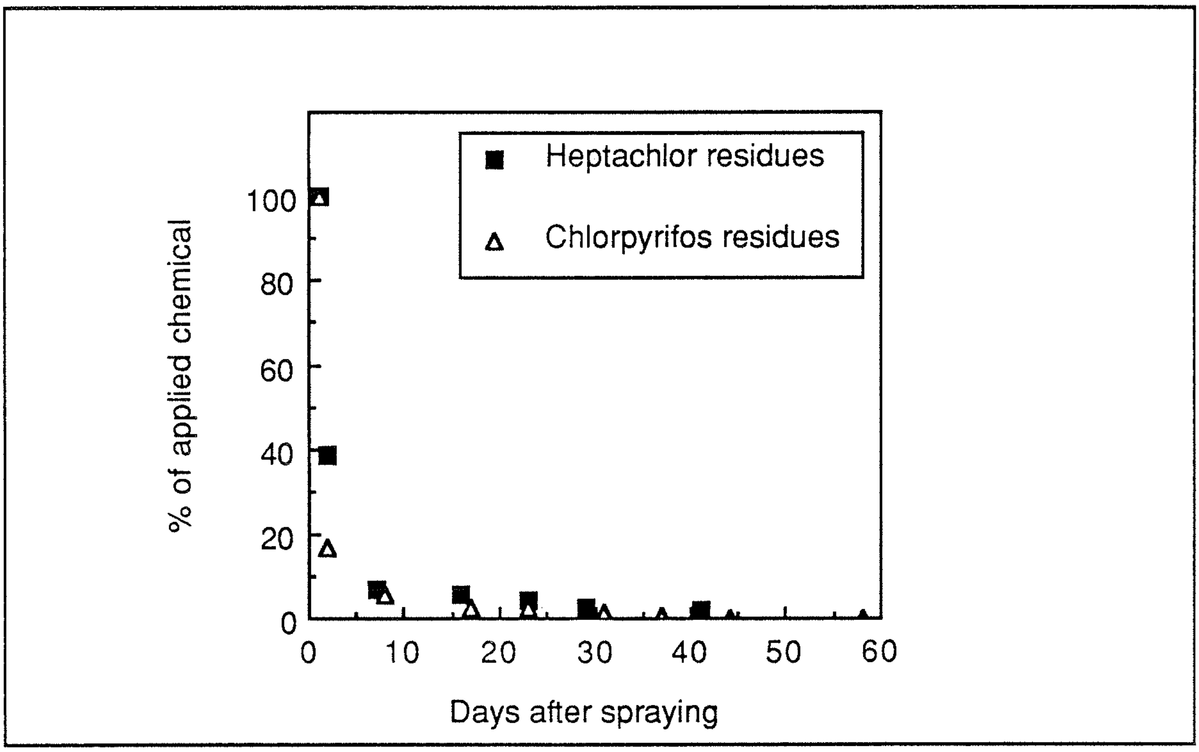

Figure 2 The percentage of applied heptachlor and chlorpyrifos remaining on vegetation after the external spraying of couch grass in summer. (Data from P Davis 1988)
Note: calculated value for heptachlor at 0 days.

It has been shown that cyclodiene insecticides (except heptachlor) are readily detectable in rainwater (Gerritse 1988) and that atmospheric dust is the main vector of transport. There should be some monitoring of cyclodiene levels in Western Australian rainfall.

6.3 Plants and animals

There have been mass kills of aquatic invertebrates at Herdsman Lake which have been directly attributable to spraying for argentine ants (Davis 1986). There has been recovery of numbers to almost pre-spraying densities twelve months after this study. There is little information on the effect of cyclodienes on aquatic animals higher up the food chain.

Levels of cyclodienes in mussels and cockles collected adjacent to industrial effluent outfalls in Princess Royal Harbour Albany were below human health maximum residue limits. Accumulations of these chemicals in molluscs indicate that local water quality is poor, and as such are cause for concern. There has been limited investigation of the levels of cyclodiene insecticides in other animals and plants other than from the monitoring of beef cattle residues.

Heptachlor and other cyclodienes have unequivocally been found carcinogenic in rats and mice (Reuber 1987, van Ravenzwaay 1988). Cyclodienes act as tumor promoters in mice and the induction time for tumor development is proportional to the total accumulated dose (van Ravenzwaay 1988). This information is applicable to native rodents (and possibly other vertebrates) which may receive significant exposure to these chemicals through biomagnification up the food chain.

6.4 Humans

Heptachlor can be detected in human tissue (Appendix 1 and 3) and may accumulate through several mechanisms. These mechanisms are shown in Figure 1 and include the ingestion of contaminated foodstuffs and contaminated groundwater, inhalation of heptachlor volatilized from argentine ant or termite treatments, and direct skin contact with contaminated soil or vegetation. The WA Health Department data given in Appendix 3 are within the range of values sited by Dingle in Appendix 1.

Serious doubts have been raised about the safety of grid spraying methods for the control of argentine ants in residential backyards, in the light of the National Health and Medical Research Council (NH & MRC) recommending the banning of cyclodiene pesticides in all outdoor areas such as childrens' playgrounds. It has been stated (Drew Appendix 3 of EPA Bulletin 325) that pregnant and lactating women should avoid contact with heptachlor. This procedure is also advocated by the WA Health Department despite their view that heptachlor (and other cyclodienes) can continue to be used for the treatment of argentine ants (albeit under controlled conditions). It is impossible for pregnant or lactating women to avoid contact with these chemicals in all situations. This is especially so in the South-west WA where the data show that cyclodiene pesticides are more mobile (volatile) in the environment than has been previously recognized.

A review of the extensive literature on health issues relating to the use of various cyclodienes, shows that there is a deep division in the expert opinion on the human health risks associated with short and long-term exposures to heptachlor and other cyclodiene pesticides. It has been stated by the WA Health Department that there is the possibility of idiosyncratic reactions in certain individuals who have been exposed to heptachlor. The NH & MRC, the WA Health Department, and the Department of Occupational Health Safety and Welfare of WA (DOSHWA) agree that there are no potential human health risks associated with the outdoor broad-scale spraying of heptachlor for the control of argentine ants as proposed by the APB, even though Velsicol Australia, the distributor of heptachlor, states that the correct method of application is by subsoil injection or by trench and fill. Both of these methods of application are intended for the control of subterranean termites.

Many of the criteria used by Australian health officials are based on those suggested by the World Health Organization which have not been formulated for Australia in particular. For example, many of the criteria for acceptable levels of cyclodiene pesticide exposures are set in the context of Third World insect-borne diseases, which are of far greater consequence than environmental or human cyclodiene pesticide contamination.

Epstein, in a submission addressing the EPA discussion paper, has suggested that there are extreme human hazards associated with the use of heptachlor in broad-scale external applications. He suggests that WA health authorities should immediately initiate long-term medical surveillance, in association with formal epidemiological evaluation, for members of the public who have been exposed to heptachlor or its metabolites. Epstein believes that this is even more urgent for high risk occupational groups such as inadequately protected workers involved in spraying programmes. There has been little research into the possible synergistic effects of mixtures of various cyclodienes and their metabolites which make up the body burdens of many West Australians. Presently available data do not allow an evaluation of the nature of the toxicity of heptachlor and other cyclodienes to humans.

7 Alternative control measures

There are a number of potential alternatives to treating with heptachlor, but none offer the long-term control of a single application of heptachlor or other cyclodiene insecticides. There have been developments in new technology which may make the application of insecticides as soil barriers safer and easier. These new methods involve the installation of below-slab plumbing during building construction, which enables the placement of insecticides below the poured slab at any time without the risks associated with conventional methods of application. These new techniques may add to the cost of construction. There currently appears to be no cheap effective alternative to heptachlor.

7.1 Spraying with organophosphates (OPs)

Organophosphate insecticides, such as chlorpyrifos, are far less persistent than cyclodienes. Table 5 of Appendix 2 lists the range of half-lives reported in the literature for some cyclodienes and organophosphates (chlorpyrifos, diazinon). Chlorpyrifos has a half-life from 50-100 days in neutral to acid soils but this may be reduced to hours or several days in alkaline conditions such as fresh mortar in recently constructed cavity brick walls. Dow Chemicals Ltd (the Australian distributor of chlorpyrifos) is unlikely to apply for registration of this chemical for use as a pre-slab termiticide in Western Australia because of the lack of persistence.

The Agriculture Protection Board is currently using this chemical in grazing paddocks and around sensitive wetland conservation areas.

Organophosphates generally have acute toxicities similar to or higher than those of cyclodienes and are therefore potentially more hazardous to inadequately protected pest control operators. Evidence contained in a submission to the EPA suggested that continual low level exposure to OPs (like that experienced by pest control operators) may cause an increased frequency of idiosyncratic reactions to these chemicals, more so than is reported for cyclodiene insecticides. It has frequently been assumed that organophosphates need to be applied much more often than the cyclodienes to achieve the same measure of control. However, recent results contained in Appendix 2 suggest that, at least in the case of heptachlor, this relative advantage of cyclodienes versus organophosphates may not hold true. Information received from DOSHWA suggests that over the life of a dwelling it would cost considerably more to use organophosphates in place of the cheaper, more persistent cyclodienes. The mobility of organophosphates and the need for frequent applications further increases potential environmental and health hazards.

Chlorpyrifos is one of the most commonly used insecticides in Western Australia. Maximum residue levels (MRLs) for a wide range of foodstuffs have been set for chlorpyrifos, and are closely monitored. Because of its widespread external agricultural usage, it is likely that humans are regularly ingesting quantities of chlorpyrifos in a wide range of foodstuffs. There are concerns in the USA about human allowable daily intake (ADI) levels, even though each of the component foodstuffs are below maximum residue levels. The Australian NH & MRC is conducting market basket surveys which monitor the total pesticide load obtained from eating a range of food stuffs. The level of human exposure to this chemical should be kept as low as possible, so that it can remain as the main control agent for agricultural pests where persistent cyclodienes have been banned.

The lower level of persistence of chlorpyrifos, and the need for more frequent spraying could result in a more rapid development of genetic resistance to this class of chemicals than may be the case for cyclodienes, which have much longer active lives. It has been stated that certain commercial formulations of chlorpyrifos (an organophosphate insecticide), use a non pesticide organochlorine compound (1,1,1.trichloroethane) as a solvent, and that this compound may be potentially hazardous. At least one commercial formulation of chlorpyrifos is available which does not use this solvent (Dursban Micro-lo) , but there is evidence to suggest that this formulation is toxic to plants (Davis *pers comm).*

There are reports of contamination of waterbodies by chlorpyrifos, for example Davis & Garland (1986) detected it in Herdsman Lake after spraying. The levels did not exceed the recommended permissible level for organophosphates (10μg/l) but they may have exceeded the EPA criterion (EPA 1981) for invertebrates. The Herdsman Lake study failed to detect chlorpyrifos in the tissues of one fish species (*Gambusia affinis*). This suggests that the chemical does not undergo accumulation in the food chain in the short-term. The WA Department of Fisheries however, has detected chlorpyrifos in a range of fish species from Wilson Inlet. The levels were generally low, and do not indicate a hazard to human health.

These data suggest that in catchments (such as the Wilson Inlet catchment) where there is widespread and constant use of chlorpyrifos to control agricultural pests, the chemical may continually enter the aquatic ecosystem and contaminate animal life.

The long-term effects of OPs on animals are likely to be less than for cyclodienes, because of the more rapid breakdown of OPs in animal tissues. This finding needs to be evaluated in the context of the requirement for more frequent applications of OPs, resulting in virtually continuous low-level exposure of non-target organisms to these insecticides.

7.2 Spraying with synthetic pyrethroids

These chemicals appear to have limited use for controlling argentine ant infestations and may offer only short-term protection against termites. This family of chemicals has a much lower environmental persistence than OPs and cyclodienes, and therefore may be more environmentally desirable. However, there is some evidence to suggest that this family of pesticides may have deleterious environmental effects. Synthetic pyrethroids have very short half-lives and need to be applied regularly to effect long-term control. Their higher water solubility means that frequent external applications may result in continual pulses of these chemicals reaching aquatic ecosystems. The 48 hour LC50 for alphamethrin applied to *Daphnia* is 0.3 ppb, and 42 ppb for heptachlor, which means that alphamethrin is 140 times more toxic than heptachlor to these tiny aquatic crustaceans. Alphamethrin is also more acutely toxic to fish than heptachlor.

7.3 Chemical baiting

Hydramethylnon baits for argentine ant control have been tested in California with outstanding success (M. Rust 1988 *pers. comm.*). It is likely that similar success will be achieved in WA with this technique, but a considerable lead time will be needed before these baits can be used with confidence here. Mirex baits have been used with considerable success in the Northern Territory for controlling the giant termite, *Mastotermes darwiniensis*. The death of fruit trees affected by the termite was reduced from around 10% per annum to less than 1% per annum. The quantity of Mirex used in baits to eradicate nests is considerably less than the quantities of cyclodienes currently needed to protect houses. Mirex (a highly toxic organochlorine) may be de-registered in the near future because of concerns over its persistence and toxicity however. There is no currently available alternative chemical that will adequately control *Mastotermes*. Arsenic baits are also currently being used to control termites.

7.4 Integrated pest management (IPM)

Integrated pest management is the selection, integration, and implementation of pest control based on predicted economic, ecological and sociological consequences. IPM seeks maximum use of naturally occurring pest controls, including weather, disease agents, predators, and parasites. In addition , IPM utilizes various biological, physical, and chemical control and habitat modification techniques. Artificial controls are imposed only as required to keep a pest from surpassing intolerable population levels predetermined from accurate assessments of the pest damage potential and the ecological, sociological and economic costs of the control measures.

The principles of IPM rely on a much greater understanding of the biology and distribution of the ants, and require a high level of public education and participation in the control processes. To ensure a coordinated approach to the control of argentine ants, public education and participation may take the form of meetings, notices, newsletters, and/or distribution of leaflets to individual householders. The APB must necessarily play a coordinating and advisory role in such programmes.

The selection of possible biological control organisms and the use of chemical baiting are central elements of IPM, but research into these alternatives is in its infancy. The lead time needed to establish some of the more promising techniques being researched overseas may be several years. It is therefore essential that this research be initiated immediately and be given a high level of support.

8 Conclusions

The EPA concludes that there are adverse environmental effects caused by the broad-scale spraying with broad-spectrum insecticides to control argentine ants. Similarly, there are adverse environmental consequences of invasions by argentine ants into natural and agricultural ecosystems. The full impact of the effect of argentine ants on the environment will only become clear as the impacts occur, because of our poor understanding of the complex interactions between native ant populations, argentine ants and the natural biota of south-west Western Australia The impacts of argentine ants on the environment are likely to be less than those caused by spraying with heptachlor.

Argentine ants in the urban environment cause considerable discomfort and potential economic damage to humans, and it is essential that ant densities do not return to those experienced in the 1950s and 1960s.

There is clear evidence that many termite treatments in Perth are not being carried out according to WA Health Department regulations. Susceptible groups within the community are unable to avoid contact with the cyclodiene insecticides, as recommended by the Health Department of WA , and many people are carrying high body burdens of these chemicals. Presently available data do not allow an unequivocal scientific evaluation of the nature of the toxicity of heptachlor and other cyclodienes to humans.

Appropriate regulation of the pest control industry will see a reduction in human and environmental exposure. The EPA supports the WA Health Department's policy to phase out the use of cyclodiene insecticides as soon as effective environmentally acceptable alternatives become available.

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Appendix 1

Cyclodiene Residue Levels in Perth Households and their Occupants resulting from Termite Control Operations

An investigation for the Environmental Protection Authority

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CONTENTS

TABLES

FIGURES

1 INTRODUCTION

This report addresses the current use patterns of the cyclodiene insecticides for termite control in Perth. Guidelines and standards set down for the application of these chemicals are reviewed, and an analysis is made of the results of a survey conducted to establish the frequency of termiticide re-treatments in Perth. A review is also presented of case studies on the levels of cyclodiene chemicals detected in Perth houses, and in tissue samples taken from occupiers of treated residences. This information is supplemented with data from a literature survey. An attempt is made to relate some of these levels to the frequency of termiticide applications. The report also examines potential sources of cyclodiene contamination other than termiticides, for example in food, in an attempt to establish the relative significance of different sources of contamination of Perth residents.

Organochlorine pesticides, within which cyclodienes are grouped, are lipid soluble and tend to accumulate in the adipose tissue and lipid-rich fraction of the membranes of cells. Consequently it is possible to evaluate the levels of organochlorine pesticides in human populations. Three principal areas of human sampling are blood plasma, adipose tissue and breast milk. Because of the high fat content and the ease with which samples can be collected, human milk has been the focus of several studies. These results will be reviewed in this report. The limitation of human milk sampling is that it represents only a small portion of the population at any one time.

2 CYCLODIENE PESTICIDES IN THE PERTH ENVIRONMENT

Between 1985 and September 1987, the uses of heptachlor in the Western Australian urban environment included its application for the control of termites, timber and tree borers, spiders, black beetle in commercial turf, and singapore and argentine ants. However, amendments made to the Health (Pesticides) Regulations in September 1987 restricted the use of heptachlor to argentine ant and termite control. Attachment 1 shows a list of of the registered uses of heptachlor in Western Australia since 1971. At present, termite control is estimated to use 83 per cent of the annual heptachlor consumption in Western Australia (WA EPA 1988). The remaining 17 per cent is used by the Agriculture Protection Board (APB) for the control of argentine ants. Shewchuk (1981) reported that the major use of dieldrin between 1971 and 1974 was also for termite control.

The current method of protecting buildings from subterranean termites in Australia is set out in the Australian Standards 1694 (1974) for physical barriers, 2057 (1986) for chemical treatment of soil and buildings under construction and 2178 (1986) for detection and treatment of infestations in existing buildings. The last two standards specify that aldrin, dieldrin, heptachlor, chlordane or a heptachlor /chlordane emulsion be used.

The standards specify that post-construction treatment with these chemicals is necessary only when bridging or breaching of the chemical barrier has occurred or is suspected. Treatment of buildings with suspended floors is considered unnecessary over the entire sub-floor soil unless these areas are inaccessible. According to the standard, treatment must abut all substructure walls, stumps, piers, pipes etc. For concrete slabs, the standard specifies post-construction treatment by trenching and treating or subsoil injection to a depth of at least 300mm. Treatment of the sub-floor soil is through drilling of holes not more than one metre apart around the perimeter of the pad and injection of not more than ten litres of emulsion per hole. After this, the holes should be plugged with a moisture-proof compound.

In addition, Western Australia's Health (Pesticides) Regulations specify that only registered pest control operators may apply organochlorine pesticides and that applications be *'at intervals of not less than five years'* south of the Tropic of Capricorn. Exceptions are if *'a chemical treated soil barrier has been rendered ineffective by removal or substantial disturbance'* or if *'a termite infestation has been detected'*. In such cases, treatment should be only to *'the disturbed portion of the barrier'* rendered ineffective and *'to any adjoining length of that barrier not exceeding 1 metre from that portion'*.

These changes reflect the knowledge that cyclodiene insecticides used in termite control normally remain effective in excess of twenty years. For example, Simpson and Shandar (1972) reported that dieldrin and the other cyclodienes were still 100% effective for termite control 18 years after application. Hadlington (1987) suggests that cyclodiene insecticides are effective under Australian conditions in excess of 30 years. The US EPA (1987) reported that heptachlor applied as 0.5 per cent emulsion gives 100 per cent protection against termites for 10 years according to tests in Arizona and in excess of 19 years protection throughout the other states. Similarly, chlordane applied as a 1 per cent emulsion provides in excess of 19 years 100 per cent effective protection from termites.

3 SOURCES OF CONTAMINATION

The State Planning Commission of New South Wales (1986) identifies potential sources of pesticide contamination of the urban environment as:

i) the proper and controlled use of pesticides in the environment;

ii) the misuse of pesticides; including excessive frequency or rate of application, uses in other than approved situations or indiscriminate and excessively widespread application;

iii) the incorrect disposal of surplus material such as wastes, residual concentrate or used containers.

There is currently considerable debate in Western Australia on the extent of pesticide contamination resulting from the proper and controlled use of these chemicals as well as disagreement over whether the broad-scale spraying of heptachlor for argentine ant qualifies as a proper use. This report addresses the latter two potential sources of contamination identified by the the State Planning Commission of New South Wales.

3.1 MISUSE AND OVER-APPLICATION

There is extensive misuse and overuse of the cyclodiene insecticides in the Western Australian urban environment. It appears that the restrictions on the use of organochlorines introduced in 1986 are not being enforced. In response to considerable publicity about insecticide abuse, the Western Australian Health Department took a number of steps to ameliorate the situation. One measure was to arrange a seminar for pest control operators in May 1988. Over 200 pest control operators attended. For some operators, this Health Department initiative appeared to have been the first introduction to the January 1986 changes in the Health (Pesticides) Regulations. In its invitation to operators to attend the seminar, the Department acknowledged this situation: 'Department enquiries have unfortunately found that in many cases pest control operators are not familiar with the recent changes in legislation'.(Lugg, 1988. Circular,16/5/88).

There can be little doubt that annual applications of cyclodiene insecticides are taking place in Perth on a large scale. This is supported by anecdotal evidence about annual applications still being reported to the consumer group Householders For Safe Pesticide Use, to the Conservation Council of W.A., to the Pest Control Unit of the Health Department, to the Environmental Protection Authority and to the Environmental Science Department at Murdoch University. After a small newspaper advertisement, the Conservation Council of W.A. and Householders For Safe Pesticide Use received calls from 55 members of the public, almost all of whom where either current signatories to contracts specifying annual maintenance treatments or had been so until recently. The two organizations received several dozen additional such calls after an article in a Sunday newspaper.

3.2 SURVEY RESULTS

Figure 1 presents more substantive evidence of the frequency of breaches of the Health (Pesticides) Regulations. It shows that a large proportion of houses in Perth still receive annual applications. The survey on which Table 1 is based was conducted between February and August 1988. The data were compiled from questionnaires completed by 243 Perth householders. The results indicate that 1.2 per cent of houses are treated more than once a year and 54.3 per cent of houses receive an annual termite control treatment, while 11.1 per cent receive a treatment once every two years. Nearly 12 per cent receive treatment every three to four years. Approximately 19 per cent are houses which receive a treatment at intervals of five years or more. Only 2.9 per cent were apparently never re-treated for termites. Based on these figures nearly 78.5 per cent of the houses surveyed are currently being over-treated. There are substantial reasons to believe that the chemicals used are cyclodiene insecticides and that therefore, the re-treatments at less than five-yearly intervals constitute breaches of the Health (Pesticides) Regulations.

At the same time, it is necessary to consider the following points:

1) The actual chemicals used were not identified by the home owners;
2) The regulations permit limited repeat chemical treatment when the chemical barrier is breached or termites are found;
3) Some operators claim to rotate treatment of a house so as to apply chemicals to only a section of the residence each year.

The first point can be countered with the argument that cyclodienes were the chemicals more likely to have been used since they have dominated the termiticide market in the past and continue to do so in the present. The principal reason is that the price of cyclodienes is considerably lower than that of the organophosphate chlorpyrifos, the only other chemical available for use against termites in Western Australia. There is further evidence supporting the conclusion that cyclodienes are more likely to have been used in the re-treatments reported in the survey. Almost all alleged insecticide misapplications investigated by the Health Department, including some arising from annual maintenance treatments, revealed that cyclodienes had been used.

As regards breaching of termite barrier or termite infestation as a justification for repeated chemical application, it has to be considered that neither breaches nor termite infestations are likely to occur on an annual basis. Furthermore, if breaches did occur, according to the regulations they should require only spot re-treatment. As regards the possibility of partial applications or rotation of annual applications, only one respondent remarked that the pest control company treats only half the house each year. This rotation would still constitute a breach of the regulations, if, as is likely, cyclodienes were applied.

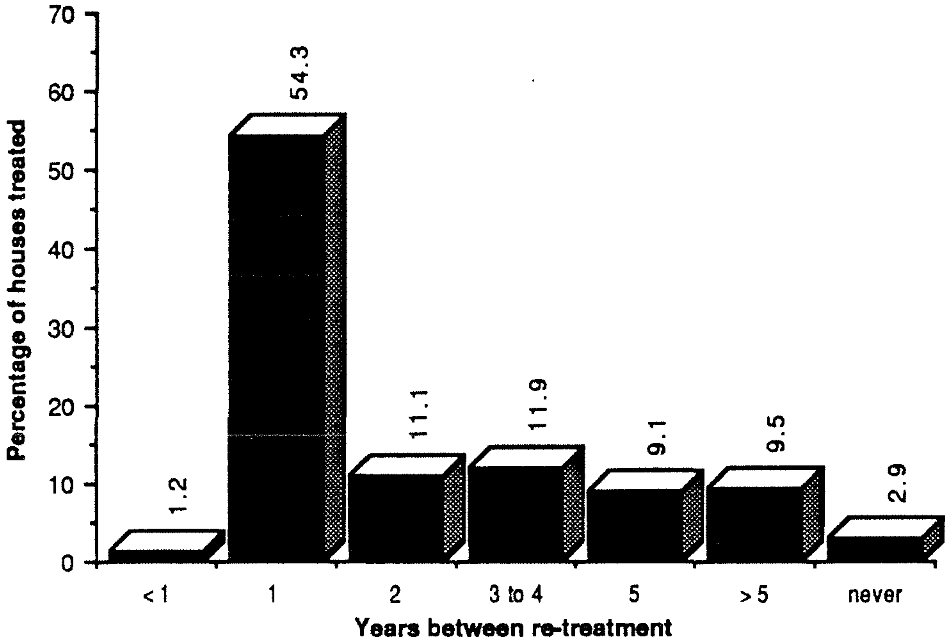
The surveys were conducted in Wanneroo, Palmyra, Darlington and Cottesloe in order to provide both a wide variation in housing style and house ages as well as in socio-economic background of respondents. The houses were chosen randomly to ensure the validity of the results. Although some variation in the method of delivery of questionnaires to households occurred, all surveys were hand-collected. This enabled the respondents to resolve any problems. It also ensured a high rate of return. The rate of response was 75 per cent. The remaining 25 per cent were occupiers of rental properties or people unable or unwilling to complete the questionnaire for other reasons.

The questionnaire was primarily designed to provide information on the frequency of re-treatments for termite control. A sample questionnaire is included as attachment 2. To provide information on the frequency of re-treatments in Perth, the questionnaire had to allow people to clearly differentiate between inspection and re-treatment (Questions 1 to 7). It also attempted to identify the specific chemical used (Question 8). However, this question was only answered by a small number of people. Questions 9 and 10 attempted to establish whether any serious misapplications had occurred in a residence and whether occupants suffered any symptoms. These questions were generally poorly answered. Many people stated that the house smelt for up to six hours after treatment. Question 11 attempted to find out why people had their houses treated. The reasons were generally well distributed. However, it was noted that when occupiers marked 'presence of white ants' as the reason, on many occasions the insects were found in the garden, not inside or underneath the residence.

The collated information suggests that the extent of past and present over-application of cyclodiene pesticides is likely to be the source of future environmental and human contamination. This conclusion is supported by current identification of the cyclodienes throughout the urban and suburban environment of Perth. Furthermore, relatively high levels of cyclodiene residues have been detected in the air of many Western Australian homes and in some human tissues (Sect 3.3).

Investigations of misapplication of the cyclodiene insecticides have revealed evidence of indoor treatment, of likely surface spraying, of application to cracks and crevices for spider control and of spraying of backyard areas including garden structures and firewood. There were also a number of incidents in which an apparent mixing of cyclodienes or of cyclodienes and chlorpyrifos took place. Accidents and spillages both inside residences and in the sub-floor area are also not uncommon. Practices such as the injection of these chemicals through holes drilled in concrete slabs is commonly accepted as being hazardous, and apparently often result in indoor spillages.

Figure 1. Frequency of Termite Re-treatments in Perth



3.3 INVESTIGATIONS OF CONTAMINATED RESIDENCES

The Health Department maintains a record of the residences it investigates. However, while many more cases of misapplication are now being recorded, many cases remain uninvestigated because householders themselves do not always recognize or wish to report or remedy termiticide misuse. Many people fail to understand the implications of cyclodiene contamination, do not wish to become involved in investigations of pest control companies or feel embarrassed or shy about their predicament. Others still believe that the longer the chemical smell persists the better the protection. Thus official statistics and media stories about misapplications may fail to reflect the actual situation .

Nevertheless, between January 1, 1986 and June 1, 1988, the Health Department of Western Australia investigated 96 incidents of commercial pesticide application. Eighty-six of these investigations were in domestic residences and the remaining ten in business premises. Of these 96 cases, 34 were reported in the first six months of 1988 compared to 28 in all of 1987 and 9 in 1986. Heptachlor was detected in most of the investigated incidents along with chlordane and dieldrin. Aldrin was reported relatively rarely. In most incidents, air residue levels of heptachlor were reported to be at higher concentrations than the other cyclodienes, for example at levels of 9.2, 28 and 30 $\mu g/m^3$ of air respectively in 1986, 1987 and the first six months of 1988. However, in one 1987 incident, air levels of aldrin were $59 \mu g/m^3$. In the three business premises investigated by the Health Department, the highest concentrations of heptachlor in the atmosphere were 6.6 in 1987 and 27 and 34 $\mu g/m^3$ in 1988 (Hansard 1988). It is apparent from these results that the number of incidents reported has increased. It is suggested that the increases are a result of greater public awareness produced by increased media coverage of pesticide issues.

In 25 of the incidents investigated, heptachlor air levels were equal to, or in excess of the $2 \mu g/m^3$ daily average level for a three year exposure, the guideline levels set by the United States National Research Council which are also used by the WA Health Department. In 14 incidents, dieldrin or aldrin residues exceeded the $1.0 \mu g/m^3$ guideline level. Of 21 of the investigated incidents, 19 in domestic residences and two in business premises, were apparently unauthorized indoor applications of cyclodiene insecticides. Only 2 incidents involved unlicensed pest control operators, while 2 involved unregistered pest control firms (Hansard, 1988). Thus, of the cases investigated almost all were performed by licensed pest control operators working for registered firms. The nature of misapplication in most of the remaining cases is not known.

3.4 FURTHER CASE STUDY INVESTIGATIONS

A number of incidents investigated by the Health Department were investigated further to produce 8 case studies. In 3 of these cases, home owners expressed their concern about the use of organochlorine pesticides to the pest control operator or firm prior to treatment. They were apparently led by the operator or the firm to expect treatment with alternative 'safe' chemicals. A number of those cases involved pregnant women and infants in the homes. In many of the cases, information about spillage or misapplication was not provided by the pest control operator until an investigation of the pesticide levels in the house was undertaken by the Health Department.

4 CYCLODIENE LEVELS IN HOUSES

In 1981, the State Government Chemical Laboratories on behalf of the Health Department undertook to measure the organochlorine pesticide residues in the air of a house treated according to Australian Standard 2057 (1977). Air samples were taken three days prior and three days after the treatment.

Table 1 Air levels of cyclodiene insecticides 3 days before and after treatment for termites (Cyclodiene levels expressed in μg/m^3 of air).

Room	Days After Spraying	Aldrin	Dieldrin	Heptachlor
Kitchen	-3	<0.1	0.1	0.1
	+3	2.4	0.1	1.0
Master	-3	<0.1	<0.1	<0.1
Bedroom	+3	5.0	<0.1	2.5
Under	-3	<0.1	<0.1	<0.1
Verandah	+3	68	0.2	11

(Government Chemical Laboratories 1981)

They showed that levels of aldrin, the main insecticide used, rose from <0.1 to 2.4 μg/m^3 in the kitchen, from <0.1 to 5.0 μg/m^3 in the master bedroom and from <0.1 to 68μg/m^3 under the verandah. When heptachlor was used, it rose from 0.1 to 1.0 μg/m^3 in the kitchen, from <0.1 to 2.5 μg/m^3 in the master bedroom and from <0.1 to 11.0 μg/m^3 in the master bedroom and under the verandah (Government Chemical Laboratories, 1981). Table 1 documents the results of these tests. Further measurements taken by the Government Chemical Laboratories in 1986 (Stacey, 1988) show that injection of cyclodienes into the soil under the floor leads to elevated levels in the air of houses. Levels of heptachlor and aldrin peaked at 2.9 and 5.3μg/m^3 respectively within the first week and remained at elevated levels after 42 days. These figures are given in Table 2.

An obvious reduction in the air levels of these insecticides occurred during the second week after application and thereafter. However this experiment did not account for fluctuations which may occur after 42 days. Fluctuations can lead to considerable variation in air residue levels. This is supported by case studies in which levels were measured repeatedly, months after application. A total of eight such case studies also document the fact that, irrespective of the fluctuations, elevated cyclodiene air residues are not likely to decline quickly to reach interim guideline levels. In all but one of these cases, the levels of cyclodiene insecticides in the air of the houses exceeded the interim guidelines adopted by the Health Department. In 2 of these 8 cases, the levels exceeded these guidelines 6 months after treatment. In another 2 cases, levels exceeded the guidelines 12 months or more after treatment. Table 3 documents these cases and Table 4 shows the persistence and fluctuations of these chemicals in the air in one of the cases investigated. In all cases, decontamination measures were undertaken to reduce the levels of cyclodiene contamination.

Table 2. Air Levels of Heptachlor and Aldrin in a House Treated According to Australian Standards. Cyclodiene residue levels expressed as µg/m^3 of air

Cyclodiene	Treatment	Day After Treatment	Level
Heptachlor	300L of 0.47% m/v injected into the soil under the floor	-5	0.12
		2	2.9
		7	2.8
		14	0.58
		28	1.1
		42	0.60
Aldrin	60L of 2.9g/L injected into the soil under floor	-2	<0.1
		2	1.6
		7	5.3
		14	0.95
		28	0.85
		42	1.9

(Government Chemical Laboratories 1986.)

Table 3. Persistence of Cyclodiene Insecticides in the Air of Perth Houses. Cyclodiene residue levels are expressed in µg/m^3 of air

Case Number	Months after treatment	Cyclodiene	Air level
1	13	heptachlor	>2*
2	12	heptachlor	>2*
3	9	heptachlor	>2*
4	6	heptachlor	>2
5	5	dieldrin	>1
6	2	heptachlor	ca.2
7	2	heptachlor	>2

*last recorded air monitoring

Table 4. Persistence and Fluctuations of Cyclodienes in the Air of a WA Residence after treatment in January 1987. Cyclodiene residue levels expressed as µg/m^3 of air

Chemical	3/3/87			*6/5/87	29/7/87	31/8/87	12/10/87	26/2/88
	Bedrm	Lounge	Bedrm	U1	U1	U1	U1	U1
Aldrin	0.4	0.3	0.62	0.29	-	0.77	1.3	0.3
Chlordane	1.1	0.7	0.30	0.25	-	0.26	-	-
Dieldrin	3.4	0.2	0.26	0.27	-	0.18	-	-
Heptachlor	26	21	6.0	4.2	2.7	7.5	6.4	3.6

U1 Unspecified room

* Decontamination was undertaken prior to this sampling.

(Table compiled from Government Chemical Laboratories data.)

These results in Table 4 show that residue levels can remain elevated over a period of 9 months. In fact, the highest aldrin level in this house was recorded after the final sampling, while the second highest heptachlor reading was 5 months after the first reading. The persistence of the cyclodiene insecticides in the air of houses is well documented in the US (US EPA 1987). The fluctuation in the Western Australian cases is also supported by the US studies (US EPA, 1987). When only short-term tests are undertaken, temporary declines may lead the researcher to believe that levels dissipate quickly and remain low. Table 2 shows considerable fluctuation over the 42 day period; however, the second highest level recorded for dieldrin is on the final sampling date. (Measurements should also take into account conditions such as temperature and humidity levels and other factors which may cause the air residue levels to rise).

5 CYCLODIENES IN HUMAN MILK

5.1 HUMAN MILK

Residues of xenobiotics (toxins) in human milk have a special significance in that human milk often makes up the sole source of nourishment for newborns and infants. High organochlorine levels in this food source are likely to contaminate the infant.

While there are obvious advantages to breast feeding, given the high lipid concentration in human milk and infants' vulnerability, the potential contamination of infants with fat-soluble toxins is of major concern. The International Programme on Chemical Safety (IPCS 1984) reported that residues of heptachlor and heptachlor epoxide in some human milk had been found to be tenfold higher than those in dairy milk and dairy products. Breast milk may be the sole source of food of an infant for prolonged periods. In addition, the infant will have absorbed residues transplacentally from a mother who has been exposed. Finally, the infant may be exposed through inhalation or dermal contact. At the same time as perinatal infants may be ingesting high organochlorine pesticide concentrations through milk, they may also be growing rapidly, doubling their mass within months. Such development requires, in comparison with adults, a considerably higher respiration volume per unit of body mass and therefore, potentially a greater intake of cyclodiene insecticides from the air.

Newborns are generally more sensitive to toxic chemicals because their kidneys, liver enzyme systems, nervous system and blood brain barriers are not fully developed (Quinby et al 1965). Kroger (1974) suggests that the low body fat of infants results in fat-soluble chemicals circulating in the body for a longer period than in adults, and that they may become available to more sensitive sites for longer periods than in adults. The United States National Academy of Science (1977) reported that the very young are more susceptible to environmental insults than are adults in the population. In addition, the Academy concluded that exposure of antenatal and neonatal laboratory animals to carcinogens results in a greater carcinogenic effect than a comparable exposure of an adult.

Mestitzova (1967, cited in Van Nostrand 1984) fed rats 6mg/kg of body weight pure heptachlor (98.1%). A significant decrease in litter size was reported in several litters of the first and successive generations. The life span of suckling rats was significantly shortened with most deaths occurring in the first 24-48 hours. This study also recorded an increased incidence of cataracts of the lens in exposed rats as well as the offspring in two successive generations. The IPCS (1984) and US EPA (1987) cite studies which show that in rats and dogs, heptachlor and heptachlor epoxide treatment of females resulted in increased mortality of pups during suckling. Drew (1988) attributes this to the increased sensitivity of the neonates to the hepatotoxic effects of heptachlor epoxide excreted in the maternal milk supply.

Based on the levels of cyclodiene insecticides in human milk, Mes et al (1984) calculated that an infant fed on breast milk could be expected to reach the adult pesticide residue level within three months of suckling contaminated mother's milk.

5.2 OVERSEAS STUDIES OF CYCLODIENES IN HUMAN MILK

Pesticide residues in human milk were first reported in 1951 by Laug et al who found that 30 of the 32 samples analysed contained DDT. Later studies showed widespread contamination with many of the organochlorine insecticides, including heptachlor epoxide. Curley and Kimbrough (1969) reported traces of heptachlor epoxide along with dieldrin and other chlorinated hydrocarbon insecticides in human milk samples from the US. Strassman and Kurtz (1977) found heptachlor epoxide, trans-nonachlor and oxychlordene in every whole milk sample from Arkansas and Mississippi in 1973-1974 at mean levels of 0.004, 0.001 and 0.005ppm respectively. Savage et al (1981) reported a detection rate of >80%, 73.9 and 63.1% in 1,436 milk samples taken and analysed in the US for dieldrin, oxychlordene and heptachlor epoxide respectively. Extensive studies overseas have reported similar frequencies of detection but at lower levels. The results of some of these studies are shown in Table 8, and are compared with some levels recorded from Western Australia.

5.3 AUSTRALIAN HUMAN MILK

Miller and Fox (1973) reported high levels of organochlorine pesticides in the breast milk of Queensland women with 100 per cent of samples positive for DDT and BHC in the rural and urban area, 100 per cent of samples positive for dieldrin in the urban area and 95 per cent positive for dieldrin in the rural area. They further found a significantly higher level of DDT in Mareeba, a high intensity agricultural area, than in urban Brisbane. Dieldrin levels showed no significant geographical variation indicating, according to the authors, that the major source of uptake was food. They also reported that the levels of these pesticides exceeded the acceptable daily intake (ADI), often by a factor greater than ten. This ADI is no longer considered safe by FAO/WHO for breast-fed infants. Table 8 shows the levels in whole milk.

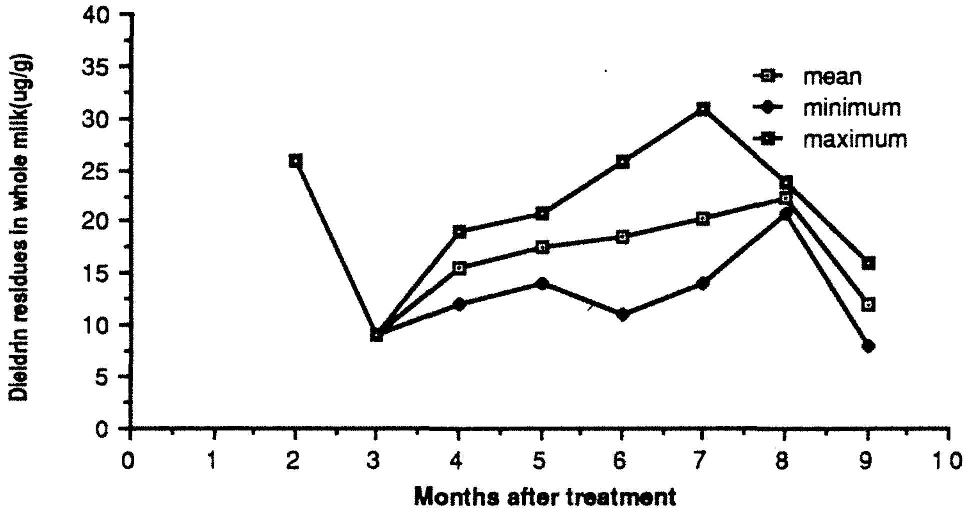
5.4 WESTERN AUSTRALIAN HUMAN MILK

A comparison of pesticide residues in the breast milk of women living in the Perth metropolitan areas between 1970-71 and between 1979-80 was carried out by Stacey and Thomas (1975) and Stacey *et al* (1985). The authors were able to demonstrate a decrease in the mean level of DDT and HCB and an overall increase in dieldrin levels from 0.005 to 0.009 ppm. The authors suggest that the levels obtained, which represent an average infant intake of approximately 0.0014mg/kg/day, are approximately 14 times the maximum acceptable intake determined by the World Health Organization (WHO). Their results are shown in Table 8. Stacey *et al* (1985) also showed that the levels of dieldrin were generally slightly higher in samples from the metropolitan area than in those from country areas. In addition, they found that dieldrin levels in the newer suburbs were higher than dieldrin levels in samples from older neighbourhoods. Statistical analysis of questionnaire results supported the conclusion that the higher levels of dieldrin found in breast milk were from houses with a recent spraying history for termites. The authors concluded that there is evidence to suggest a direct link between the use of dieldrin for termite control and high dieldrin levels in breast milk.

In a follow-up study biased towards houses treated for termites in Perth, Stacey and Tatum (1985) reported that the level of dieldrin in human milk continued to rise until the seventh or eighth month after termite treatment. These results are presented in Figure 2. It should, however, be noted that these experiments extended only to the ninth month after treatment.

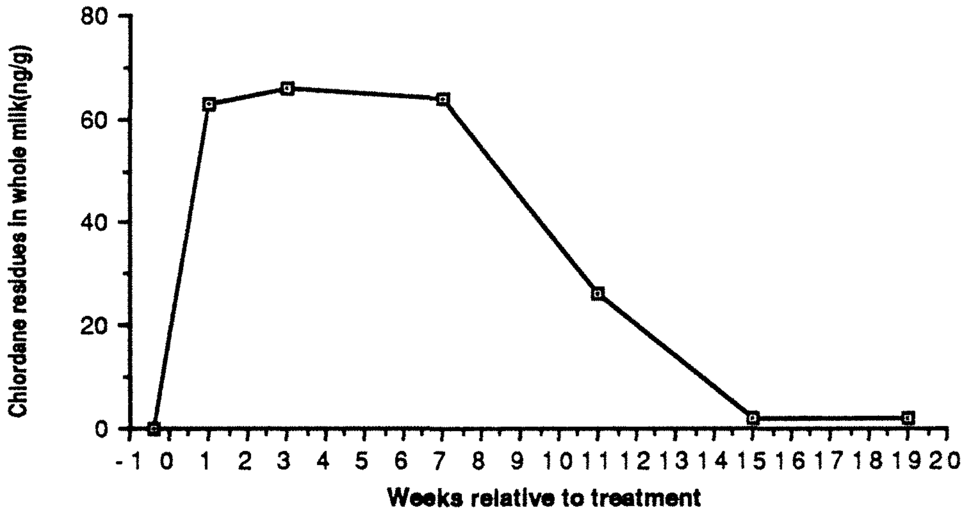
No conclusions can be drawn from these studies for later periods. In a recent overseas study Taguchi and Yakushiji (1988) reported that the level of chlordane in human milk continues to rise for five years after cyclodiene treatment. This study was based on observing the effects on breast milk after a single termiticide treatment. Many Western Australian homes receive multiple re-treatments, many of them full re-treatments, within the same period. One can only speculate on the implications of these practices for Western Australians.

Figure 2. Levels of dieldrin in human milk after treatment.



Stacey and Tatum (1985) also noted a move away from the use of aldrin to heptachlor and chlordane as termiticides. This resulted in heptachlor and heptachlor epoxide being detected at a mean value of 1.0 and 4.0ppm respectively in human whole breast milk. The levels the authors obtained are substantially higher than values reviewed in this section for other countries. Table 8 compares the values found in samples of Western Australian whole breast milk with those reported in other studies. Stacey and Tatum also noted that in one donor, levels of chlordane rose from trace levels to 66 and 64ng/g in the third and seventh week following treatment after which the concentrations declined. These results are presented in Figure 3. Heptachlor epoxide was reported to rise from trace levels prior to treatment to 29ng/g four and five weeks after treatment and then to decline slowly.

Figure 3. Levels of chlordane in human milk after treatment



(Figures 2&3 adapted from Stacey and Tatum 1985)

In order to gain further support for the direct association between termite control operations and the concentrations of cyclodienes in breast milk, Stacey (1988) measured both the level of cyclodienes in the air of the house and in breast milk. He reported that the concentrations of heptachlor epoxide in breast milk were similar to those in the previous study, tended to lag slightly behind the rise in heptachlor recorded in the air samples.

These data are presented in Table 5. They strongly support the conclusion that the use of cyclodiene insecticides for termite control in houses leads to an increase in cyclodiene levels in the milk of nursing mothers living in treated houses and in this study revealed concentrations in excess of reported international levels (see Table 7).

Table 5. Comparison of Heptachlor Levels in Air and Human Milk Samples from Perth WA.

Days After Treatment	Air (µg/m^3) Heptachlor	Whole Milk (ng/g) Heptachlor	Whole Milk (ng/g) Heptachlor Epoxide
- 1	0.09	trace	4
+ 3	1.2	6	13
+ 7	1.3	3	30
+ 14	0.62	trace	42
+ 21	0.38	trace	36
+ 35	0.42	2	47
+ 49	0.35	4	27
+ 63	0.26	1	15

(Stacey 1988)

In a 1981 study conducted by Government Chemical Laboratories for the Health Department, spraying of the ground foundations and floor joists according to Australian Standard 2057 (1977) resulted in exceptionally high levels of organochlorine in the breast milk of the occupant. On the ninth day after spraying, whole milk residue levels rose to 0.010 and 0.005mg/l (ppm) for dieldrin and heptachlor respectively and to 0.22 and 0.11mg/kg (ppm) for dieldrin and heptachlor respectively on a fat basis. These results are shown in Table 6.

Table 6. Breast Milk samples in Relation to the Timing of Termite Treatment

Days After Spraying	Fat	Dieldrin		Heptachlor and Metabolites	
		Whole Milk	Fat Basis	Whole Milk	Fat Basis
	%m/v	mg/l	mg/kg	mg/l	mg/kg
-12	3.2	0.003	0.09	0.002	0.06
2	3.1	0.005	0.16	0.002	0.06
5	4.4	0.007	0.16	0.004	0.09
9	4.5	0.010	0.22	0.005	0.11
16	2.6	0.005	0.19	0.004	0.10

(Government Chemical Laboratories 1981.)

Table 7. Mean Levels of Heptachlor and Dieldrin in Human Whole Milk: in Western Australia, United States, Canada and Japan

Area/Year	Heptachlor (ppb)	Dieldrin (ppb)	Author
Perth, W.A. 1980-81	4.0 (hept.epox) 1.0 (heptachlor)	13	{Stacey & Tatum {1985
U.S. Total 1975	1.0		{Savage et al 1976
Arkansas & Mississippi 1974	4.0		{Strassman & {Kurtz
1977 Mississippi 1973-75			{Barnett
-pesticide area	3.0	6.0	{et al 1979
-non pesticide area	2.0	4.0	{
Canada 1975	1.0	2.0	{Mes &Davies 1979
Canada 1987			
{-indigenous	0.2	0.4	{Davies &
-general	0.5	0.5	{Mes 1987
Japan	0.66		{Tojo 1986

A comparison between the levels of dieldrin measured by Stacey and co-workers (1972, 1985) and those measured by the Health Department shows that the Health Department's results demonstrated consistently and significantly higher levels in human milk.

Table 8. Levels of Cyclodiene Insecticide Residues in Human Whole Milk in Australia

	Dieldrin (ppb) mean	Dieldrin (ppb) range	
PERTH			
1969-1970	14	1-40	Health Department(i)
1970-1971	5	3-11	Stacey & Thomas(1975)
1974	8	2-60	Health Department(i)
1974-1975	13	5-60	Kununurra (i)
1977	14	4-50	Health Department(i)
1978	18	5-50	Health Department(i)
1979-1980	7	2-30	Stacey & Tatum(1985)
1980	6	1-15	University of Western Australia & Health Department(i)
1980-1981	13	2-35	Stacey & Tatum(1985)
VICTORIA			Newton & Green(1972)
Rural	5		
Urban	4		
BRISBANE	30	13-68	Miller & Fox(1973)
MAREEBA	21	0-58	

(i) Cited in Shewchuk (1981)

These levels (see Table 8) show a variation in the means between 4 and 18ppb with a total range from 0 to 60ppb. Using the Acceptable Daily Intake set by WHO for dieldrin which is 0.0001mg/kg/day and assuming a milk intake by an infant of 140ml/kg/day, Shewchuk (1981) calculates that the derived MRL for dieldrin would be 0.0007mg/l (0.7ppb) for whole milk. The results in Table 8 would indicate that the MRL levels may have been significantly exceeded in Western Australia.

Comparison of the levels in Tables 7 and 8 clearly shows that the levels of cyclodienes in human milk are significantly higher in Australia and in Western Australians than in most other countries.

6 CYCLODIENES IN HUMAN ADIPOSE TISSUE

Two Western Australian surveys of cyclodiene residues in human adipose tissue showed that dieldrin was present in all samples. The results are presented in Table 9. Mean residues range from 0.21 to 0.67µg/g.

Table 9. Levels of Dieldrin in Adipose Tissue of Western Australians

Western Australia	Sample Number	Dieldrin level Mean	Range
		µg/g	
Wasserman et al (1968)	58	0.67	0.25-0.99
Lugg (1969)			
Male & Female		0.21	0.03-0.82
Male	32	0.122	0.03-0.82
Female	14	0.18	0.05-0.32

Source:Shewchuk 1981.

Wasserman et al (1968) detected high levels of dieldrin in the adipose tissue of Western Australians. These high levels were not reproduced by Lugg (1969) however. Shewchuk (1981) suggests that the levels recorded by Lugg (1969) are normal and compares them with levels recorded in the US. In 1971 however, the US EPA had initiated procedures to cancel registration of both aldrin and dieldrin. The manufacturing of aldrin and dieldrin in the US ceased in 1974, in an attempt to lower the exposure to these chemicals.

Analysis of 292 samples of human adipose tissue from an outer suburb hospital of Sydney by Ahmad et al (1988) revealed significant levels of DDT and dieldrin. The authors found that only three of the 292 samples had no detectable levels of DDT and metabolites and that only two samples had no detectable levels of dieldrin. The authors considered the levels of dieldrin in their samples (the highest level being 0.61µg/g) to be substantially higher than those of most overseas studies. They also suggest that the use of dieldrin as a termiticide will continue to be a source of contamination even after organochlorine residues in food slowly decline following the banning of the organochlorine insecticides for agricultural use throughout Australia in September 1987.

7 CYCLODIENES IN FOETAL TISSUE AND BLOOD

No research into the levels of cyclodiene insecticides in foetal blood and tissue in Western Australia appears to exist. However, given the elevated levels of these chemicals in human milk and adipose tissue of Western Australians compared with those of other countries, it is likely that Australian foetal blood and tissue would exhibit elevated cyclodiene levels. Curley et al (1969) reported that chlorinated hydrocarbon pesticides can be detected in the tissue of stillborns and in infants dying in the very early neonatal period and in the cord blood of neonates. While they found a great variation in the concentration of these compounds, the detected residue levels were within the same range as those observed in adults. The authors reported residues of heptachlor epoxide ranging from 0.07 to 0.51, 0.46 to 1.00, 0.30 to 1.56, 0.03 to 1.67 and 0.19 to 1.14ppm in the adipose tissue, brain, lungs, heart and liver respectively. Additionally, heptachlor epoxide was detected at levels ranging from 0.0002 to 0.0043ppm in the cord blood.

Polishuk et al (1970) reported that organochlorine insecticides found in fat tissue of pregnant women were present in both maternal and foetal blood. They suggest that the metabolism of organochlorine insecticides is enhanced during pregnancy and that once mobilized, organochlorines are able to pass the placental barrier. The concentrations of cyclodiene insecticides in foetal blood were similar to those in maternal blood. By contrast, Polishuk et al (1977) reported that the concentration of dieldrin and heptachlor epoxide were higher in extracted lipids of foetal blood and placenta (1.22 and 1.00ppm respectively) than in maternal blood and uterine muscle (0.53 and 0.28ppm respectively). According to the authors, these facts suggest quantitative differences in the ability of these tissues to metabolize and/or store organochlorine compounds. The data emphasize the importance of the maternal organism in protecting the foetus against environmental hazards.

Izakovic and Ruttkay-Nedecka (1972) reported that the number of rat foetuses resorbed in both generations after treatment with heptachlor showed that rat foetuses in early stages of their embryonic development could be adversely affected by the use of heptachlor. Green (1970, cited in US EPA.1987) reported that rats fed 5ppm of heptachlor for two generations showed reduced pregnancy rates. In a three generation reproduction study, rats exposed to 1 or 5mg/kg heptachlor were reported to exhibit statistically significant changes in EEG patterns.

8 FOOD AS A SOURCE OF CYCLODIENES

Following the recommendation of the WHO/FAO Joint Export Committee on Pesticide Residues, and the US Market Basket Survey in 1961 and a 1966 survey in England, the NH& MRC in 1969 recommended that Australia undertake similar surveys. As a result the first pesticide residue survey in the total diet was conducted.in 1971. The NH&MRC reported on organochlorine residues other than heptachlor or heptachlor epoxide in food. It found dieldrin in 64% of the 240 samples equal to or above 0.001ppm.

Of the 59 foods sampled in the Australian 'market basket' survey in 1985, 33 (55.9%) contained detectable levels of chlorinated organic compounds. Of these, heptachlor and heptachlor epoxide were detected in 10 of the 1114 samples and dieldrin in 22 of the 1121 samples (NH&MRC 1987). However, contrary to food standards which are based on raw foods, such as the Maximum Residue Limits, analysis in these surveys is based on processed or cooked foods. This means that when considering the 1987 figures, allowance needs to be made for loss of residue through processing before comparisons can be made with other studies.

Two recent pesticide residue surveys on fruit and vegetables conducted in Perth demonstrated that while pesticides were found in a range of the surveyed vegetables, the levels were extremely low. As well, most pesticides detected were not organochlorines. However, it is important to note that on two occasions in the first survey and on three occasions in the second survey, growers were found to have taken no notice of the withholding periods for some pesticides and in two of the cases were using a pesticide not registered for use on the crops grown. On these occasions, growers were not following the instructions on the labels of pesticide containers (Health Department, 1988).

The opinion of the Western Australian Health Department and the NH&MRC is that concentration and frequency of detection of the cyclodiene insecticides in food are consistently low and that the 1987 banning of these chemicals in agriculture will further reduce residues. An exception maybe the misapplication of insecticides around the home which results in high levels in home grown food products. The average dieldrin levels of eggs from poultry yards sprayed with aldrin and dieldrin exceeded 5mg/kg, fifty times the Food and Drug Regulation MRL of 0.1mg/kg for eggs (Shewchuk, 1981). According to Nugent (1984), hens introduced into an area sprayed twelve months earlier with heptachlor showed 3.0mg/kg of heptachlor metabolites and 0.10mg/kg of chlordane and metabolites in their eggs.

This conclusion is consistent with falling residue levels experienced in food surveys in other countries which withdrew these chemicals from agricultural and horticultural use prior to Australia doing so. For example, decreases were reported in cows' milk in the U.S. (Steffey et al 1984), in Greece (Fytianos et al 1985) in Israel (Pines et al 1988) and in general food products in the US (Johnson and Manske 1976, and Nisbet, 1977).

Declining cyclodiene residue levels in food, however, are not generally reflected in the levels detected in human tissues and breast milk, especially in Perth. This suggests that there must be another main source of human cyclodiene contamination.

9 CONCLUSIONS

It appears that considerable emphasis has been placed on the control of pesticides in the agricultural environment in the past in an attempt to reduce the level of human exposure to these chemicals through food. While this approach has obvious merit, little emphasis appears to have been placed on the main source leading to contamination of household environments and consequently to the contamination of Western Australians with cyclodiene insecticides.

Substantial evidence has been provided in this report to show that the pest control industry in WA is not successfully controlled. As a result, Western Australians are exposed to high levels of cyclodiene contamination.

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Attachment 1 The registered uses of heptachlor in WA 1971-1986

1971	Control of amnemus weevil in tropical legumes Control of white-fringed weevil in lucerne Control of wireworms, black beetle and earwigs in maize Control of wheat root grub in cereals Control of black beetles, cockchafer grubs, curl grubs, ants, cutworms, earwigs,mold crickets,slaters,weevils, wireworms in turf Control of beetle borer in bananas Control of termites
1975	As above plus: Control of apple curculio and Fuller's rose weevil in soil around apple and pear trees
1978	As above plus: Control of white fringed weevil and black beetle in potatoes Control of argentine ants and native ants Control of timber borers
1979	As above plus: Control of native spiders
1985	Uses as of 1985: Control of termites, timber and tree borers Control of spiders on external walls by crack and crevice applications Control of argentine ants under W.A. Department of Agriculture direction Control of singapore ants under Government of Local Government direction Control of black beetle in commercial turf Control of black beetles in potatoes as a pre-plant soil treatment Control of apple curculio and Fuller's rose weevil in soil around apple and pear trees
1987	As of 18 September, 1987, the uses of heptachlor for the purposes below are cancelled Control of borers Control of native spiders Uses in turf (black beetle) Uses in animal buildings Apple weevil and Fuller's rose weevil in apple and pear trees and white-fringed weevil in potatoes **Remaining uses** For termite control only along with the other cyclodiene insecticides. **Future Uses:** The Health Department has a policy to phase out uses of organochlorine pesticides as and when viable alternatives become available.

Source: Correspondence from the Health Department of Western Australia, August, 18,1986, Pesticides Advisory Committee.
Health (Pesticides) Regulations,Amended September 18,1987

PESTICIDE TREATMENT SURVEY

Name :

Address:

This part of the survey is to be completed by <u>one</u> member of the household.

1 How old is your house (approximately in years)? ....

2 Has your house been checked for termites?

- [ ] Yes
- [ ] No
- [ ] Don't know

If yes, when?

....

3 How regularly is your house checked for termites?

- [ ] More than once a year (if so please specify)
- [ ] Once a year
- [ ] Once in every 2 years
- [ ] Once in every 3-4 years
- [ ] Once in every 5 years
- [ ] Once in 6 or more years
- [ ] Never

3a Has your house been treated for termites?

- [ ] Yes
- [ ] No
- [ ] Don't know

If yes, when? ....

9 i) Did you smell or notice any changes in the air of the house after treatments?

- [ ] Yes
- [ ] No
- [ ] Can't remember

ii) If yes, please explain (eg how long did it remain? What did it smell like?)

....

....

....

10 Did any of the occupants of the house suffer any ill health or sickness after the treatment?

- [ ] Yes
- [ ] No
- [ ] Can't remember

11 Why did you have your house treated?

- [ ] Thought it was the correct thing to do
- [ ] Pesticide company recommendation
- [ ] Under contract with pesticide company
- [ ] Govt. or L.G. recommendation (specify dept)
- [ ] Council or building regulation
- [ ] Loan approval
- [ ] General precaution
- [ ] Presence of white ants
- [ ] Other - please specify

....

Appendix 2

Mobility of Organochlorines in a Bassendean Sand

An investigation for the Environmental Protection Authority

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Western Australia

MOBILITY OF ORGANOCHLORINES IN A BASSENDEAN SAND.

investigation by

Robert Gerritse

CSIRO, Division of Water Resources,
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1. OVERVIEW OF WORK THAT WAS DONE IN AUGUST 1988.

a. -Literature from 1968-1988 was scanned for data on mobilities of organochlorines in soils.

b. -Adsorption in a Bassendean sand of lindane, dieldrin, chlorpyrifos, heptachlor, chlordane and pp-DDT was measured by leaching the pesticides through a small column of soil at a pore water velocity of 1000 cm/day.

c. -Results from the column leaching experiment were compared with results predicted with a one dimensional numerical simulation model. Distribution coefficients were obtained from fitting the modelled output to the experimental results. Examples of experimental and simulated breakthrough curves are shown in Figs. 1 and 2. Results were compared with data from the literature study (Table 1).

d. -The potential flux of organochlorines (and one organophosphate for comparison) through evaporation from the surface of a Bassendean sandy soil and into the soil profile was calculated with a numerical simulation model. Results are given in Tables 4 and 5.

e. -A column of Bassendean sand, treated with lindane, dieldrin, heptachlor and pp-DDT, was purged with air. Soil conditions and air flow were approximately similar to those that had been used in an experiment with a volatilization chamber (Farmer et al., 1972). Results of both experiments are compared in Table 7.

f. -Profiles of a Bassendean sand were sampled at 4-6 cm intervals from the soil surface to groundwater on the eastern shore of Lake Goolellal along transects into the lake. In addition cores of about 15 cm were taken from the lake sediment and sampled at 3 cm intervals. The area had been sprayed with heptachlor for argentine ant control in 1980 and 1985. Samples were sent to the Chemistry Centre in Perth (Ebels, G.) for analysis of organochlorines. Results are shown in Fig.3.

2. RESULTS AND DISCUSSION

leaching to groundwater and surface water

From experimental leaching data (K_{om} in Table 1) it can be concluded that movement of organochlorines in the water phase in most soils is extremely slow. Mobility is governed by K_{om} through:

$$V_X = V_O \,/\, ((\Theta + K_D)*BD) \,, \qquad (1)$$

where :-V_X = effective linear velocity of pesticide X in the water phase of the soil (LT^{-1})
-V_O = rate of recharge (LT^{-1})
- Θ = moisture content (L^3M^{-1})
-BD = bulk density of soil (ML^{-3})
-K_D = K_{om} * OM (OM = soil organic matter content and K_{om} = as given in Table 1) (L^3M^{-1})

For a Bassendean sand, sampled from the top 15 cm, (OM=0.9%, BD=1.7 g/cm^3, water capacity = 0.2 ml/g) calculated effective mobilities in the soil water phase are given in Table 3 for a recharge rate V_O of 10 cm per year.

It can be concluded that, because movement of organochlorines with the water phase in a Bassendean sand is very slow, any contamination of groundwater or surface water must be due to processes other than leaching.

volatilization

The potential volatility of pesticides in a moist soil can be expressed with the Henry coefficient K_H, which gives the ratio between the concentrations in gas and water phases at equilibrium. An approximate classification of volatility on the basis of the Henry coefficient is given in Table 2. The effective volatility is determined by K_H/K_D (Table 1). Henry coefficients for organochlorines are relatively high (especially for heptachlor), indicating that, at least in moist soils, transport through the gas phase may be important.

Evaporation of organochlorines from a Bassendean sand at two moisture levels (5 and 20%) was simulated with a one dimensional numerical diffusion model. From the results in Tables 4 and 5 it follows that, even after one year, substantial amounts of pesticides can be lost from the soil through evaporation. Especially heptachlor is very volatile, which explains the relatively high concentrations often detected in the air near treated areas (1-20 ng/m^3, IARC, 1979). The half life of heptachlor in soil (Table 6) would be determined by evaporation rather than microbial or chemical degradation. The large spread in reported half lives for organochlorines (Table 6) could be partly due to variations in rates of evaporation. Factors such as moisture, temperature and wind velocity can significantly affect the rate of evaporation (Tables 4, 5 and 7). As a soil dries out volatilization decreases rapidly below a moisture content of about 2-5%. From dry soils volatilization of organochlorines is essentially zero (Farmer et al., 1972).

In Table 7 results are shown of a volatilization experiment with Bassendean sand. The sand was treated with organochlorines, packed into a column, moistened and purged with air (saturated with water vapour) at a pore velocity of 45 m/sec. After one week (≈ 50.000 pore volumes) the column of soil was saturated with water and leached. From the concentration of organochlorines in the leachate and the respective K_D's (Table 1) the residual amounts of organochlorines were calculated. The difference between initial and residual amounts was ascribed to volatilization. Degradation and conversion of the organochlorines during the relatively short period of the experiment were considered negligible.

When air flow occurs only at the surface of the soil, the rate of evaporation is less but still substantial enough to cause significant losses (data of Farmer et al., 1972, in Table 7).

Transport of organochlorines through the gas phase deeper into the soil is much less than into the atmosphere at the surface of a soil (Table 5). The amounts involved are such, however, that they could explain the consistent detection of low levels of organochlorines in groundwaters under treated soils. An exact calculation of potential contamination of groundwater by organochlorines through evaporative transport would involve the use of a numerical model which combines leaching (model PESTIC* for data in Figs. 1 and 2) and evaporation/diffusion (model DIFFUS* for data in Tables 4 and 5). The development of such a model for application to a Bassendean sand system will be done at a later stage.

Global atmospheric mobility of organochlorines was noted as early as 1968 when peak concentrations of 0.0001-0.05 μg/l were measured for DDT in rainfall and Antarctic snow (Tarrant & Tatton, 1968, Peterle, 1969). In 1972 a global average of 0.06 μg/l DDT in precipitation was predicted with an atmospheric model (Woodwell et al., 1972). Other organochlorines detected in rainfall are lindane, chlordane, dieldrin and endosulfan (Strachan, 1976, Tabatabai, 1983, Salo et al., 1986), often at environmentally significant levels. Atmospheric dust appears to be the main vector of transport of organochlorines through rainfall as most of the deposition occurs in the very early phase of a rain shower (Strachan, 1976). Heptachlor and its epoxide have consistently <u>not</u> been found in rainfall (Strachan, 1976, Salo, 1986), which is perhaps due to a greater volatility and photo-reactivity.

It can be concluded that not enough is known about pathways into and transport in the atmosphere of organochlorines to explain or predict concentrations in precipitation. Though levels observed in rainfall are low they can exceed environmental criteria for surface waters. <u>It would be very interesting in this respect to obtain data on organochlorine levels in precipitation for Western Australia.</u>

chemical and microbial degradation

In soil, organochlorines can be degraded chemically and microbially to compounds that are more toxic and/or more persistent than the parent compounds. An example is the microbially mediated conversion of heptachlor into heptachlorepoxide. Interconversion can also occur, e.g. trans-chlordane can be converted by microorganisms into heptachlor. To evaluate the total mobility of a particular organochlorine, the formation, disappearance and mobilities of all possible chemical and microbial degradation products need to be considered. Kinetics and pathways of degradation of organochlorines are quite complex and basic physical-chemical data (e.g. on adsorption, dissolution, vapour pressure) for most reaction products are not available.

Organochlorine residues in sediments and soils in and around Lake Goolellal

Soils and sediments were sampled along two transects, 20 m apart, into the lake at the end of Lakeway Drive. Organic matter contents of the samples are given in Table 8. All samples were analyzed for organochlorines. Soils were found to be contaminated with chlordane, heptachlorepoxide and dieldrin. In most profiles the organochlorines were contained mainly in the top 4 cm of soil and not detectable below 10 cm (<0.001 mg/kg). Levels were highest within 50 m of the shore line. In the 15 cm core samples from the sediment of the lake no dieldrin or heptachlor + heptachlorepoxide could be detected. Chlordane was found mainly in the top 10 cm of the lake sediment at roughly the same level ($\approx$ 0.1 kg/ha, Fig.3) as in the soils. On an organic matter basis (Table 8), chlordane levels in the sediment of the lake are, however, about 10 times less than in the surface soils. Chlordane and DDT (= DDT + DDD + DDE), also present mainly in the top 10 cm, appeared to increase in the lake sediment with distance from the shore (Fig.3). Concentrations of chlordane in the top 10 cm of the lake sediments ranged from 0.05-0.15 mg/kg and of DDT from 0.005-0.015 mg/kg. From the distribution data in Table 1 and the organic matter contents in Table 8 solution concentrations of chlordane and DDT in the lake at equilibrium with the sediment can be calculated to be of the order of 0.005 μg/l for chlordane and 0.0001 μg/l for DDT. A comparison of these estimated solution levels of chlordane and DDT with actual levels will be made as soon as data for the lake water are available. The environmental significance of these levels should also be established through biological availability tests.

Records of the Department of Agriculture show that the area along the lake from which soil was sampled had been sprayed with heptachlor in 1980 at $\approx$ 7.2 kg a.i./ha and in 1985 at $\approx$ 5.4 kg a.i./ha. Input of chlordane, which is always present in technical heptachlor, would have been 1.4 and 1.1 kg/ha respectively. The area around Lake Goolellal has a history of market gardening, so that total input of heptachlor and chlordane may have been higher. Records of input of organochlorines other than used for argentine ant control are not available.

Although the limited data set of Fig.3 cannot be considered to be representative for the entire sprayed area around the lake, it may be tentatively concluded that, based on the 1985 input alone, after 2 years less than 2-3 % of heptachlor and less than ≈ 10 % of chlordane remain in the sprayed soils. Based on these data half lives of heptachlor and chlordane would be significantly less than a year, which for chlordane is much less than has been reported in the literature (Table 6). The presence of DDT and of relatively high concentrations of chlordane in the lake sediment is difficult to explain without a detailed record of input of pesticides in the area.

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* PESTIC and DIFFUS, proprietary software, CSIRO - Division of Water Resources - Private Bag - P.O. Wembley - WA 6014 - (R.G. Gerritse).

TABLE 1

MOBILITY DATA FOR PESTICIDES

	K_{om}		K_H	S_{H2O}	P_v
	(l/g)		(-)	(μg/l)	(ng/l)
LINDANE	0.5–1.5	(1.6)	0.00013	7000–750000	150–50000
DIELDRIN	2 – 7	(13)	0.0005	200	5–200
ALDRIN	100	(nd)	0.001–0.02	2–200	150–500
CHLORPYRIFOS	10 – 20	(≈ 10)	nd	300–1100	500
HEPTACHLOR	5 – 25	(≈ 25)	0.1	50–50000	5000
CHLORDANE	20	(≈ 25)	nd	0 ?	100–200
pp-DDT	10 – 200	(> 25)	0.002	1–10	1–5
PCB's	20 – 50	(nd)	nd	nd	nd
DIAZINON	0.01–0.5	(nd)	0.00005	4000	2000

K_{om} = the ratio (distribution coefficient) between the amount of pesticide adsorbed to the soil (per *gram* of soil organic matter) and the amount, dissolved in a *liter* of soil solution.

K_H = Henry constant = the ratio between the concentration of pesticide in the soil gas phase and the concentration in the soil solution.

S_{H2O} = solubility in water.

P_v = vapour concentration of pure pesticide at ≈ 20°C

-The data shown were compiled from publications over the period 1968-1988.

-Data for K_{om} in brackets were obtained from leaching experiments in a small column of saturated Bassendean sand (organic matter content 0.9%) at pore water velocities of about 1000 cm/day. Breakthrough curves resulting from step inputs of pesticides were used to calculate the distribution coefficients (nd = no reliable data obtained).

TABLE 2

VOLATILITY RATING* OF ORGANOCHLORINES
ACCORDING TO THEIR HENRY COEFFICIENT

K_H range	Volatility rating
$< 5.10^{-6}$	negligible
$5.10^{-6} - 5.10^{-4}$	low
$5.10^{-4} - 5.10^{-2}$	significant
$> 5.10^{-2}$	high

*the effective volatility in a soil is proportional to K_H/K_D (Table 1)

TABLE 3

MOVEMENT OF PESTICIDES WITH WATER IN A BASSENDEAN SAND.

	K_D (ml/g)	recharge (cm/year)	water capacity (ml/g)	effective mobility (cm/year)
LINDANE	14	10	0.2	0.4
DIELDRIN	117	10	0.2	0.05
CHLORPYRIFOS	90	10	0.2	0.07
HEPTACHLOR	225	10	0.2	0.03
CHLORDANE	225	10	0.2	0.03
pp-DDT	>225	10	0.2	>0.03

Transport of water through the Bassendean sand was assumed to occur at a water content of 0.2 ml/g . Effective mobilities of the organochlorines in the water phase were calculated with Eq.1 from data in Table 1.

TABLE 4

CALCULATED POTENTIAL LOSSES OF PESTICIDES THROUGH VOLATILIZATION FROM THE SURFACE OF A BASSENDEAN SAND.

	moisture (ml/g)	loss after: 1y	5y	moisture (ml/g)	loss after: 1y	5y
LINDANE	0.2	8%	22%	0.05	15%	40%
DIELDRIN	0.2	4.5%	14%	0.05	9%	26%
HEPTACHLOR	0.2	75%	99%	0.05	96%	100%
pp-DDT	0.2	2.4%	8%	0.05	5.2%	16%
DIAZINON	0.2	15%	40%	0.05	29%	67%

Pesticides were assumed to be contained in a 10 cm layer of soil. The pesticide concentration in the air at the top boundary (surface) was taken to be continuously zero (diffusion coefficient in air ≈ 4000 cm^2/day). Only molecular diffusion in the gas phase was modelled. Losses due to gas phase diffusion and leaching from the lower boundary deeper into the soil were neglected.

TABLE 5

CALCULATED POTENTIAL LOSSES OF HEPTACHLOR THROUGH GAS PHASE DIFFUSION FROM A COLUMN OF BASSENDEAN SAND*.

at:	surface (= top of column)				boundary at 100 cm			
after:	1y	1y	5y	5y	1y	1y	5y	5y
moisture (ml/cm^3) =	0.05	0.2	0.05	0.2	0.05	0.2	0.05	0.2
---- loss -------->	87%	68%	95%	92%	2%	1%	5%	4%

* Diffusion in the gas phase was modelled for a 100cm long column of soil, considering both top (zero surface concentration) and bottom (infinitely long column) boundaries. Losses due to leaching were neglected. Organic matter content was assumed 1.0% for the top 10cm and 0.1% for the rest of the column.

TABLE 6

REPORTED RANGES OF HALF-LIVES OF PESTICIDES
IN SOILS (literature 1968-1988)

	half-life range (days)
LINDANE	50 - 5000
DIELDRIN	500 - 10000
ALDRIN	100 - 1000
CHLORPYRIFOS	50 - 100
HEPTACHLOR	50 - 500
CHLORDANE (technical)	400 - 1500
CHLORDANE (cis-isomer)	100 - 700
pp-DDT	1000 - 10000
PCB's	> 1000
DIAZINON	10 - 50

TABLE 7

RESULTS OF LABORATORY SCALE MEASUREMENTS OF THE VOLATILIZATION OF ORGANOCHLORINES FROM SOIL..

	soil	T	moisture	air flow	initial concentration	loss after 1 week
	-	(oC)	(ml/g)	(m/h)	(mg/kg)	(%)
	Bassendean sand (O.M = 0.9 %) :					
LINDANE	-	20	0.1	45	6	85
DIELDRIN	-	20	0.1	45	30	90
HEPTACHLOR	-	20	0.1	45	15	96
pp-DDT	-	20	0.1	45	30	98
	silt loam (O.M = 0.6 %)* :					
LINDANE	-	30	0.1	30	10	63
DIELDRIN	-	20	0.1	30	10	30
DIELDRIN	-	30	0.1	30	10	40
DDT	-	30	0.1	30	10	9.2

-Solutions of pesticides in hexane were added to a Bassendean sand. After evaporation of hexane the soil was packed into a stainless steel cylinder (length 15 cm, cross sectional area 1 cm^2, 18.5 g soil, 3 cm^3 gas phase), moistened and purged for 1 week at a rate of 1 l/h with air, saturated with water vapour.

* -Data taken from Farmer et al., Soil Sci. Soc. Amer. Proc., vol 36, 1972, 443-450. The silt loam, after addition of pesticides, was put in a volatilization chamber. Air flow occurred only at the surface of the layer of soil in the chamber.

TABLE 8

ORGANIC MATTER CONTENTS (in % of dry matter) OF SOILS AND SEDIMENTS SAMPLED IN AND AROUND LAKE GOOLELLAL

Site no.[0] →	1[1]	2[1]	3[1]	4[2]	5[2]	6[2]
-- depth (cm) :						
0- 4[1] or 0- 3[2]	2.0	6.0	24	30	56	60
4-10[1] or 3- 6[2]	1.6	4.0	5.8	6.0	64	58
10-21[1] or 6- 9[2]	1.2	2.5	1.8	-	70	60
21-33[1] or 9-12[2]	0.6	1.4	1.0	2.6	40	58
33-42[1] or 12-15[2]	-	-	0.65*	2.0	40	66
65-75[1]	-	0.6*	-	-	-	-
133-155[1]	0.2	-	-	-	-	-

[0] = site numbers as in Fig.3.

[1] = from soil profile

[2] = from lake sediment

* = in or at water table

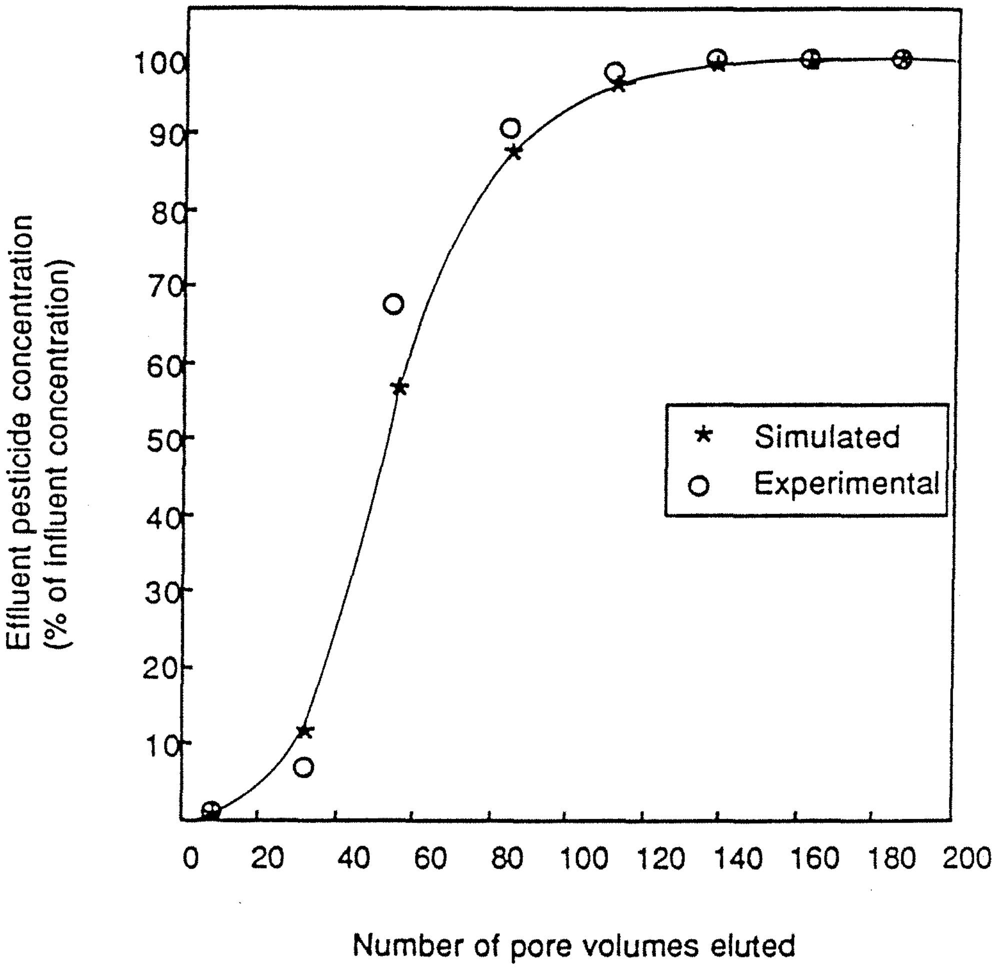

Figure 1 A comparison of simulated and experimental values of the leaching of lindane through a small column of Bassendean sand.
[Column characteristics:- length = 4.9cm, cross sectional area = 0.44 cm^2, mass of sand = 1.3g, pore volume 0.37ml, pore water velocity = 1000cm/day, soil organic matter content = 0.9%, dispersion length = 0.5 cm]

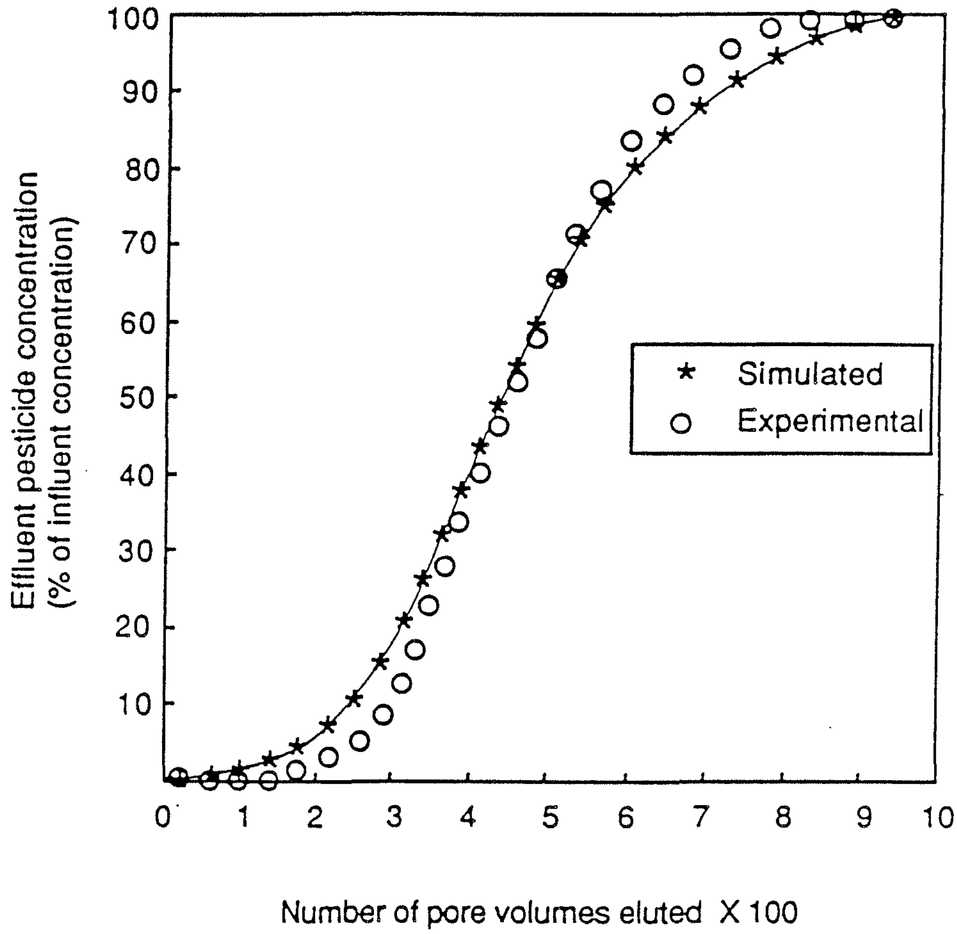

Figure 2 A comparison of simulated and experimental values of the leaching of dieldrin through a small column of Bassendean sand. Column characteristics as for figure 1.

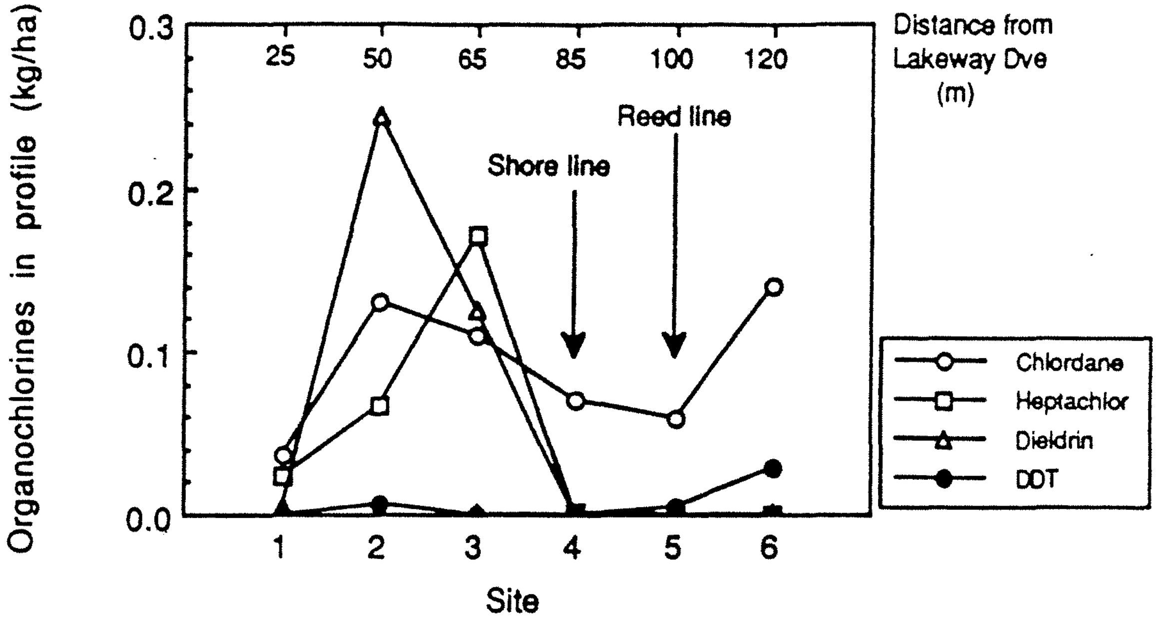

Figure 3 Total amounts of organochlorines on a kg/ha basis in sediments and soils in and around Lake Goolellal. Sites were selected on the Eastern side of the Lake at the end of Lakeway Drive (approx. 60m Nth of fence) along two equidistant (20m) transects perpendicular to the shoreline.

Appendix 3

Levels of Heptachlor in Human Tissues

Information provided to the Environmental Protection Authority

Health Department of Western Australia
189 Royal Street, East Perth 6004
Western Australia

Health Department of Western Australia

Mr C C Sanders
Director
Environmental Investigations Division
Environmental Protection Authority
1 Mount Street
PERTH WA 6000

ENVIRONMENTAL PROTECTION AUTHORITY'S INVESTIGATION INTO THE USE OF HEPTACHLOR

I refer to your letter of 28 July 1988 requesting results of tests on organochlorine residue in human tissue from the Western Australian population.

The Department has been involved in monitoring organochlorines in human tissues from as early as 1969. Much of this early information relates to DDT, Aldrin, Dieldrin, Lindane but not to Heptachlor. In regard to the latter, the information that is available to the Department is attached at Attachments 1 (Blood Results), 2 (Human Milk Results) and 3 (Other).

I would like to take the opportunity of making a number of comments which it is believed should be considered by the Environmental Protection Authority.

1. All results provided need to be interpreted with a great degree of caution and with a full understanding of the toxicology of the substance under consideration as well as of human physiology. Wherever appropriate, a thorough knowledge of the process entailed in deriving maximum residue limits is essential.

2. The blood results are unlikely to be representative of the organochlorine profile in the WA population since they are the results of tests on people who fall into two main categories :-

60 Beaufort St Perth WA 6000 Tel (09) 328 0241 Telex AA 93111 Telegrams WAHEALTH
Letters PO Box 8172 Stirling St Perth 6000

a) those who are, or are very likely to be, occupationally exposed to organochlorines, eg, pest control operators; and

b) those who had been potentially exposed to organochlorines as a result of some misapplication or misuse of these pesticides.

As such, they are likely to show a skewed distribution towards a higher level than would be expected if a survey had to be conducted on the general population.

3. There are no normal levels for these results. Any level which is above the limit of laboratory detection is considered high although not necessarily hazardous to health.

4. Levels of organochlorine pesticides in blood are only of limited significance since the pesticides are stored in the body fat, there is no correlation between blood and fat and detection in the blood may mean either recent exposure or mobilisation from body reserves. They do not indicate body burden.

5. The milk results are derived from :-
   a) Market Basket surveys of the general population, including other States and Territories,
   b) the limited surveys we carried out on a highly selected group of people,
   c) published WA data which unfortunately does not include Heptachlor.

6. The fat results are on biopses taken from people who considered they had sufficient exposure to organochlorine to allow surgical intervention. We realise that the scanty results are of no great significance to the Department (and indeed to the EPA) to give an indication of the body burden to the community at large.

7. In view of comment 6., the Department is at present considering undertaking a survey of fat samples obtained from postmortems carried out by Departmental pathologists. This may give a better representation of the burden on the community.

8. The Department is also considering a small survey of organochlorine levels to be found in breast milk collected from patients in a large Teaching Hospital.

ATTACHMENT 1

BLOOD RESULTS

State Health Laboratories

	<.005	.005 - .010	.010 - .015	.015 - .020	.020 - .025	.025 - .030	>.030
1983	15	2	3	1	1		
1984	106	5	3	3	1	1	
1985	72	5	1				1
1986	69	5	1				
1987	38	1	-				

Heptachlor results between Dec 1983-July 1987
(Results in parts per million)
Level of detection 0.005 ppm

Chemistry Centre

	<.001 - .005	.005 - .010	.010 - .015
1987	4	-	-
1988	14	1	1

Heptachlor results between July 1987 - July 1988.
(Results in parts per million)
Level of detection 0.001 ppm

HUMAN MILK RESULTS

Information regarding levels of heptachlor in breast milk in Western Australia is scanty. The information that is available to the Department is as follows.

1. The 1985 NH&MRC Market Basket (noxious substances) survey analysed human milk for a number of chlorinated organic compounds including heptachlor heptachlor expoxide. None were identified at the level of detection of 0.005 mg/kg.

2. The Market Basket (noxious substances) survey 1986 reports that "one of the 30 samples of human milk had a heptachlor expoxide level of 0.005 mg/kg".

3. Samples of "pooled" human milk carried out before 1970 did not detect heptachlor although other organochlorines were detected.

4. Twenty samples of human milk were tested by this Department in 1980. A copy of the analysis done by the Government Chemical Laboratories is attached. (Appendix 2a).

5. In May 1981, breast milk from a mother whose house was sprayed with heptachlor was analysed before and after the spraying. These are the results :-

Before spraying	- 0.005 mg/l
2 days after spraying	- 0.020 mg/l
7 days after spraying	- 0.030 mg/l
14 days after spraying	- 0.056 mg/l

   (no details of how the spraying was carried out are available).

6. In addition, we have in our files a copy of a survey conducted in NSW by a Research student. The results which are of an order of magnitude higher than those found in WA, have not been included since the accuracy of the analysis was suspect. The report could be made available to the EPA if required.

30 Plain Street, Perth, Western Australia 6000
Telephone: 325 5544
Address all correspondence to the Director

OUR REF: Original on
YOUR REF: 1131/62 Vol.II
ENQUIRIES TO:

22 September 1980 CD

Commissioner of Public Health
& Medical Services
Department of Health & Medical Services
60 Beaufort Street
PERTH WA 6000

Attention: Mr. G. Kaiser

MATERIAL: Twenty samples of human milk through the University of WA Biochemistry Department, Public Health Department No's F 300-319, marked as below.

LAB. No 42349-68/80

FROM WHOM RECEIVED AND DATE: Department of Health & Medical Services on 4 July 1980.

RESULT OF EXAMINATION:

Marks	Lab.No.	Fat*	DDT and metabolites	Dieldrin	HCB	Heptachlor and metabolites
		percent m/v	mg/L			
		as received				
1	42349	5.37	0.031	0.006	0.010	0.008
2	42350	3.69	0.024	0.002	0.008	0.006
3	42351	2.93	0.023	0.004	0.007	0.005
4	42352	2.97	0.017	0.001	0.004	0.003
5	42353	2.79	0.016	0.001	0.004	0.004
6	42354	2.47	0.018	0.001	0.004	0.004
7	42355	2.07	0.012	0.001	0.004	0.010
8	42356	5.35	0.070	0.009	0.002	0.001
9	42357	3.01	0.048	0.006	0.001	<0.001
10	42358	1.78	0.028	0.002	0.001	<0.001
11	42359	2.57	0.038	0.005	0.001	<0.001
12	42360	3.31	0.038	0.006	0.001	0.001
13	42361	4.31	0.052	0.007	0.002	0.001
14	42362	3.28	0.040	0.006	0.001	0.001
15	42363	2.16	0.041	0.013	0.006	0.003
16	42364	2.08	0.047	0.015	0.006	0.003
17	42365	2.19	0.042	0.014	0.006	0.003
18	42366	1.48	0.020	0.006	0.003	0.002
19	42367	1.17	0.026	0.009	0.004	0.002
20	42368	2.59	0.013	0.004	0.002	0.002
	Minimum		0.012	0.001	0.001	<0.001
	Maximum		0.070	0.015	0.010	0.010
	Mean		0.032	0.006	0.004	0.003

* The fat results determined and provided by the University of WA Biochemistry Department.

../2

No other common organochlorine pesticides were detected in the samples.

This is the first time that heptachlor and metabolites have been detected in human milk samples submitted to these Laboratories. The W.H.O. acceptable daily intake for heptachlor is 0.0005 mg/kg/day. On the basis of 140 mL intake/kg/day, a MRL for human milk can be calculated from the ADI as 0.0035 mg/L. The mean result of these samples is therefore below this "W.H.O." level and the levels in 5 samples exceed it.

J.H. Genovese

J.H. GENOVESE
CHEMIST & RESEARCH OFFICER

W R Wood

W. R. WOOD
ACTING CHIEF
FOOD & INDUSTRIAL HYGIENE DIVISION

Copy to: Dr. R.C. Lugg
Department of Health & Medical Services

ATTACHMENT 3

FATS

a) Fat samples results from biopses carried out on three people in September 1987 were 0.17, 0.09, 0.66 mg/kg. One sample was repeated in March 1988 and the result was 0.17 mg/kg.

OTHERS

b) Results on necropsies carried out on human tissue from children at Princess Margaret Hospital in 1980 did not detect organochlorine pesticides other than DDT and its metabolites and Dieldrin.