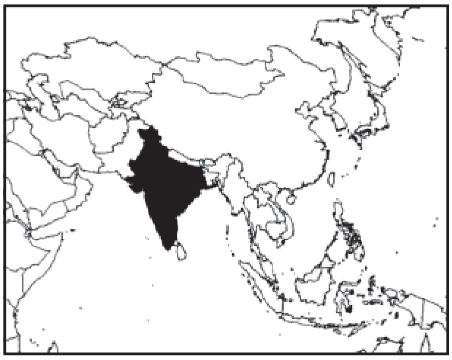
4
Case studies

This chapter provides examples of studies and experiences of relevance to the reduction and/or elimination of POP pesticide use. Some case studies touch on more general issues of concern in connection with pesticide use and alternative strategies for sustainable pest and vector management. The various pest or vector management measures presented are examples of what is possible in specific settings. They do not constitute universal recommendations. Each situation is unique and will require local assessment, site-specific considerations and local adaptations. The principles and decision-making criteria for IPM and IVM constitute the permanent core of this process.



4.1. Comparing bio-environmental management and indoor residual spraying for malaria control in India[1]

Malaria incidence in India dropped dramatically following the introduction of programmes for indoor residual spraying in the 1950s, but has resurged since the mid-1960s. Insecticide and drug resistance, financial constraints and decreasing community acceptance of spray programmes all contributed to this resurgence.

The challenge to find safer, more sustainable, community-based strategies led the Indian Council of Medical Research to support pilot activities on Integrated Disease Management. One of the pilot areas was the Kheda District in the State of Gujarat. The pilot activity was implemented between 1983 and 1989. The district is part of an area of low malaria endemicity: transmission intensity is low and seasonal, the population has little immunity to the parasite and there are periodic epidemic outbreaks of the disease, linked to particular weather patterns. Under these conditions, routine active case detection is not cost-effective, it is difficult to measure the impact of vector control interventions and making relevant comparisons between alternative vector control methods is a statistical challenge.

[1] Summarised from: Phillips, Margaret, A. Mills and C. Dye 1993. Guidelines for Cost-effectiveness Analysis of Vector Control. *WHO/CWS/91.4* PEEM Secretariat, WHO, Geneva, and Khaware, Ray Kishor and Priti Kumar, 1999. Bioenvironmental Malaria Control in Kheda District, Gujarat, India in WWF, 1999 *Disease Vector Management for Public Health and Conservation*

Most people in the Kheda district are subsistence farmers, growing two rice crops every year. The extensive irrigation network and associated factors provide a favourable environment for mosquito breeding. By 1980, vectors had become resistant to DDT, HCH and malathion. Increasingly, citizens were refusing house spraying. The awareness of the communities on health issues, including malaria, was generally low.

The project in Kheda was designed to test an alternative, non-chemical malaria control strategy, combining enhanced health services with local ecosystem changes that discourage vector breeding. The strategy was preventive, aimed at avoiding epidemics of malaria by efficient treatment of people who could serve as reservoirs of the disease, combined with reduction of vector numbers through elimination of vector breeding sites. A stepwise implementation of the pilot activity started in 1983 with field work to monitor the impact of anti-larval and anti-parasitic measures. Project workers, including village level resident health workers, were hired by the project and received special training. An important step was to create community awareness on health-related issues as a basis for participation. Contacts were established with village councils, leading to growing local networks of staff, village leaders, teachers, and interested villagers. The project organised educational activities for villagers at the local facilities of the Malaria Research Centre and later in the communities themselves. Villagers could see for themselves mosquito larvae, adult mosquitoes and the malaria parasites through a microscope and learn about mosquito breeding around their houses and around the village. Group meetings for villagers were organised for open discussions and resolving doubts. Female health workers made house-to-house visits to involve women, whose decisions are important for water issues and uses. They taught women how to store and manage water in a way that would prevent the breeding of malaria vectors. They also encouraged interested women to expand their know-how to other women. These activities were important to motivate villagers to participate in the project.

Bio-environmental managament was cheaper than DDT in this study.

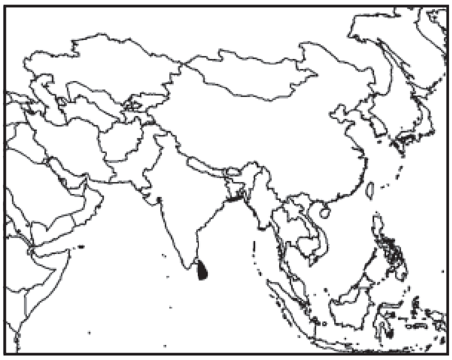
Village health workers carried out a weekly surveillance of malaria cases. They were trained to take blood samples from persons with fever, that were analysed by the project within 24 hours. Village workers treated persons with confirmed or suspected malaria.

Survey teams of entomologists, support staff, daily wage workers and volunteers from the village carried out extensive surveys of mosquito breeding sites. Most breeding sites were found within and around houses, and included irrigation canals. They also identified the two major species involved in malaria transmission and their preferred breeding sites. After the identification, breeding sites were eliminated or stocked with larvivorous fish. Weekly checks of the breeding sites took place. If mosquitoes were found in houses, their occupants were shown how to prevent further breeding. Guppies were found to be the most effective larvivorous fish. Hatcheries were set up in the project area to rear and distribute them.
The promotion of ponds to grow both larvivorous and commercially marketable fish was one of the community income-generating activities the project developed in collaboration with several NGOs.

The study covered six years and results at the end of that period showed that levels of malaria incidence under the conventional programme of indoor residual house spraying (IRS) and under the innovative programme of intensified case detection/ treatment and bio-environmental vector control (EMVC) were very similar - about two cases annually per 1000 persons. A cost-effectiveness analysis was carried out in 1989, comparing the two programmes.

The per capita cost was Rs 5.5 in the IRS programme and Rs 4.5 in EMVC programme. The cost-effectiveness analysis took into account only the direct costs of the two programmes. Variables that could not be expressed in monetary terms, such as the environmental benefits of not using pesticides, were not included. Additional side benefits of the integrated programme, such as fish production, were not included, either. Including these benefits into the analysis would further enhance the cost-effectiveness of the the integrated approach of case detection/immediate treatment and bio-environmental management for vector control.

4.2. Water management for malaria control in Sri Lanka[1]



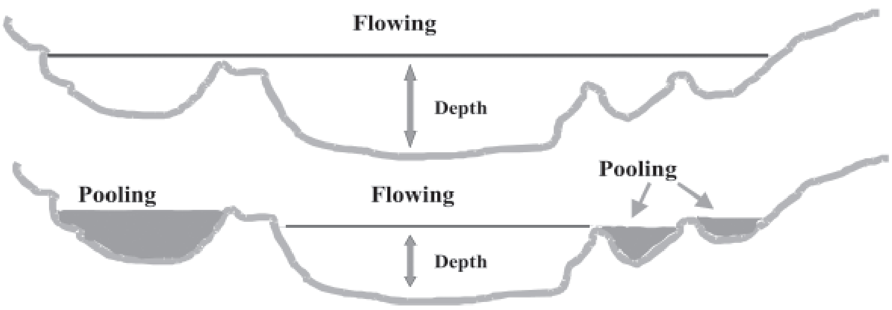
Sri Lanka is among six countries in the world, outside of Africa South of the Sahara, which share a third of the remaining global burden due to malaria. The number of deaths is relatively low, partly because of the quality of health services and partly because *P. vivax* still is the predominant parasite species, although the trend is towards an increased share of *P. falciparum* parasites. Transmission occurs in the dry (<2000mm rain/year) and intermediate zones (between 2000 and 2500 mm) with perennial transmission showing seasonal peaks linked to rainfall patterns. Great epidemics occur after droughts, when the southwest monsoon fails, because of the ecology of the local vector, which breeds profusely in rockpools remaining in dry rivers. The intensity of transmission facilitates conclusive studies on the effectiveness of different vector control options.

Malaria has been a serious public health problem in much of the North-Central Province of Sri Lanka for decades. A multi-disciplinary research team with expertise in vector biology and control, parasitology, health care, social science, economics and irrigation engineering (representing the International Water Management Institute, the University of Peradeniya and the Anti-Malaria Campaign of the Ministry of Health) spent five years investigating the malaria problem in the Huruluwewa watershed, located within the North-Central Province.

Water management schemes based on focused studies lead to reductions in vector incidence

The watershed has a 20 000 hectares catchment area of mixed forest and agricultural land, irrigated by an ancient tank-irrigation system, which more recently has also been receiving

[1] Adapted from a contribution by Dr Felix P. Amerasinghe, Department of Zoology, University of Peradeniya, Sri Lanka; a useful up-to-date reference is Konradsen, F. *et al.*, 2000. *Malaria in Sri Lanka: current knowledge on transmission and control.* International Water Management Institute (IWMI), Colombo, Sri Lanka



Depth (cm)	Week	Larvae/week
0 -19	20	17.9
20 29	4	1.8
30 - 39	6	3.5
40 - 49	7	2.4
50 or more	26	0.7

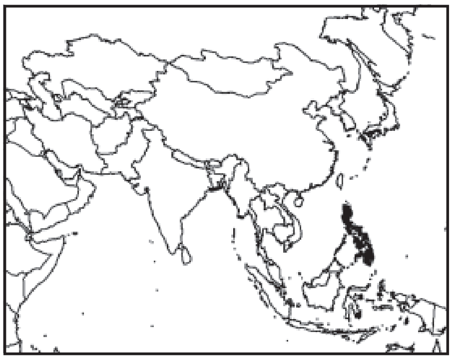
There is a relationship between wather depth and vector breeding

Konradsen et al. 1998

water issued from the Mahaweli System. The Yan Oya stream is the feeder canal to the Huruluwewa watershed. The main malaria vector in this area is *Anopheles culicifacies*. The main breeding habitats are the stream-bed pools that remain when water levels are low.

A significant risk determinant of malaria transmission is the distance between houses and the stream. At a system-wide level, villages closer than 500m to the stream had higher vector densities and a higher incidence of malaria. The study showed a relation between the stream water depth and vector breeding. When water levels in the stream are low, more stream-bed pools form and once the water level is below 20 cm, the number of larvae increases significantly. Detailed analyses of the water dynamics of the entire watershed area followed. Models showed that with the current flow in the stream, water levels are low during two periods of the year, resulting in high densities of mosquito larvae. If the stream would be flushed regularly during these dry periods, breeding habitats of mosquitoes would be disturbed, reducing larval densities. The most viable management option was a redistribution of existing water flows in order to maintain a water depth sufficient to discourage the breeding of the vector.

Cost analyses were done comparing the water management measures with vector control interventions such as indoor residual spraying, mosquito nets and chemical larviciding, as well as with curative measures (hospitals, mobile clinics, village-level treatment centres) in the area. These showed that flushing streams through seasonal water releases from upstream reservoirs would be the most efficient malaria control measure.



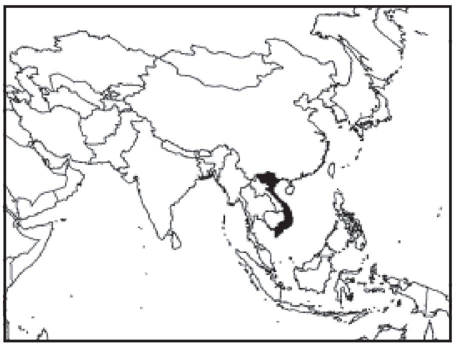
4.3. Malaria control in the Philippines[1]

After World War II, malaria control efforts in the rural areas of the Philippines relied exclusively on mass drug treatment and DDT for indoor residual spraying. In the 1980s these activities were complemented by active case detection to focus drug treatment and efforts to reduce breeding sites and densities of mosquito larvae. Across the board, malaria incidence was kept low through these measures, although fluctuations occurred. The use of DDT was banned in 1992, for environmental reasons.

Pesticide costs and malaria incidence have both dropped by 40% since DDT was banned

More recently, the National Malaria Control Service changed its strategy. Initially several pyrethroid insecticides were selected to replace DDT for indoor residual spraying. These were more expensive and posed higher risks to members of the spray teams because of their acute toxicity. In 1993, an external review of the Malaria Control Programme recommended that only one pyrethroid was to be used for residual house spraying. Based on results of pilot activities, it was also recommended to reduce residual house spraying and to increase the use of Insecticide Treated Nets (ITN). At present, periodic stratification of malaria endemic areas serves as the key criterion in the selection of area-specific measures. At the community level, Lead Contact Groups exist, composed of health officials, neighbourhood co-operatives, NGOs and community members. These groups are responsible for decisions on cost-sharing for ITNs, their proper use and maintenance.

The total cost of insecticides for malaria control in the Philippines has actually decreased 40 % since the banning of DDT - and malaria incidence dropped more than 40 % in the period 1993-96! Much of this significant success can be attributed to active community participation, and continued local involvement in a de-centralised structure will help sustain the positive situation.



4.4 Dengue control using copepods in Viet Nam[2]

Dengue fever was ranked as one of the most important public health problems in Viet Nam in the 1990s. Mosquitoes of the genus *Aedes*, mainly *Ae. aegypti*, transmit the disease. The main control strategy has, until recently, consisted of emergency interventions using synthetic insecticides against larval and adult

[1] Summarised from: WWF. 1998. *Resolving the DDT dilemma: Protecting Biodiversity and Human Health*. Toronto and Washington, D.C.; and,
Matteson, Patricia. 1999. The Philippine National Malaria Control Programme in WWF: *Disease Vector Management for Public Health Conservation*

[2] Based on a text provided by Dr Brian H. Kay, Queensland Institute of Medical Research, Brisbane, Australia, in September 1999

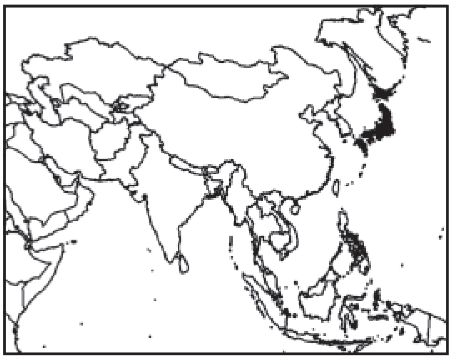
stages of the vector (these do not belong to the POPs category). This case study illustrates clearly to what extent biological control methods implemented by local communities can be effective.

In the mid-1990s, however, a review of the strategy was made with the assistance of Drs Brian Kay and John Aaskov and a national plan of action was formulated. A key component of this plan for disease prevention was to develop the use of copepods. Copepods are minute crustaceans that occur naturally in large and small water bodies. Certain copepod species are predators of mosquito larvae and can play an important role in controlling disease vectors. Ten species of the copepod genus *Mesocyclops* have been found in Viet Nam - all of them effective predators of *Aedes* larvae. Up to 30 % of local water tanks and wells contain *Mesocyclops*. Transfer of water from these sources to other water containers, wells, etc., to establish the copepods in the new places presented an opportunity for sustainable, locally managed disease prevention. A pilot project was carried out in 1994 in Phanboi village. With the collaboration of local households, all containers were inoculated. The effect was dramatic, and since this first trial, virtually all *Aedes* mosquitoes have disappeared from the community.

Community participation
+
enhancing natural control mechanisms
=
Success!

Extensive recycling of discarded containers such as plastic bags and plastic bottles reduces the number of potential breeding places for mosquitoes. Disease reduction becomes an additional benefit of this informal income-generating activity, and recycling thus also becomes an important component of the dengue control programme.

The programme is now being extended to other villages and provinces, and the positive effects are profound. Incidence of clinical dengue cases in "treated" areas during the extensive 1998 epidemic was less than one tenth of the incidence in neighbouring un-treated areas. The change from a curative to a preventative strategy is being facilitated by a substantial increase in funding.



4.5. Integrated management of Japanese encephalitis vectors[1]

Japanese encephalitis (JE) is a serious viral infection transmitted by mosquitoes of the *Culex vishnui* group, which breed by preference in flooded rice fields. It has a high fatality rate, especially among children, and those who survive clinical infection often suffer from lifelong mental disorders. A vaccine exists, but is expensive and cumbersome to deliver as two booster vaccinations are required at precise intervals after the initial vaccination, to achieve protective immunity.

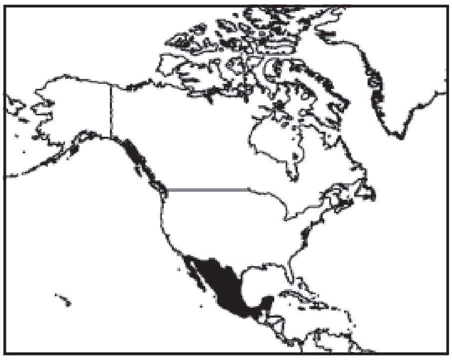
[1] Summarised from: IPM Working for Development - *Bulletin of Pest Management.*No 9, Sept. 1998. and Robert Bos, WHO (pers. com.)

Outbreaks of JE have occurred in recent decades in several countries in South and South-East Asia. This phenomenon can be linked to an expansion of areas under rice cultivation, particularly into more arid zones, an intensification of rice cropping (to two or three harvests annually) and an increase in pesticide use. Other elements in the rice production ecology contributing to outbreaks of JE are pigs (the amplifying host for the virus) and ardeid birds (herons, egrets), that transport the virus over larger distances. JE vectors have developed resistance to insecticides primarily used to control agricultural pests .

Research conducted in Tamil Nadu, southern India, has shown that using farm manure and green manure (including blue green algae) instead of artificial fertilisers will significantly reduce mosquito incidence. Introducing edible, mosquito-eating fish reduced larval populations by 80 % and increased total profits 2.5-fold.

Fish that eat mosquito larvae and other measures can play an important role in reducing vectors in irrigated rice systems

Water management (particularly alternate wetting and drying of rice fields) is another viable option to reduce vector breeding, particularly as water scarcity is forcing many farmers to adopt more cautious irrigation regimes anyway. The use of neem oil to reduce mosquito breeding has shown potential at the start of the cropping cycle. Improved pig husbandry, aimed at reducing pig-mosquito contact will contribute to keeping the virus out of circulation.



4.6. *Mexico's action plan to eliminate the use of DDT in malaria control*[1]

Malaria is a long-standing public health problem in Mexico. Sixty percent of its territory from sea level to 1,800 meters above sea level presents favourable conditions for transmission. Some 45 million people live in these areas. Ninety percent of all malaria cases occur in five States: Oaxaca, Chiapas, Sinaloa, Michoacán and Guerrero. These coincide with the distribution of two vector species: *Anopheles albimanus* and *A. pseudopunctipennis*. Behavioural aspects limit the impact of insecticide treated nets (ITNs) in Mexico: people generally tend to spend several hours of the early evening watching television, at which time they are exposed to biting anophelines.

In the 1940s and 1950s, malaria was one of the main causes of mortality, responsible for an average of 24,000 deaths annually and afflicting an estimated 2.4 million others. In recent years, the incidence of malaria had declined significantly, to less than 5,000 cases, and no deaths from malaria have been reported since 1982, indicating the success of the control program. However, the control of the disease had been highly dependent on DDT spraying (more than 2000 tons per year in the 1970s). Mexico continued the use of DDT in malaria campaigns until the 1990s, not only because of its effectiveness, but also because of its low cost and lack of acute toxicity for spray teams, compared to alternative chemical pesticides.

1 Adapted from a contribution by Bill Murray, Pest Management Regulatory Agency, Health Canada

In 1995, Mexico adopted a more integrated approach for malaria control, to substitute the heavy dependence on house spraying. For the reduction of transmission risks in the *A. pseudopunctipennis* areas, a successful community-based programme to clear algae from ponds was established with a dramatic effect on vector breeding. Furthermore, improved sanitation, surveillance and a minimum use of pesticides to control mosquitoes and larvae are considered key elements in this new approach. The reduction of DDT use, from 1260 tons sprayed in 1991 to 477 tons in 1997 was accelerated by a North America Regional Action Plan (NARAP) developed to reduce the exposure of humans and the environment to DDT and its metabolites. This NARAP was developed by Canada, USA and Mexico as parties to the North American Agreement on Environmental Co-operation (NAAEC), and was the result of Commission for Environmental Co-operation (CEC) Resolution 95-5 on Sound Management of Chemicals. New research on the human health effects of long-term exposure to DDT and the continuing need for an effective and comprehensive malaria control program in Mexico, provided additional incentives for regional action. DDT production in Mexico was stopped in 2000 and supplies of DDT are kept for authorised government use in malaria vector control only.

The objective of the NARAP is to reduce DDT use by 80 percent in five years and eventually phase it out completely for malaria control in Mexico. To achieve this goal, Mexico developed a national action plan with an initial geographical emphasis placed on areas with the highest number of cases. The general objective of Mexico's action plan is to develop and assess local alternatives to DDT for the control of malaria at a national level and to assess the health and environmental impact of DDT and alternative pesticides. More specific objectives are:

- To strengthen the current integrated programme to control malaria in Mexico through assessment of the effectiveness of alternative control methods.

- To assess the cost-benefit/cost-effectiveness of all alternative control methods.

- To obtain general baseline information on current pesticide use, with emphasis on agricultural uses of pesticides proposed as alternatives to DDT in malaria control, and to update a Geographical Information System with datasets on this use as a decision-making tool.

- To monitor environmental levels of DDT and other pesticides used in the malaria campaign in water, soil, food, selected animal species and humans.

- To assess the health impact on human populations of DDT residues and alternative pesticides used in the malaria campaign.

The effectiveness of a number of alternative control measures have been assessed in the State of Oaxaca:

- field assessment of pyrethroid-impregnated mosquito nets as a complementary measure,
- field evaluation of deltamethrin and lambda-cyhalothrin as a substitutes for DDT for house-spraying, and
- establishment of a production facility for parasitic nematodes of mosquito larvae.

A national and regional action plan to phase out DDT is expected to give results

These three projects showed promising results. However, these were small projects that have not yet been integrated into the national plan. A more holistic evaluation is under development. The studies in this phase will be used to develop and validate relevant methodology with alternative strategies and possible effects of alternative chemicals.

The use of DDT has been avoided during the most critical conditions for controlling malaria outbreaks during recent hurricanes and floods in the aforementioned states. DDT has been replaced by pyrethroids in these cases. New application techniques to reduce the quantity of pesticides used will be evaluated along with greater emphasis on community participation in the surveillance and treatment of cases.

Observations with respect to the above six vector control case studies

- Economic considerations are important when deciding on vector control programmes. Data must therefore be accurate and relevant. This includes opportunity costs of community participation and external benefits (such as commercial fish production linked to the production of larvivorous fish, or the gains from timber production where trees are planted to lower water tables).

- Malaria transmission is often cyclical, following weather patterns. Vector ecology will also vary between areas. This must be considered when drawing conclusions from comparative studies on disease and vector management using conventional and innovative methods

- Community participation will be sustainable if there is real economic benefit for a large segment of the local population. NGOs can play an important role in ensuring this. Building on existing socio-economic structures and traditions can lead to greater success. The introduction of "new" activities such as fish production in areas where fish is not part of the traditional diet may be less sustainable and will need more coaching.

- Strengthening the regulatory role of the health sector is an important pre-requisite for the successful application of results from multi-disciplinary research.

- Improved formulations and innovative applications of new pesticides may seem to be more expensive than older types, but can in fact reduce the costs of vector control programme. This is particularly true where spraying programmes become better targeted and are supported by non-chemical interventions, as shown in the case of the Philippines.

- The degree by which the decentralisation of malaria control programmes supports IVM with reduced costs and improved levels of protection should be carefully assessed.

- Environmental management programmes are often more resilient and sustainable than service delivery programmes relying on regular spraying, case detection, drug treatment or vaccination. This is particularly important in times of social and political instability. An example: during the Iran-Iraq war, schistosomiasis was kept under control in Iran in irrigation schemes that included environmental modification measures, while it increased in schemes relying only on case detection and drug treatment, which were disrupted.

4.7. Controlling termites in Australia[1]

There are many harmful drywood and subterranean termite species in Australia, several of which can do great damage to houses and other buildings. Some are present in the whole continent, while others are found in the northern parts only. The most important are:

- *Cryptotermes brevis* - an extremely destructive drywood termite, introduced into Australia in the 1960s. It can cause severe damage to structural timbers, but generally not in agriculture and forestry.
- *Mastotermes darwiniensis* - a large subterranean termite found in the northern, (sub-)tropical part of the country. It can cause dramatic damage to buildings, and will also attack sugarcane and forest trees.
- *Coptotermes spp.* - species of this subterranean genus cause most building damage in Australia, and are also serious pests of trees.

A total ban on POP pesticides is in effect in Australia since 1997. The only exception is mirex, which is still approved for use as a toxicant in termite baits in orchards in northern Australia. National annual use is less than 10 kg.

Termite control in Australia has moved from relying mainly on persistent chemicals up to the late 1980s to a situation today, when physical methods have become useful complements to or replacements for pesticides. The physical methods are primarily used for new constructions, while existing houses are usually still protected with chemicals. House construction methods in Australia have changed over the last three to four decades, so that the majority of houses are now built on concrete slabs. Post-construction treatments can therefore in general not be applied, in contrast to the previous situation when it was possible to spray underneath suspended floors. The control principles, equally applicable in all countries, are: (1) minimise access from the ground; and (2) monitor for termite activity.

Responsibility for controlling termites now lies more with builders than with pest control operators. Australia is one of the few countries that has developed a particular building code on termite protection (Australian Standard 3660-1993), specifying measures to protect against (primarily) subterranean termites.

Building design measures being promoted and employed include

- reducing the amount of timber, particularly where inspection is difficult
- making inspection of the subfloor easy
- properly built concrete slabs to facilitate inspection and deter termites. Particular care must be taken around pipes and wires, and in wall cavities.

Annual or more frequent inspections against termite infestations need to be made,

1 Based on: Elimination of Organochlorine Termiticides. Australian Case Study. Prepared by the Agricultural & Veterinary Chemicals Policy Section Department of Primary Industries & Energy, GPO Box 858 Canberra ACT 2601 Australia for the IFCS Meeting on POPs, 17-19 June, 1996 in Manila, Philippines, and
Information on termite control in Australia received from Ian Coleman, Agricultural & Veterinary Chemicals Policy Section Department of Primary Industries & Energy and Michael Lenz, Division of Entomology, Commonwealth Scientific and Industrial Research Organization (CSIRO), in Canberra.

since no single method provides complete protection. Optic fibre techniques are nowadays being used to facilitate inspection in hard-to-reach building parts.

Measures directed against termites aim to deter their concealed entry into a building (popularly, though incorrectly, referred to as preventive measures) or they can be curative. Details are provided in the Australian Standard (AS) 3660 Termite management [1]. AS 3660 deals with "whole-of-the-house" protection while the Australian Building Code, which refers to AS 3660, is concerned with protecting the structural elements of a building.

Good building design and practices can greatly reduce the attractiveness of a building to termites. This includes drainage, adequate ventilation of areas under the floors and use of termite resistant materials. It will also facilitate inspection of structural elements (through, for example, removable skirting boards or slab edge exposure). In Australia, regular inspections, maintenance of buildings and of the integrity of a termite management system are considered critical to the long-term success of termite control measures.

Measures to deter concealed entry by termites into a building

- *Physical barriers*. For buildings with a raised (suspended) floor (with crawl space), the traditional method is to fit metal termite shields on top of foundation walls, supporting piers, etc. Termites attempting to cross the shields are easily visible and can be stopped. The same applies for termites crossing exposed sides of foundations. Vigilance on the part of the house dwellers and regular inspections are, of course, required.

  For buildings on concrete slabs (slab-on-ground constructions) two types of physical barriers are available: (1) sheet materials (stainless steel mesh; solid, but flexible stainless steel; marine grade aluminium) and (2) graded particles (crushed stone). These days most of the systems are no longer installed as full barriers under the entire slab area, but as partial barriers, i.e. across the wall cavity and around service penetrations and at joints in concrete slabs. This change became possible once AS 3660 (1995 edition) recognised that a so-called engineered slab, can form part of the termite barrier system.

  All major commercial physical barrier systems also provide shielding and barriers for service penetrations and can be readily adjusted to a range of construction practices. A growing number of specific devices are available just for the protection of service penetrations (pipe collars) .

- *Chemical barriers*. Specified areas of the soil under and around a building are treated with termiticides (handspray, rodding, trenching; reticulation systems) to create a barrier that will deter termites from gaining concealed access. While aldrin, dieldrin, heptachlor and chlordane were effective for periods of 20-30 years or more, replacement pesticides have a shorter residual effect.

[1] Termite management AS3660, 2nd edition, 2000. Standards Australia, Sydney. AS 3660 states: The Standard includes methods to deter concealed entry by termites from the soil to the building above the termite barrier system. A termite barrier system constructed in accordance with this standard cannot prevent termite attack, as barriers may be bridged or breached. Where termites bridge barriers the evidence may be detected during inspections (Part 1, page 6).

Chlorpyrifos[1] and bifenthrin have been approved in Australia for pre- and/or post-construction treatment, although there are concerns about the shorter protection time provided. Retreatments have to be made more frequently than with organochlorines, and dosage rates must be strictly adhered to.

Presence of chlorpyrifos and bifenthrin is readily detected by termites which then avoid the barriers. Some modern termiticides cannot be detected by termites and these products have a somewhat delayed toxic effect. Hence, termites will enter soils treated with these chemicals and pick up the insecticide which they may transfer to their colony. One such product, imidacloprid, is registered for the protection of structures which can readily be retreated, for example buildings with suspended floors. Evaluation of other compounds with a similar mode of action is under way. Retreatments are facilitated if a reticulation system, consisting of interconnected tubes, is installed under the concrete slab.

Chemical barriers can also be created by applying the insecticide to a non-soil carrier, such as fibrous blankets or plastic sheeting which can be placed underneath concrete slabs or as a partial barrier in the wall cavity. One product commercially available in Australia which has deltamethrin as its active ingredient consists of a fibrous matting sandwiched between two layers of plastic. Other systems following the same principles are under evaluation.

- *Termite resistant materials.* Different types of termite resistant materials, including timber treated with compounds to preserve wood are also listed in AS 3660

Curative measures
Retrofitting or repair of physical and chemical barriers can be an option in certain situations. Otherwise, Australian authorities recommend the following curative measures:

- *Insecticidal dusts.* Dusts are commonly applied to termite-infested houses in Australia. Arsenic trioxide is the main agent. Recently, a new dust has been registered with the molt inhibitor triflumuron as the active ingredient. Other dust formulations are under evaluation. The effectiveness of dusting operations can be enhanced by first luring the termites into aggregation or trap devices, where exposure can be greatly increased. Several trap and treat systems are commercially available and many control operators have developed their own devices.
- *Biological barriers.* The potential of biological agents such as the fungus *Metarhizium anisopliae* and nematodes has not yet been fully explored. Spore formulations of the fungus have proven effective as dusts and in bait systems under certain circumstances. No registered fungal product for termite control is available.
  Much research is currently focused on the use of bait systems for managing active termite infestations. To date, only one system with the molt inhibitor hexaflumuron as active ingredient has been registered.

[1] Immediately before this document went to print, the following information update was received from the United States of America: in accordance with EPA regulations, chlorpyrifos can no longer be used in the USA for residential use. Existing stocks must be off store shelves from January 2002. Post-application exposure risks were the main reason for this regulatory action. For the time being chlorpyrifos can still be used as a pre-construction termiticide, pending future risk assessment. Existing stocks of the compound can be used in post-construction situations until 2003 (Janice Jensen, USEPA, pers. comm).

A comparison of the costs of different control measures was made in 1994 (table 3). Although it is clear that the organochlorines compared favourably with chlorpyrifos, the integrated approach is obviously the most efficient strategy.

Table 3:
Costs (in Australian dollars) of termite protection measures in Australia in 1994

Control Method	Building under construction (170-200 m^2)	Retreatment	Comment
Integrated Termite Management Approach (involving a range of control measures)	$200-$300 (but may vary depending on building modification)	Variable up to $500	Annual inspections necessary and may involve destruction of nest
Organochlorine	$237-$496	$200-$1500	Regular inspection advised. Annual retreatments are often done unnecessarily, may only be necessary every 5 or 10 years
Chlorpyrifos	$480-$715	$290-$2150	Regular inspection advised. More frequent retreatments may be necessary compared to organochlorines
Stainless Steel Mesh Barrier: Partial treatment (perimeter and entry points)	$500-$800	Not Required	Inspection of building for termite activity still required
Stainless Steel Mesh Barrier: Full slab underlay	$3000-$4000	Not Required	
Crushed Stone Barrier	$800-$1000	Not Required	Inspection of building for termite activity still required

In conclusion: the strategy for termite management in Australia described above clearly shows that moving from pesticide reliance, with its inherent hazards, to an integrated approach involves a range of measures. Some will be the responsibility of individuals: people living in houses will, for example, need to be on constant alert for early signs of termite attacks. Governments will have to develop building standards and standards for wood impregnation that are locally appropriate and based on research carried out in the concerned area. This is particularly important for developing tropical countries, as standards from temperate regions may be totally unsuitable. Architects and builders must pay greater attention to termite risk when designing and constructing houses, since the first line of defence must be buildings that are unattractive to termites.

4.8. Cotton in Sudan - IPM as a response to the pesticide treadmill[1]

The Gezira is a large fluvial plain south of Khartoum. A large scale irrigation system is in place covering over 800,000 ha. Cotton is grown by almost 100,000 tenants in rotation with other crops. They are actively engaged in most crop husbandry duties. Crop protection is, however, directly under the authority of the Gezira board, which decides on actions, selects and purchases chemicals and implements pest control actions, mainly aerial sprays. World-wide, cotton consumes more than one quarter of all chemical insecticides used in agriculture.

Before 1960 chemical pest control in Gezira was mainly limited to one single, early season spray of DDT, against cotton jassid, the main pest. In following years the control of jassids failed. On top of that two other insects, the American bollworm and the cotton whitefly caused increasing damage. These previously unimportant pests could become important due to the decimation of their natural enemies by DDT. The response was to spray more frequently, using other insecticides in addition to DDT, and using mixtures of different compounds. The pest situation continued to get worse despite this intensified pesticide use. The spray frequency reached up to nine applications per season.

In the 1978-79 growing season whitefly outbreaks occurred of unprecedented magnitude and caused heavy damage. Yield levels dropped from 1500 kg to 1100 kg of seed cotton/ha. Cotton growing was trapped in an insecticide treadmill: more and more treatments were made, with less and less results.

In 1979 an international group of experts convened by FAO and UNEP formulated a plan to alleviate the problem. The main elements were:

- Prohibition of further use of DDT
- Abolition of package deals between Scheme management and agro-chemical companies
- Initiation of research on possibilities for upward revision of treatment thresholds and substitution of broadspectrum for selective insecticides.

[1] based on Kees G. Eveleens and Asim A. Abdel Rahman, 1993, *ILEIA Newsletter* Vol. 9, No. 2. Can Ol' King Cotton kick the habit?

Implementation of the plan led to positive results. Between 1981 and 1989 the average number of insecticide applications was reduced to 4-5 per season. Yields increased to 1500 kg of seed cotton/ha.

Period	No. of insecticide appl./season	Yields (kg seed cotton/ha)
1967 - 1975	4-6	1500
1976 - 1981	> 8	1100
1982 - 1989	4-5	1500

IPM was, however, not used to its full potential, while conventional crop protection was not completely replaced.

The main technical constraint to full operation of IPM is the timing of the first spray. As the group of international experts concluded: "...it is the first spray that does the most damage to natural enemies of pests and commits the manager to a season-long sequence of insecticide applications." The first spray was postponed to some extent. However, mixtures of broadspectrum insecticides were still used as before. In 1992 the Agricultural Research Corporation decided to no longer use mixtures of compounds against a single pest. In the field natural enemies of more hardy species could be seen again in large numbers.

Successful IPM programmes are farmer-focused. An important non-technical constraint in IPM programmes is insufficient human resource development. In Gezira several factors worked against a farmer focus. The central management of the scheme had resulted in a hierarchical chain of command in which relevant information for farmers is passed as orders rather than extension that would allow farmers to increase their knowledge and to actively participate in decision making. Efforts to end this tradition will further encourage and strengthen IPM implementation.

4.9. IPM of the coffee berry borer[2]

Coffee is an important cash crop for many farmers and plays an important role in the economy of entire nations. It also suffers from attacks by several serious pests and diseases, such as the coffee berry borer (*Hypothenemus hampei*), the white stem borer (*Monochamus leuconotus*), the coffee mealybug (*Planococcus kenyae*) and coffee berry disease (*Colletotrichum coffeanum*). Pesticide use in coffee is extensive in many places and applications are often made according to a fixed schedule. This has several negative effects and causes excessive costs. Natural regulation is disrupted when natural enemies of the pests are killed, increasing crop vulnerability to future pest attacks. Frequent pesticide applications have also caused resistance. The coffee

[2] Mainly based on material received from the Pesticide Trust (UK) and Internet information available from CABI

berry borer in New Caledonia has, for example, developed high levels of resistance to endosulfan, the most commonly used insecticide in coffee in many countries.

Biological control can be a way to control difficult pests such as the coffee berry borer

Several IPM strategies to control the coffee berry borer can be considered:

- The pest survives from one season to the next in berries left on the trees or on the ground. Picking up and destroying these berries will effectively break the life cycle and limit damage the next season. This method is obviously very labour intensive, and studies are now underway in Colombia to make it less demanding.
- Direct biological control using parasitic wasps has been carried out in Latin America. Two species of parasites are already established, and research continues on two more. The aim is to make mass production more economical.
- The insect-pathogenic fungus *Beauveria bassiana* will infect and kill borers in the berries. It is produced commercially, and the spore-containing formulation can be sprayed like a pesticide. The effect is better under humid conditions. Although the fungus occurs naturally, the effect can be greatly enhanced if direct treatments are made, and this method is used by some farmers in Colombia.

4.10. Phasing out methyl bromide - an on-going parallel process

The POP pesticides are not the only issue of global environmental concern; ozone depletion is another one and has led to agreements under the Montreal Protocol to control the use of methyl bromide, a pesticide used for soil fumigation as well as in the food industry. Production and consumption were frozen at the 1995 level (2002 level for developing countries), and a schedule for stepwise reductions has been agreed on. The phase-out will be faster in industrialised countries, while developing countries will have more time. The former shall have achieved 100 % elimination by the year 2005, while the latter will have another ten years to reach the same goal.

To make the elimination of methyl bromide possible for all but critical uses, alternative control strategies and methods are developed and promoted. Technical committees and working groups have been set up in several countries, addressing specific areas of use.

Examples:

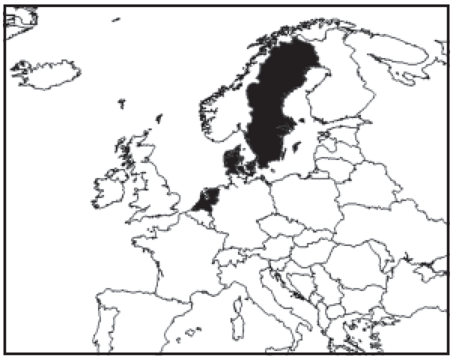
- The Canadian Methyl Bromide Industry / Government Working Group Subcommittee on Alternatives for the Food Processing Sector, has developed a guide for IPM in the food industry.
- The US Environmental Protection Agency (EPA) has set up the Methyl Bromide Phaseout Web Site, giving information on the process and providing many concrete case studies of successful alternative methods and strategies.
- UNEP has set up the Methyl Bromide Technical Options Committee (MBTOC).
- Many organisations, such as UNIDO, UNDP, the World Bank and UNEP are currently involved in a large number of demonstration projects to promote alternatives to methyl bromide in different countries and crops.

Some countries have already taken a lead in reducing methyl bromide use.
The Netherlands, which is the world's major producer of cut flowers and plants,

used to be a major consumer of methyl bromide for soil fumigation. Early concerns about the dangers to health and environment led to its elimination as a soil fumigant during the 1980-1991 decade. At the same time, production of horticultural crops actually increased.

The process to phase out methyl bromide shows that international action is possible and effective

The transition away from methyl bromide involved alternative direct control methods such as soil sterilisation with steam instead of fumigation, but also changes in cultivation methods - for example, using non-soil substrates that do not need fumigation.
In addition to stricter regulations, adequate funding to investigate and introduce the new methods has been a crucial factor in the successful transition.



4.11. Pesticide reduction schemes in Europe[1]

Concern over environmental contamination and loss of biodiversity in the 1980s prompted political decisions in several European countries to reduce the use of pesticides in agriculture. Three countries in Northern Europe - Denmark, Sweden and the Netherlands - have mandated and made drastic cuts in pesticide use.
Although the preconditions were very different, a common feature of the three programmes was a combination of government measures and voluntary farmer involvement. All three countries have achieved significant reductions in pesticide use. Key features of the programmes include:

National schemes to reduce pesticide use can give results if a coherent policy is applied

- A coherent strategy for achieving the target was set up
- Specific taxes on pesticides were imposed (on value, amount active ingredient and/ or differentiated according to hazard)
- Stricter registration and re-registration procedures were introduced, leading to restrictions and removal of less desirable products from the market
- Training and certification of applicators was made mandatory. More hazardous pesticides are only sold to certified applicators.
- Certification of new application equipment was made mandatory and testing of existing equipment was subsidised.
- The use of pesticides in sensitive areas (e.g. along streams) was restricted.
- It was made mandatory (or voluntary) to keep records of pesticide applications and the environmental effects of pesticides.
- Increased and targeted research on IPM , IPM components and the environmental fate of pesticides was funded.
- The plant protection extension service was strengthened to provide farmers with better decision support.
- Ecological (organic) agriculture was given specific support.

1 Adapted primarily from: Matteson, P.C. 1995. The "50% Pesticide Cuts" in Europe: A Glimpse of Our Future? *American Entomologist*, Winter 1995: 210-220

4.12 Obsolete pesticides and associated contaminated materials in Ethiopia.

In 1997 an FAO Project Task Force was established, with Swedish support, to comply with a request of the Ethiopian Government to evaluate the scale of the problem of obsolete pesticides in that country.

The Task Force is composed of experts from a variety of relevant disciplines and fielded a first mission to Ethiopia in 1998 to verify the inventory of obsolete pesticides of the Ministry of Agriculture and to assess the suitability and acceptability of options for their complete and environmentally safe disposal.

The use of local cement kilns for the destruction of obsolete pesticides was considered as a first option and rejected as technically unsuitable. The Ethiopian authorities themselves were not in favour of this option, either.

High Temperature Incineration (HTI) at a licensed hazardous waste incineration facility was considered the only acceptable disposal option. Such facilities are only found in industrialized countries. Full ratification of the Basel Convention, which regulates the transboundary movement of hazardous waste, including obsolete pesticides, was therefore called for.

The project document prepared on the basis of this mission made an initial estimate of 1500 tonnes of obsolete pesticides, areas of heavily contaminated soil, and unspecified numbers of pesticide contaminated containers and equipment such as sprayers in over 450 sites. The cost of disposal was estimated at US$4,5 million. The USA, Sweden and the Netherlands pledged support towards this task.

Delays in project initiation were caused by lack of additional funds forthcoming, but field operations eventually started in April 2000 under the supervision of a full-time resident Project Manager. Main activities completed in the first eighteen months include:

- Meeting with representatives of donors, ministries concerned, NGOs and IGOs to discuss the project goals and to secure the necessary pledges for financial and political support.
- Setting project objectives in consultation with local Ministry of Agriculture (MoA) counterparts and senior Ministry personnel.
- Designing a realistic project plan in consultation with the MoA and other parties.
- Training of forty selected federal and regional MoA personnel during a 5-day training programme in inventory taking.
- Establishing a National Project Coordination Committee where all project stakeholders are represented. This forum allows all parties to be kept fully informed of project activities and to comment on plans for the coming months. It affords full project transparency and involvement of parties concerned with the decision making process.
- Completion of a nation-wide re-inventory exercise. This process identified over 940 sites and more than 2,800 tonnes of obsolete pesticide stocks. In addition, it specified the amount of heavily contaminated soils at 1000 tonnes and empty drums and contaminated spray equipment at 350 tonnes.

- Review of the local formulation plant to assess its capacity to reformulate products found in Ethiopia. Unfortunately the current lack of Environmental Impact Assessment data and the observed poor management of the plant mean that this option cannot be considered. Work undertaken by UNIDO may address the problems and allow a re-appraisal of the situation in future. Re-formulation may help prevent future accumulation of obsolete pesticides.
- Commissioning of existing laboratory equipment and training of MoA personnel in the use of the equipment. It was also necessary to provide pesticide standards and other essential laboratory chemicals.
- Sampling of obsolete stocks to determine the amount of material which could be reformulated or given an extension to the manufacturers two-year shelf life.
  In total approximately 400 tonnes of stocks were identified which could be used as a strategic stock for the control of migratory pests such as desert locust and armyworm.
- Review of current IPM initiatives in Ethiopia and the sponsorship of the first national IPM workshop. This has allowed a National IPM Framework to be completed by the Ministry of Agriculture (MoA) which will be presented to the donor community for support in the years to come. This should assist in the prevention of future accumulation by decreasing the reliance on chemical pesticides.
- Review of existing Pesticide Registration initiatives. Ethiopia has robust registration procedures. This will help prevent import of unnecessary and unlicensed pesticides into Ethiopia in the future.
- Review of existing Donor programmes for agricultural inputs, including pesticides.

Next, FAO opened an international tender for bids for the disposal of obsolete pesticides and the clean-up of contaminated sites in Ethiopia. Under the ensuing contract for the removal of 1500 tonnes of obsolete pesticides, the Finnish disposal contractor started repackaging operations in May 2001. By September 2001 some 300 tonnes had been repackaged, and the endeavour is expected to be completed by June 2002. All waste will be shipped to Finland for environmentally sound disposal.

The biggest challenge facing the project remains the securing of the external support still necessary for the outstanding disposal tasks. This highlights the need to enlist pesticide manufacturers to support and contribute to the disposal process.