

## 3.

# Specific aspects of pest and vector management

This chapter provides information on a range of issues relevant to the task of reducing and/or eliminating the use of POP pesticides and selecting alternative approaches.

### 3.1. Pesticide policy reform in support of IPM and IVM<sup>1</sup>

Evidence has been accumulating for some time that pesticide use frequently is above its socially defined optimum, i.e. the benefits do not outweigh the costs (see also section 3.2.). This may be due to fundamental economic distortions, for example inappropriate subsidy and price policies (Repetto, 1985). Such policies will counteract efforts to introduce and sustain IPM and IVM approaches, and changes are therefore called for. The process of change should start with an analysis of national pesticide policies and should lead to the formulation of an optimal combination of policy instruments. A more recent phenomenon is the growing capacity of developing countries to produce pesticides locally. Often mainly first or second generation, highly toxic pesticides are produced, for local use or for export to countries with weak or poorly enforced policy/regulatory frameworks (WRI, 1999).

The first step towards policy reform is to establish a well-structured overview of the crop protection situation in the country following a framework of pesticide policy analysis (Agne *et al.*, 1996). Such a status report will give quantitative as well as qualitative indicators of the factors that drive pesticide use.

The report can serve as a point of departure for the initiation of a dialogue aimed at building consensus for action. Experience has shown that workshops with participants from different disciplines are effective tools for raising awareness and improving the quality of the discussion. Changes in pesticide policy will often challenge existing structures and interest groups. Proponents of change must therefore be adequately equipped with well-founded scientific arguments. Support from international groups with experience in such debates is also essential.

In order to significantly enhance the probability that the introduction and strengthening of IPM/IVM activities and programmes be sustainable, the changed pesticide policy must be integrated into the mainstream of agricultural, economic and envi-

**The development of a regulatory policy framework is an essential first step in the process of rationalising the use of insecticides.**

<sup>1</sup> Partly based on a text generously provided by Professor Hermann Waibel, University of Hannover, Germany

ronmental policy-making. Policies promoting capacity building and resource allocation to ensure that the enforcement of pesticide regulations is carried out effectively are a crucial part of the overall framework.

In the health sector, schedules for in-door residual spraying became well-entrenched in many endemic countries at the time of the global malaria eradication programme. These rigid schedules were designed for quasi-military operations with maximum, sometimes redundant coverage, all geared towards the time-limited goal of eradication. When the global eradication effort was abandoned at the end of the 1960s, they continued to be the core of vector control programmes in many countries. Only in the 1990s could the start of a general shift towards targeted or selective spraying be observed, in the wake of the adoption of the new WHO Global Malaria Strategy at a summit meeting in 1992 in Amsterdam. Economic pressures played an important role in this process: donations of insecticides for vector control by industrialised countries were gradually phased out and the spread of insecticide resistance forced the introduction of more expensive products and formulations.

Health sector reform provides the enabling environment for a further evolution of vector control programmes. Decentralisation is a critical component of this reform and as decision making on interventions moves to the local level, the nature and frequency of chemical vector control may be further rationalised and optimised for specific settings. In countries where health sector reform has not yet led to changes in vector control policies and programmes, situation analysis, risk mapping and stratification, together with the development of improved decision-making criteria and procedures will be important steps towards a reduction in the reliance on insecticides.

### **3.2. The costs of changing pest control strategies – and the costs of not changing**

It is frequently argued that banning, restricting or reducing pesticide use will come at considerable cost to individuals and society. This argument has been used against efforts to limit current pesticide use. Studies have analysed the effects of either banning or restricting individual pesticides without considering suitable alternatives, or sweeping statements have been made about the overall impact of more general reductions or restrictions on chemical inputs at large.

**The costs of changing pest control practises are often exaggerated. The benefits can out-weigh the costs!**

Although there obviously are economic consequences to any action taken (or not taken), predictions may be fraught with inaccurate assumptions and confounding factors. They often tend to overestimate costs of pesticide reduction and/or elimination.

A critical review of economic impact studies (Jaenecke, 1997) brought to light the most frequent shortcomings:

- The cost of “losing” the use of a pesticide is not weighed against the benefits to health and environment from its elimination. Although changes in yields and production costs may lend themselves more easily to economic estimation, the long-term impact of exposure may be more significant. Improvement of productivity resulting from better health, for example, has been shown to more than

compensate for the additional pest damage (Rola and Pingali, 1993; Antle and Pingali, 1994).

- No attention is given to the fact that reducing pesticide use will slow down development and spread of pesticide resistance, thereby conserving the efficacy of the pesticide for more urgent situations.
- The ability of farmers and other pesticide users to adjust to new circumstances is not accounted for. It is assumed that crop choices and cropping methods are fixed givens, while in real life they are flexible and subject to decisions that are part of adaptive management.
- It is usually fairly easy to compare the costs of different (alternative) pesticides being used for the same purposes, and in similar situations (see below). Changes towards integrated management methods require much more complex calculations, since a range of practices will be involved. They are therefore usually omitted. Excellent guidance on how such calculations can be made for vector control operations is provided by the joint WHO/FAO/UNEP Panel of Experts on Environmental Management for Vector Control (PEEM) (Phillips *et al.*, 1993). See the first case study in chapter 4 for an example from India, where exclusive reliance on non-chemical methods proved more cost-effective than DDT use.
- The capacity of researchers and industry, given clear incentives and policy signals, to produce innovation is underestimated. The faster-than-estimated global phase-out of chlorofluorocarbons (CFCs) and chlorine-bleached paper pulp can serve as encouraging examples of this.

A few studies in which external costs related to pesticide use have been included indicate that these costs can be very large. Cost items in a study on agricultural pesticide use in Thailand (Jungbluth, 1996) included for example:

- health costs (treatment, working days lost by those ill and by those taking care of the ill)
- costs of exceeded residue levels (leaving a proportion of produce unfit for marketing)
- costs related to pesticide resistance and resurgence
- pesticide-related research
- costs of pesticide quality control and residue monitoring
- costs of pesticide regulation
- costs of pesticide-related extension

These costs put together amounted exactly to the total value of pesticides sold in Thailand. The “true costs” of the pesticide would thus be double that of the chemical alone. Similar studies in Germany and the USA showed “additional costs” of 23 and 200%, respectively (Jungbluth, 1996).

The low cost of DDT is often used as an argument for its continued use. This may have been a relevant consideration in the past. Recent cost comparisons show, however, that the argument has lost much of its validity, as detailed below. The product cost of, for example, synthetic pyrethroids may still be higher than that of DDT. When taking into account operational cost such as transport, storage and application, however, the overall cost of indoor spraying with alternative insecticides per house per six months will in several instances overlap with the cost of DDT. This is especially true for pyrethroids, as they are much less bulky than DDT, thus reducing transport and storage costs.

**Table 2: Cost comparisons of insecticides for indoor vector control (excluding operational costs) (adapted from Walker, 2000)**

Insecticide (SP = pyrethroid)	Dosage (grams of active ingredient per m <sup>2</sup> ) per spray	Assumed number of sprays per six month period	Product cost range (US\$) per house per 6 months - 200 m <sup>2</sup> /house (based on 1998/1999 prices)
DDT	2	1	1.50 – 3.00
malathion	2	2	3.20 - 6.40
fenitrothion	2	2	7.70 - 15.40
bendiocarb	0.1 - 0.4	2	4.00 - 10.00
propoxur	2	2	28.00 - 56.00
lambda-cyhalothrin (SP)	0.02 - 0.03	1	3.75 - 4.50
deltamethrin (SP)	0.025 - 0.05	1	12.00 - 24.00
permethrin (SP)	0.125 - 0.5	2	2.8 - 13.60
cyfluthrin (SP)	0.02 - 0.05	1	2.20 – 5.50

### 3.3. Pesticide resistance

Resistance is a phenomenon whereby a pathogen, pest or vector population, through the selection of genetic traits or through mutations, gains the ability to survive treatment with a chemical at a dose that would originally have been lethal. It is a characteristic that is selected through the repeated use of the same pesticide. Resistance has its roots in genetic variation and natural selection, i.e. the least susceptible individuals in each generation are most likely to survive and reproduce, genetically conferring their lower susceptibility to their offspring. From this follow the principles that

- all pest and vector organisms will eventually develop resistance if current patterns of pesticide use are continued.
- any pesticide will eventually give rise to the development of resistance.

In reality, the speed with which resistance evolves varies greatly between species and ecosystems. Many mosquito vectors, for example, have developed resistance fairly rapidly, while no significant resistance has yet been detected in tsetse flies and triatomine bugs (vectors of Chagas disease). Insecticide resistance is a huge and costly problem in both agriculture and public health. It shortens the “effective life” of a substance. This leads to higher product costs. Increased resistance will usually also lead to increased use, at least initially, since farmers and other users will increase application rates and frequencies in an attempt to maintain pest

**Pesticide resistance is a significant threat to the effectiveness of pesticides that may be needed in urgent situations – and a strong argument for IPM and IVM**

and vector species under control. This translates into higher cost and a greater environmental impact. Widespread pesticide resistance causing uncontrollable pest situations has in fact been one of the main driving forces behind the development of IPM. The impact of agricultural applications of insecticides on resistance in populations of disease vectors has been covered in chapter 2.

Of particular concern is cross-resistance, whereby the use of one pesticide will induce resistance to other pesticides as well. This is most frequent among closely related substances (e.g. between pyrethroids), but can also occur between different pesticide groups such as organophosphates and carbamates. Different mechanisms may be at play at the genetic level. Of relevance to malaria control is the fact that cross-resistance can occur between DDT and pyrethroids through the expression of the so-called *kdr* genes. This has been observed in West Africa (Chandré *et al.*, 1999). In other parts of Africa, for example southern Africa, such cross-resistance has not (yet) been observed, because there pyrethroid resistance in anopheline mosquitoes is caused through other genetic mechanisms.

Susceptibility to a pesticide should be regarded as a resource to be maintained, since situations may occur where no other practical option is available. From a sustainability perspective, this is similar to cases of life-saving antibiotics that are rendered useless by careless over-prescription and use.

Intensive pesticide use in agriculture may increase the risk of resistance developing in vector populations. Spraying pyrethroids in rice paddies (where mosquito larvae breed) can, for example, reduce the effect of impregnated mosquito nets. This again underscores the need for a holistic, cross-cutting approach, consistent regulations and co-operation between different sectors.

Several strategies can be applied to slow down or even avoid the development of resistance. First and foremost among these is the reduction of pesticide use. This is yet another strong argument in favour of adopting the IPM/IVM approaches, with their priority reliance on environmental management and non-chemical control methods. Other possible resistance management strategies include:

- limiting the treated area to the most urgent foci;
- using pesticides with low persistence, especially in agriculture. (High persistence was previously considered a desirable property in a pesticide, e.g. for residual treatments, but it increases risks of selecting for resistance and of other ecosystem disruptions);
- leaving refugia untreated to conserve susceptible individuals in pest populations;
- using additives to enhance the pesticidal effect;
- monitoring for early signs of resistance. Resistance can sometimes be slowed if detected early;
- Within the context of IPM/IVM, installing a programme of pesticide rotation.

Using mixtures of unrelated pesticides has also been recommended as a resistance management strategy, but strong supportive evidence is lacking. There are reasons for caution: so-called synergistic effects may increase user hazards, as mixing pesticides can raise toxicity dramatically, and extensive use of such mixtures may create super-resistant pests.

In conclusion, close collaboration and frequent communication must be ensured between institutions responsible for health, environment and agriculture. Any on-going or proposed control strategy will have implications for all these sectors, and it

is vital that policies and strategies are consistent and mutually supportive. Effective collaborative arrangements are important for institutions and organisations at all levels, from local to international.

### 3.4. Pesticide stocks and the obsolete pesticide problem

Eliminating the use of POP pesticides is not only a question of providing viable alternative strategies, but also of removing remaining sources of POPs. Production of most POP pesticides has ceased, but remaining stocks are of utmost concern. A recent FAO estimate puts the total amount of obsolete pesticides of all types in non-OECD countries at between 400,000 and 500,000 tons (FAO, 2001). More than 20% of global stocks is of the organochlorine type - current or potential future POP pesticides. The amount in Africa and the Near East alone is around 47,000 tons.

#### Obsolete pesticides

- constitute an immediate threat to the health of humans and livestock, particularly since they are often stored in populated areas
- may sooner or later leak into and contaminate groundwater and the environment in general. Stores are often in deplorable condition, with defective containers, no rain protection, unfenced sites, etc.
- may find their way to the illicit pesticide market. This can lead to unacceptable residue levels in food and export crops

**Stocks of obsolete pesticides are a huge threat to health and environment in many developing countries**

FAO has assumed a lead role in organising and co-ordinating the disposal of obsolete pesticides. The Organization addresses the problem in a number of ways:

- mobilising resources and organising disposal operations together with governments, donors, non-governmental organisations and agrochemical companies
- monitoring compliance with international standards among contractors
- promoting methods that reduce reliance on pesticides (IPM)
- providing guidelines on ways to limit stocks to short-term requirements.
- recommending that pesticide purchases under aid agreements only be made from companies pledging responsibility for unused products

A pesticide disposal project specifically aimed at Africa and the Near East is currently being implemented by FAO, and a number of disposal operations have already taken place under its aegis (FAO, 1997). Although over 1200 tonnes have been disposed of, an overwhelming amount remains. Since it appears that a large part of the obsolete pesticides are organochlorines, disposing of this is of critical importance if POPs are to be successfully eliminated. Similar projects have been initiated in other regions together with UNEP and the Secretariat of the Basel Convention. WHO works closely with FAO in the area of disposal of stockpiles of obsolete public health insecticides.

In a number of countries, the use of existing stocks of pesticides has been restricted. Lack of resources and mechanisms to effectively enforce such restrictions is a matter of concern. In some cases, a total ban on the use of all remaining stocks may be more realistic and easier to administer.

Several countries continue to allow the use of DDT for public health purposes, either for regular indoor residual spraying, for targeted spraying or as an emergency response to disease outbreaks. The Stockholm Convention on POPs considers the use of DDT for vector control acceptable in cases where alternatives that are locally safe, effective and affordable are not available. Such use must follow practice and procedures recommended in WHO guidelines, which include the need to ensure that the insecticide is not diverted for other, illegal uses (WHO, 1995). The use of existing stocks of DDT in malaria vector control programmes is promoted as an acceptable disposal option in the WHO Action Plan (WHO, 2001). For this disposal option to be valid, the stockpiled DDT must meet WHO specifications (available from the WHO web site: [www.who.int/whopes/specifications\\_and\\_methods.htm](http://www.who.int/whopes/specifications_and_methods.htm)) Shipment of stockpiled DDT for its proper use in another country may contribute to a reduction in the need for its further production. Such shipments will have to be carried out in accordance with the rules laid down in the relevant international Conventions: the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal ([www.basel.int](http://www.basel.int)) and the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade ([www.pic.int](http://www.pic.int)).

Stocks of obsolete pesticides may accumulate for a number of reasons:

- Excessive and unsolicited donations.
- Import (purchase or donation) of poor quality pesticides.
- Products have been banned and remaining stocks cannot be used.
- Inadequate stores and poor stock management. Products and containers may deteriorate, “first-in first-out” rules are not followed, etc.
- Unsuitable products, packaging and/or labelling.

Many of these problems have their roots in inadequate planning by recipient countries as well as in poor procedures for administration and co-ordination of donations. Aggressive promotion of pesticides by commercial interests may also play a role.

Preventing the accumulation of surplus quantities of pesticides in the first place is of prime importance. Countries with obsolete stock problems often lack disposal facilities and disposal abroad is extremely costly. Accumulation and eventual disposal of pesticides puts a tremendous burden on scarce resources. Therefore the following items of good practice must be considered:

- Each party (government, donor agencies, industry, users) must be fully aware of its responsibilities.
- Pesticide use must be minimised and IPM/IVM principles must be adopted in both policy and practice
- Overstocking of pesticides must be avoided. Stocks must be kept as low as possible.
- Accurate needs assessments must be made and distribution systems must be reviewed regularly.
- For imported products, including donations, clear acceptance criteria must be applied: suitable type and formulation, proper packaging and labelling.
- Proper handling, storage and stock management must be ensured. Donations of pesticides should only be made on the condition that this is complied with. Where necessary, training in these issues must be funded as part of the package and in advance of delivery of the pesticides.
- Procurement must only be made from companies taking full responsibility for unused products, pledging to take them back or have them safely disposed of.

### 3.5 Farmer Field Schools

A Farmer Field School (FFS) consists of a group of 25-30 farmers that will meet in the field regularly, usually one morning every week for the duration of the crop that



is chosen for the FFS. It is organised at village level. A facilitator who has been trained in IPM will work with the group to facilitate the weekly meetings. The group will set up study fields of about 1000 m<sup>2</sup>, to compare IPM practices and Farmer Practices (FP) common for the village where the FFS is organised. The FFS programme consists of carrying out a weekly agro-ecosystem analysis. Also, every week a special topic is selected for in-depth discus-

sion, to strengthen knowledge on specific elements. The activities are carried out in such a way that they favour team building and positive group dynamics, to promote group bonding and to create an atmosphere conducive for learning and sharing of experiences between the group members (Gallagher, 2000).



#### *Agro-ecosystem analysis*

Farmers work in small groups of about five persons to observe their study fields on IPM and FP. The groups observe and record all elements in the field: the plants (height, number of green and yellow leaves), pest populations, natural enemy populations, disease incidence, weeds, water situation and weather conditions. After their observations the small group

will analyse their findings by making a drawing. The drawing shows the crop, pests and natural enemies, diseases, weeds, weather and the water situation. The numbers observed are recorded on the drawing as well. In the small group farmers will discuss what would be the best management option for the IPM field, based on the observations of this week as well as previous weeks, and interactions between the different elements in the field. The management recommendation is recorded as

well. Each small group will present their findings to the whole group. A discussion by the whole group will lead to a common decision on the management of the IPM field for the week to come.



#### *Special Topics*

Sessions addressing special topics are conducted every week. The selection of the topic

will depend on the stage of crop development, and on specific problems encountered in the field. They reinforce knowledge about certain parts of the ecosystem.

Some examples:

◇ *Crop Development.*

During the season small groups of FFS members collect plants in a certain stage, observe and draw them. The FFS members discuss the requirements of the plants in this particular stage, leading to broader discussions on nutrient, soil and water management.



◇ *Crop compensation.*

Crops have the capacity to compensate for damage caused by insects eating leaves or tillers. Crop health and the development stage will influence the degree of compensation. To understand compensation better, and to make it part of decisions, farmers in a FFS set up small studies in their study fields.

At different stages of crop development they remove leaves (25% and 50%) in marked areas, or tillers (20% and 30%). The plants in the marked areas are observed regularly by the FFS during the season and measurements are taken of the crop development of treated and untreated plants. At the end of the season harvest data are collected for treated and untreated areas.

◇ *Effects of insecticides on natural enemies.*

Small groups carry out studies on the effect of insecticides on natural enemies. Natural enemies are collected from the field, and put into jars. Some jars will be sprayed with insecticides, others serve as control. Groups record their observations, and discuss what they mean for the agro-ecosystem.

◇ *Insect Zoo.*

FFS members set up small studies in caged pots to study life cycles of pests and natural enemies. They observe the different stages of development of an insect, and the duration of each stage. Also studies on predation are carried out. A certain predator is placed in a jar with a number of pest insects, and observations are made on the amount eaten daily. If unknown insects are found in the field small studies are set up to confirm the function of the insect in the field: eating plants, being a predator or a parasite. The group members show their zoos to others, and report on their results. At the end of the season the results of the insect zoo, as well as other observations, are used by small groups to draw food webs. These are discussed by the whole group.



An FFS aims at making farmers better decision makers in the process of managing their crops.

Many tools are available that are part of integrated management approaches, based on the principles of IPM. The choice of tools will depend on observation and analysis of the situation, possibilities to use them, and socio-economic conditions. Examples of IPM tools are presented in chapter 2 (page 29). Better knowledge on IPM allows farmers to reduce pesticide use while maintaining or improving yields.

Following are some results of FFSs on cotton in Pakistan: IPM plots were sprayed 1.4 times, while conventional plots were sprayed 5.4 times. Two FFS groups even managed to avoid spraying altogether. Beneficial arthropods were numerous in the IPM plots. Average yields were almost 10 % higher in the IPM plots compared to the conventional plots (1363 vs. 1245 kg/ha). In seven of the ten sites, IPM plots yielded better than conventional spraying. The savings in input costs (1974 vs. 6066 rupees/ha) increased the economic gain even further. Reduced pesticide use also lowered the health risk for farmers and the pollution load on the environment.

**Farmers making informed decisions in their own fields can reduce pesticide use, increase yields and improve profitability**

Successful IPM is driven by the actual users – mainly farmers. It is not a service provided from “above” – by a government service, a private company, a donor, or a foreign NGO. Full participation of the users is a prerequisite. Women have a crucial role to play – in many developing countries, the majority of farmers are women – and their training needs and other priorities are important.

An FFS is an entry point for farmers to take the lead in a range of other IPM related activities, such as:

- becoming trainers conducting FFS for others in their community,
- engaging in local research activities to optimise practices for the local situation,
- engaging in curriculum development activities with trainers and researchers
- taking the lead in local planning, implementation and evaluation of IPM activities at community level, including fund raising from local government, the farmer community or other organisations in their area.

### 3.6. Capacity building in intersectoral collaboration

Most developing countries have policies supporting expansion and/or intensification of their agricultural production systems, aimed at improved food security and better socio-economic conditions, in particular poverty alleviation. Certain types of agricultural development, however, may have negative effects on health, especially



with respect to increased risks of vector-borne disease transmission. Agricultural development activities may cause changes in environment and ecology that favour vector development or prolong the transmission season. Often agricultural development is accompanied by demographic changes. Resettlement or informal migration may expose population groups with no

immunity to new disease organisms carried by vectors or new arrivals may introduce the disease into local communities where environmental receptivity (i.e. the presence of the vector) has increased through environmental change.

In principle, socio-economic benefits of agricultural development will translate into an improved community health status. Improved nutritional status will go hand in hand with better access to health services as local infrastructure improves. Increased purchasing power facilitates access to medicines and mosquito nets, and improvements in housing conditions. Some vulnerable groups, however, may not profit fully from the benefits and will be exposed to increased risks of vector-borne diseases. In the planning and design of agricultural development projects health issues usually are not sufficiently considered. Efforts from the different sectors are needed to ensure that in future agricultural and other types of development take health issues into consideration and that negative effects are avoided to the extent possible.



From past experience it is clear that a number of impacts on community health can occur that are of relevance in the context of the issues covered in this guidance document:



- changes in irrigation water management, land use patterns, cropping cycles and the introduction of high yielding crop varieties may all create conditions conducive to the propagation of disease vectors;
- increased or intensified use of pesticides for the control of agricultural pests may carry a range of health risks resulting from increased exposure to the compound itself or its residues;
- pesticide application in agro-ecosystems may lead to an accelerated induction of insecticide resistance in disease vectors, eventually rendering indoor residual spraying ineffective.

Such adverse effects on human health can be averted by submitting plans for agricultural development to an impact assessment. The method and procedures of health impact assessment (HIA) have been developed, tested and docu-



mented over the past fifteen years. They are described by Birley (1995) and WHO (2000). HIA is based on the principles of equity, environmental sustainability and economics. Critical steps in the procedure include screening and scoping, the formulation of HIA terms of reference, carrying out the assessment, appraisal of the assessment report and negotiating resource allocations for the implementation of recommended measures.

Capacity building in health impact assessment has three basic components:

- creation of an enabling policy environment that will facilitate the involvement of all relevant sectors at crucial decision-making moments;
- development of intersectoral decision-making skills among middle-level managers in different public sectors, and
- strengthening the environmental health unit in ministries of health so it can perform essential health sector functions related to HIA, including co-ordination with other sectors.



**Problem-based learning can complement Farmer Field Schools as an adult learning approach aimed at improved decision making in pest and vector management.**

The joint WHO/FAO/UNEP Panel of Experts on Environmental Management for Vector Control (PEEM) has developed and tested a capacity building package for the first two components. Seminars for senior government officials, aimed at incorporating health issues in the development policies of other sectors were held in a number of African countries. The training course to develop skills of middle-level managers was tested in three African countries, in the countries of Central America and in four

States of India. For maximum benefits in adult education the course proposes a task-oriented, problem-based learning process. Recently, an analysis of the course development process was published (WHO/DBL, 2001). A detailed training manual will be published in 2002.

Impact assessment is an important first step towards the use of alternatives to POPs pesticides, because it requires different sectors to collaborate in a common framework. It should not be confined to human health, but should also consider issues in a broader environmental assessment approach. Without a proper impact assessment of development projects and programmes, it is likely that reliance on pesticides will be higher than strictly necessary. The experience of adult learning methods as a valid educational approach is not limited to HIA capacity building. Problem-based learning in a more formalised setting can complement the Farmer Field Schools approach by aiming at civil servants involved in plant protection and vector control policy making and in translating such policies into action.

### 3.7 Eliminating the use of POP pesticides against termites

One of the longest lasting uses for POP pesticides has been for the control of termites – mainly in construction, but also in agriculture. Preferred pesticides have been chlordane and heptachlor, but aldrin, dieldrin and mirex have also been used.

There are approximately 2500 different termite species in the world. Termites can for practical purposes be divided into four groups based on their living habits:

- *Dampwood termites* feed mainly on dead and deteriorating trees, stumps and other wood in the ground. They are virtually without importance as pests and provide useful ecosystem services.
- *Drywood termites* are common on most continents. They can survive in very dry conditions. They can attack and destroy structural timber, but generally do not cause damage in agriculture and forestry. They do not need contact with soil.
- *Subterranean termites* are the most common pests, and cause 95% of all termite damage to buildings. They build often extensive tunnel systems on and under the soil as protection against desiccation and enemies, and enter buildings from the ground, e.g. through openings in the foundation.
- *Mound building termites* can build mounds on the soil or in trees. They occur in Africa, Australia, South-East Asia and parts of South America. They contribute to building up soil.

In agriculture, termites are pests of intensification. Overgrazing or introduction of non-indigenous, more productive crops can be the cause for termites becoming a problem in an agro-ecosystem. Management measures should be based on understanding the biology and ecology of the termites.

In buildings and constructions, POP pesticides were used against termites because of their persistent character. As the negative aspects of using POP pesticides have become apparent, however, one country after another, has phased out their use for this purpose, turning instead to integrated approaches. Reference is made to the case study in section 4.7, with an example from Australia. Different construction methods are used to prevent termites from entering a building and structures are monitored regularly for termite activity.

UNEP and FAO are collaborating with termite experts on biology and ecology of termites and alternative approaches for management. More information is available on UNEP's POPs homepage ([www.chem.unep.ch/pops](http://www.chem.unep.ch/pops)).

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