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# **PERSUAP for IRS Using Alpha- cypermethrin for Malaria Control in Madagascar's Central Highlands**

SO5 IEE Amendment

**October 25, 2006**

This publication was produced for review by the United States Agency for International Development. It was prepared by RTI International.

# **PERSUAP for IRS Using Alpha-cypermethrin for Malaria Control in Madagascar's Central Highlands**

SO5 IEE Amendment

Prepared for  
United States Agency for International Development

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The author's views expressed in this publication do not necessarily reflect the views of the United States Agency for International Development or the United States Government.

**PESTICIDE EVALUATION REPORT AND SAFER USE ACTION PLAN FOR  
IRS USING ALPHA-CYPERMETHRIN FOR MALARIA CONTROL IN  
MADAGASCAR'S CENTRAL HIGHLANDS**

**PROGRAM/ACTIVITY DATA:**

Program/Activity Number:  
Country/Region: Madagascar/AFR  
Program/Activity Title:  
Sub-Activity: IRS Using Alpha-cypermethrin for Malaria Control in  
Madagascar's Central Highlands

Funding Begin: FY06                      Funding End: FY06              LOP Amount: \$197,000

PERSUAP Prepared By: M. Biscoe and A. Thompson, RTI International

Current Date: October 25, 2006

IEE Amendment (Y/N): Y  
Filename & date of original IEE: SO5: Use of Selected Health Services and Products  
Increased and Practices Improved

**ENVIRONMENTAL ACTION RECOMMENDED:** (Place X where applicable)

Categorical Exclusion: \_\_\_\_\_                      Negative Determination: X\_\_\_\_  
Positive Determination: \_\_\_\_\_                      Deferral: \_\_\_\_\_

**ADDITIONAL ELEMENTS:** (Place X where applicable)

CONDITIONS: X\_\_\_\_                      PVO/NGO: \_\_\_\_\_

**SUMMARY OF FINDINGS:**

Madagascar's MOH has been receiving insecticide and additional commodity support for its Central Highland IRS Campaigns through the World Bank's Health Sector Support Projects, CRESAN I (providing support from 1990-999) and CRESAN II (providing support from 2000-2006); however, CRESAN II is scheduled to end in December of 2006, leaving a gap of support for Madagascar's 2006-2007 IRS Campaign. To fill this gap, USAID proposes to provide approximately 4 tons of alpha-cypermethrin to the Madagascar MOH for its November to December 2006 IRS Campaign. The insecticide is to be used in the central highlands of Madagascar prior to the season of highest transmission.

A **Negative Determination** is recommended for this program. This Environmental Assessment identifies the mitigating measures by which the potential for impact on the

environment can be minimized and the benefits of the program maximized. The conditions are that the MOH, as much assistance from USAID as necessary, will implement the risk reduction actions outlined in the Pesticide Evaluation Report and Safer Use Action Plan (PERSUAP) and summarized here and in the section entitled REQUIRED AND RECOMMENDED MITIGATION MEASURES: The Safer Use Action Plan. An overview of conditions of the Pesticide Evaluation Report and Safer Use Action Plan (PERSUAP) is detailed below.

1. *The Safer Use Action Plan is to be implemented with relevant partners as a management tool for dealing with and accomplishing the objectives. The SUAP:*
  - Specifies the tasks or steps necessary to achieve the objective;
  - Addresses potential difficult issues or problems in implementation (with ways to solve them);
  - Looks at cross-functional impacts of actions; and
  - Includes a schedule with deadlines for the most important actions, the resources necessary to achieve the objective, and ways or methods to measure the objective(s).
2. *IRS supervisors, team leaders, and spray operators will be trained according to WHO standards. Insecticide poisoning management training will be provided to health workers. Pyrethroid poisoning treatment medications will be provided to trained health workers by the MOH, with USAID assistance if necessary. Insecticide storage facility storekeepers will also be trained on proper stores management.*
3. *Occupational exposure to insecticides will be minimized through personal protective equipment (according to WHO specifications). An IEC Campaign will educate house owners on their roles and responsibilities during the spray campaign to avoid exposure, and supervisors will remind residents of these responsibilities during spray campaign.*
4. *Environmental contamination will be kept to a minimum through strict auditing, handling, washing and disposal practices to the extent feasible. Each insecticide sachet will be strictly accounted for.*
5. *As required by Automated Directives System (ADS) 204.5.4, the Strategic Objective (SO) team will actively monitor ongoing activities for compliance with the requirements and recommendations in this assessment, and modify or end activities that are not in compliance. If additional activities are added to this program that are not described in this document, an amended PERSUAP or Environmental Assessment (EA) must be prepared and approved prior to implementation of those activities. This includes any commodities, pesticide products being considered under the program but not covered in the present PERSUAP.*

**APPROVAL OF ENVIRONMENTAL ACTION RECOMMENDED:**

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## Acronyms

ATSDR	Agency for Toxic Substances and Disease Registry
C	Celsius
EA	Environmental Assessment
FAO	Food and Agriculture Organization of the United Nations
GEF	Global Environment Facility
IEC	Information, Education and Communication
IEE	Initial Environmental Examination
IPCS	International Programme on Chemical Safety
IRS	Indoor Residual Spraying
ITNs	Insecticide Treated Nets
IVM	Integrated Vector Management
LLINs	Long-Lasting Insecticidal Nets
mm	millimeter
MOA	Ministry of Agriculture
MOH	Ministry of Health
MRL	Minimal Risk Level
NIP	National Implementation Plan
PEA for IVM	Programmatic Environmental Assessment for Integrated Vector Management
PPE	Personal Protective Equipment
SUAP	Safer Use Action Plan
RTI	Research Triangle Institute
USAID	United States Agency for International Development
USEPA	United States Environmental Protection Agency
WP	Wettable Powder
WHO	World Health Organization
WHOPES	World Health Organization Pesticide Evaluation Scheme

## Summary and Context

The United States Agency for International Development (USAID) proposes to support Madagascar's November-December 2006 Indoor Residual Spraying (IRS) Campaign for malaria vector control in the central highlands using alpha-cypermethrin. Madagascar's central highlands are characterized by perennial malaria transmission, and IRS would be used to reduce malaria incidence in the season of highest transmission. Another aspect of malaria vector control supported by the Ministry of Health (MOH) includes Insecticide Treated Nets (ITNs) and Long Lasting Insecticidal Nets (LLINs). Larvicide trials are beginning piloted with support from the World Health Organization (WHO) and the Global Environment Facility (GEF), and environmental management is currently not actively pursued by the government due to the breeding habits of the primary malaria vector, *Anopheles funestus*.

USAID support for malaria epidemic prevention in the central highlands of Madagascar would include the following components:

- Purchase of approximately 4 tons of alpha-cypermethrin, and adequate amounts of personal protective equipment for spray operators as required;
- Technical assistance as needed for PERSUAP implementation; and
- Technical assistance as needed for science-based targeting of interventions.

The components of the IRS program are intended to mitigate any harmful human health and environmental effects that could occur as a result of spraying with alpha-cypermethrin. To the greatest extent possible, best professional practices will be carried out in every aspect of the IRS program. Indirect effects of the program that cannot easily be mitigated and monitored include environmental contamination or inadvertent contamination of household washtubs as a result of daily spray operator hygiene, rinsing and maintenance of sprayers, and washing of Personal Protective Equipment (PPE).

## Recommended Mitigation Measures: The Safer Use Action Plan

The Safer Use Action Plan (SUAP) puts the conclusions reached in the PERSUAP into a plan of action, including assignment of responsibility to the appropriate parties connected with the pesticide program. Based on the specific situation of Madagascar's IRS Campaign, key components to the SUAP are listed below. These components are designed to mitigate and monitor human health and environmental impacts of the IRS Campaign, as well as provide policy guidance that is consistent with USAID's Draft Programmatic Environmental Assessment for Integrated Vector Management (PEA for IVM) and the Stockholm Convention.

## Operational Requirements

- **Prohibit spraying of rooms** where sick or pregnant persons lie and cannot be moved out of the house during spraying and for one hour post-spraying.
- **Train storekeepers and drivers** in accordance with the guidance provided in this Environmental Assessment (EA) and the Food and Agricultural Organization’s (FAO’s) Pesticide Storage and Stock Control Manual (see **Annex 7**).
- **As needed, train health workers** in insecticide poisoning treatment, and **ensure treatment medicines** for insecticide exposure are available in districts targeted for IRS.
- **Train spray operators, team leaders, and supervisors** according to best practices, as outlined by the WHO and this PERSUAP, **particularly integrating training on recognition of pesticide poisoning symptoms**, advised actions when symptoms occur, and referral options (see Pesticide Procedures E, *Any Acute and Long-Term Toxicological Hazards, Either Human or Environmental, Associated with the Proposed Use and Measures Available to Minimize Such Hazards*).
- **Procure close-toed shoes or boots** for spray operators as part of their Personal Protective Equipment (PPE) in accordance with WHO guidelines; discourage wearing of sandals.
- **Reduce environmental contamination** through strict auditing of insecticide sachets, supervision of pesticide use, and thorough instruction on daily spray operator hygiene, rinsing and maintenance of sprayers, and washing of Personal Protective Equipment (PPE) in accordance with WHO guidelines.
- **Reduce household exposure** by covering furniture that cannot be moved with cloths prior to spraying.
- **Educate target communities** through an Information, Education, and Communication (IEC) campaign, citing importance of removing all food, water and utensils from house prior to spraying, moving furniture to the center of the room or outside, staying out of the house during and 1 hour after spraying, not allowing children or animals in the house until floor residue is swept outside.
- **Inform fire brigades** of the location and contents of storage facilities.
- **Revise IRS Oversight Checklist (Grille de Supervision)** to address only the use of Fendona (as opposed to DDT).
- USAID requests that **non-contaminated insecticide packaging (e.g., boxes, paper) be disposed of locally**—WHO recommends that this packaging be returned to a supervisor for “safe” disposal, and FAO recommends disposal at a landfill or “recycling” the packaging as fuel for a cement kiln or power plant (WHO 2002; Thompson 2004). **Any packaging or personal protective equipment that has been heavily contaminated should be triple-rinsed, shredded or punctured, and taken to a hazardous waste facility.**

- ***Provide post- IRS Campaign evaluation*** to USAID/Madagascar, including records on insecticide used and results from spot-checking.
- ***It is recommended (not required) that a new MOH pesticide storage facility be constructed*** according to the Food and Agriculture Organization of the United Nations's (FAO's) *Pesticide Storage and Stock Control Manual*, to decrease risk of spillage, protect pesticide products from rainfall, and decrease risk of exposure to employees working in MOH headquarters.

### **Policy Requirements**

- ***Restrict IRS activities to the Central Highlands, and prohibit IRS in sensitive areas***, including protected areas and sensitive ecosystems. Spray with care in areas where beekeeping occurs.
- ***The MOH must provide official notice to the National Environment Office*** of the planned IRS activities including information on the area where IRS will take place, pesticide use practices, the education of workers and beneficiaries, and the USAID PERSUAP requirements.
- If necessary, ***request temporary registration for Fendona*** from the Ministry of Agriculture. In the past, alpha-cypermethrin has been temporarily registered for use in IRS activities. If this temporary registration has expired, the MOH must request an additional temporary registration of alpha-cypermethrin from the Ministry of Agriculture.
- ***USAID will discuss importance of an environmental assessment*** for any pesticides used in IRS with MOH and Department of Environment staff-- online resource for conducting assessments will be provided (<http://www.encapafrika.org/>)
- ***The MOH and USAID will develop a Memorandum of Understanding (MOU)*** to establish MOH responsibilities for compliance with the PERSUAP. The MOU will also establish USAID, Research Triangle Institute (RTI) International, Ministry of Agriculture and Department of Environment responsibilities for monitoring MOH compliance with the PERSUAP, as appropriate. According to USAID's Automated Directives System (ADS) 204.5.4, the USAID Mission Strategic Objective (SO) team is required to actively monitor ongoing activities for compliance with the requirements and recommendations in this assessment.

### **Policy and Planning Recommendations**

- ***Work with the FAO, Voarisoa, or similar institutions*** to acquire knowledge about responsible pesticide to integrate into IRS Campaign management and Training of Trainers. Use FAO's *Pesticide Storage and Stock Control Manual* as a starting point.

- ***Increase the length of training and practice time*** for supervisors, team leaders and spray operators.
- ***Increase collaboration with stakeholders outside MOH***, particularly the Department of Environment, Institut Pasteur de Madagascar, and NGOs.
- ***Develop and implement a resistance management strategy*** to ensure the continuing effectiveness of malaria vector control insecticides.
- ***Improve epidemiological surveillance systems*** to acquire better knowledge of intervention efficacy and improve targeting of IRS, thus reducing pesticide use.

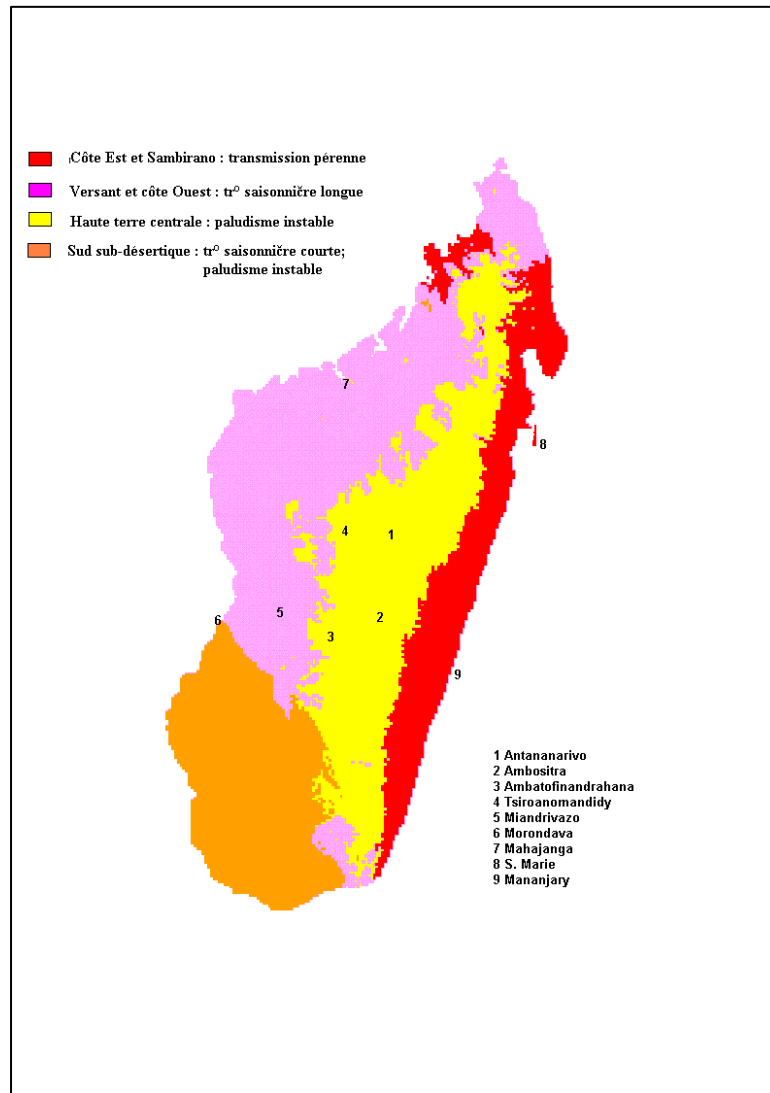
The operational requirements are summarized in **Annex 1** of this PERSUAP, according to the time that the actions should be taken. Upon signature of this PERSUAP, it is understood that these required mitigation activities are to be implemented during the planning and implementation of the IRS Campaign.

## Background and Purpose

### Need for Action and the Preferred Alternative

Due to the variety of altitudes and climatic zones in Madagascar, the ecology of malaria is complex. The central highlands and the south are characterized by unstable hypoendemic transmission, the west and the east coasts are characterized by stable holoendemic transmission (see Figure 1). The eastern part of Madagascar lies in a tropical lowland zone where studies have found a parasite prevalence rate of 20% among the general population. The western and southern parts have seasonal variations and studies have found an average parasite prevalence rate of 10% and 5% respectively. Contrary to what is found in other endemic countries in continental Africa, asymptomatic carriers of the parasite are rare. In the central highlands where acquired immunity is low, malaria epidemics, once under control, resurged in the late 1980's and caused thousands of deaths. Although brought under control once again with intradomiciliary spraying, there is still a risk of epidemics recurring during the hot and rainy season. 98% of infections are caused by *Plasmodium falciparum*.

**Figure 1. Malaria Transmission Patterns in Madagascar.**



Source: Madagascar Ministry of Health

Malaria is the first cause of morbidity and mortality among cases presenting to health facilities. Outside of the central highlands region, malaria is the leading cause of morbidity among children under 5 seen at the primary health centers. In 2000, malaria accounted for 15% of all deaths and 22% of deaths among children under 5 reported by district hospitals, with a case fatality rate of 11.5% among children under 5 years. The mean case fatality rate among children under 5 with severe malaria seen at the district hospitals there is 24%.

**Table 1. Malaria Cases in Madagascar, 1999.**

Malaria cases seen at:	All outpatients		Children under 5	
	Number	% Total Cases	Number	% Total Cases

All primary health centers, public and private (probable cases)	1,392,483	19%	553,350	23%
All district hospitals (probable and confirmed cases)*	28,974	12%	7,386*	17%

\*Data from 104/111 district hospitals.

1999 Population of Madagascar: 14.6 million.

Source: MOH Health management information system, 1999.

IRS Campaigns conducted in the 1950s and 60s reduced malaria substantially, leading to virtual elimination of *Anopheles funestus*. In 1961, WHO even classified Madagascar as one of the malaria pre-eradication areas. After this period, the Government of Madagascar de-emphasized epidemiological surveillance and vector control for malaria prevention, which allowed a slow but steady recolonization of the central highlands by *An. funestus* in the 1970s and 80s. As a consequence, the central highlands of Madagascar experienced an “explosive” epidemic in the late 1980s that killed between tens of thousands of people (Curtis 2002).

Since that time, the malaria situation in the central highlands has improved due to the resumption of IRS and increased accessibility to chloroquine in major epidemic. From 1993 to 1998, a “general” IRS Campaign was conducted; the general campaign targeted nearly all rural communes of central highlands, particularly those located between 900 and 1500 meters in elevation.

The 1993-1998 general central highland IRS Campaigns were mainly funded through the World Bank, and helped protect an average of 2.3 million people per year. Additionally, with the support of the Italian Cooperation, the Ministry of Health established a Malaria and Warning Epidemiological Surveillance System that became operational in 1997. In the 1999-2000 transmission season, the Ministry of Health used a more targeted approach in its central highland IRS Campaign; instead of targeting the majority of rural communes, it targeted the communes most at risk (the Ministry still does this today).

After the 1999-2000 IRS Campaign, the MOH ceased IRS and monitored the malaria case load. After two years of an increased caseload in the central highlands, the MOH decided to resume IRS in central highland communes, choosing communes based on the following criteria:

- The commune exceeded the epidemic threshold in the previous transmission season
- The commune was not treated in the previous campaign
- The commune must be located at an altitude between 500 and 1500 meters

It should be noted that the commune (rather than the secteur or zone) is the administrative unit analyzed for its inclusion in the IRS campaign each year.



From 2002 to 2005, similar targeted IRS Campaigns were planned and implemented in geographic locations based on these criteria.

In 2005, Pierre Guillet and John Govere of the WHO examined Madagascar's malaria control operations, making several recommendations. Among these recommendations, Guillet and Govere advised the MOH to establish a resistance management program as a response to growing DDT resistance in one vector in the central highlands. The MOH is now committed to the idea of resistance prevention, but is facing budgetary constraints in the implementation of a resistance strategy. Guillet and Govere also advised the Ministry to return to a general spraying of the central highlands (as was done from 1993-1998) to eradicate the *An. funestus* population (Guillet 2006). The 2006-07 spray campaign is a targeted rather than a general spray campaign that would cover all communes in the central highlands; however in the near future, Ministry of Health would like to conduct a general Indoor Spraying Operation for three years, and conduct targeted IRS campaigns the following two years as advised by the WHO.

## Figure 2. Alternatives Considered and Not Considered for this PERSUAP

### Alternatives Considered

IRS Campaign

USAID support would include the following components:

- Purchase of approximately 4 tons of alpha-cypermethrin, and adequate amounts of personal protective equipment for spray operators as required;
- Technical assistance as needed for PERSUAP implementation; and
- Technical assistance as needed for science-based targeting of interventions.

### Alternatives Not Considered

ITN/LLIN Program

USAID currently supports ITN/LLIN programs in Madagascar.

Larviciding

WHO and GEF are funding a 5-year 3-district larvicide pilot program in Madagascar.

Environmental Management

The Ministry of Health has not pursued Environmental Management as a malaria vector control strategy because breeding occurs primarily in rice fields, making elimination of breeding sites difficult.

### Human Health and Environmental Effects of Preferred Alternative

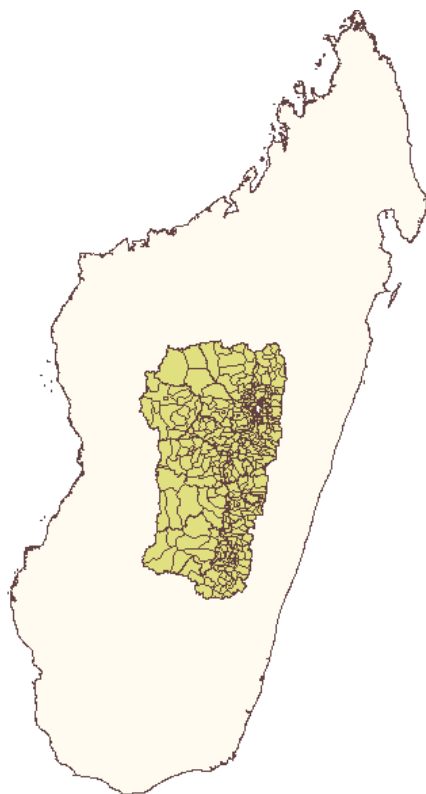
As a consequence of implementing the Preferred Alternative, approximately 50,000 households or 250,000 people will be covered by USAID support for this vector control program. This protection will reduce the incidence of adult morbidity, miscarriages, low birth-weight, and adverse effects on fetal neurodevelopment due to malaria. It will also reduce the incidence of malaria-related childhood anemia, complications, organ failure, and death.

The environmental effects of the preferred alternative are discussed in Pesticide Procedures G, *Compatibility of the Proposed Pesticide with Target and Nontarget Ecosystems*.

## Affected Environment

Antananarivo province and the northwest part of Fianarantsoa province are the areas where the Ministry of Health conducts IRS Campaigns (see Figure 3). As previously indicated, not all communes in these areas are targeted for IRS; the communes are chosen based on its epidemiology, altitude, and previous treatment through IRS.

**Figure 3. Central Highlands of Madagascar**



The 2006-07 Malagasy IRS Campaign covers 26 Secteurs in this area, as illustrated in Table 2.

**Table 2. Administrative Divisions in Madagascar Guiding IRS Campaign Logistics Planning**

Administrative Level	Number
Province	2
Zone	9
Secteur (District)	26
Commune	70

USAID-support will provide coverage for 250,000 people of the 1.2 million anticipated to be covered by the entire IRS Campaign.

# Environmental Consequences

## Unavoidable Adverse Effects

### *Alpha-cypermethrin*

The risk of vehicle accidents and consequent insecticide spillage is always present. Such spillage could expose both humans and aquatic environments to alpha-cypermethrin with adverse consequences. It is also possible that the impacts of normal residential exposure of pregnant women could include neurological effects on unborn fetuses, but further research is necessary to test this hypothesis (Berkowitz, et al. 2003). This fetal exposure in the home would be an unavoidable risk of the IRS operation. Human inhalation of toxic fumes in the event of a storehouse fire is also an unavoidable risk, as open-burning of alpha-cypermethrin creates nitrogen formaldehyde, acrolein, and hydrogen cyanide (UK NPIS accessed 2006). A conservative screening risk assessment conducted for the Programmatic Environmental Assessment for Integrated Vector Management (PEA for IVM) indicates that there is a low risk of adverse human health impact from alpha-cypermethrin contaminating groundwater systems as a result of burial of the insecticide.

## Irreversible or Irrecoverable Commitments of Resources

All financial support of the IRS Campaign is irretrievable. Any USAID-procured, non-insecticide commodities that remain with the MOH after the 2006-07 IRS Campaign will not be tracked to ensure their proper use. As a result, it is possible that USAID may indirectly support activities that have not undergone environmental review.

## Environmental Impacts of the Proposed Action

The primary environmental risk for use of alpha-cypermethrin includes negative impacts on bee hives and contamination of aquatic ecosystems, which could adversely affect freshwater fish and invertebrate species. Environmental contamination as a result of spray operator activities will be difficult to mitigate, as spray operators do not return to a central location to wash themselves, their sprayers, and their PPE; instead, they conduct these activities on their own accord in the communes they have recently sprayed and where they temporarily reside. The potential environmental impacts of the proposed action are discussed further in *Pesticide Procedures G, Compatibility of the proposed pesticide with target and nontarget ecosystems*.

## Direct and Indirect Effects and Their Significance

### *Direct Effects*

USAID will directly support the use of alpha-cypermethrin for malaria vector control in the central highlands of Madagascar. This support will provide protection against epidemic malaria to approximately 250,000 people and will reduce the incidence of adult morbidity,

miscarriages, low birth-weight, and adverse effects on fetal neurodevelopment. It will also reduce the incidence of malaria-related childhood anemia, complications, organ failure, and death.

**Indirect Effects**

Indirect effects of the program that cannot easily be mitigated and monitored include environmental contamination or inadvertent contamination of household washtubs as a result of daily spray operator hygiene, rinsing and maintenance of sprayers, and washing of Personal Protective Equipment (PPE).

**Complementary and Conflicting Policies, Plans, or Controls for the Areas Under Consideration**

**Madagascar’s Environmental Regulations**

According to the National Environment Office, an Environmental Impact Assessment (EIA) or Environmental Review is not required for use of alpha-cypermethrin in Madagascar’s IRS activities in the Central Highlands. In lieu of a Malagasy EIA, the Ministry of Health must provide official notice to the National Environment Office of the planned IRS activities including information on the area where IRS will take place, pesticide use practices, the education of workers and beneficiaries, and the USAID PERSUAP requirements.

**Other Donor Activities**

The other major donors to the Ministry of Health’s malaria control activities include the World Health Organization (WHO) and the Global Environment Facility (GEF), the World Bank, and the Canadian Cooperation. The World Bank is the only donor supporting the Ministry of Health’s IRS activities, and since 1993 has supplied the Ministry of Health with all insecticides required for the IRS Campaigns in the central highlands. USAID support this year will fill a gap in World Bank funding for IRS.

**Pesticide Procedures**

**A. The USEPA Registration Status of the Requested Pesticide**

Table 6 describes the registration status of alpha-cypermethrin in Madagascar and the United States, and Table 7 describes the toxicity classes for alpha-cypermethrin.

**Table 3. Registration Status of Suggested Pesticide**

Is the pesticide...	Alpha-Cypermethrin
Registered by the host country (for public health use)?	YES*
Registered by EPA?	NO (but

Is the pesticide...	Alpha-Cypermethrin
	Cypermethrin, a related compound, is)
WHO-recommended?	YES

\*In the past, alpha-cypermethrin has been temporarily registered for use in IRS activities. If this temporary registration has expired, the MOH must request an additional temporary registration of alpha-cypermethrin from the Ministry of Agriculture.

**Table 4. Toxicity Classes of Suggested Pesticide**

	Alpha-cypermethrin
EPA Toxicity Class	No consensus value
WHO Toxicity Class	II: Moderately Hazardous

**B. The Basis for Selection of the Requested Pesticide**

The chemicals used in IRS, ITNs and larviciding all have different properties and are more or less appropriate in different circumstances. The following threshold criteria must be met in making decisions on pesticides used in malaria vector control:

- Pesticide registration in the host country
- Acceptability of the pesticide to the National Malaria Control Program
- Risk to human health
  - Pesticides must be approved by the WHO and should be preferred based on their safety as described in Section 5.1.3.3.
- Risk to environment, livestock and/or agricultural trade

Beyond these four threshold considerations, technical and logistical factors must be addressed in comparing and selecting insecticides for malaria vector control. The primary factor to be addressed is:

- Vector resistance

Secondary factors include:

- Appropriateness of surface for spraying
- Duration of effectiveness (and implications for cost)
- Cost of insecticide

Tertiary factors include:

- The need for an insecticide of a different class to prevent resistance
- Major classes of insecticides used in other vector control interventions that could promote resistance
- Major classes of insecticides used in the agricultural sector that could promote resistance
- Host-country capacity to prevent pilferage

Madagascar used DDT until 2003. Since 2004, on account of resistance management and the Stockholm convention, the following criteria have been used for insecticide selection:

- Field tested insecticides with satisfactory results both in terms of efficacy, residual effect, and use safety
- Reasonable cost if compared to DDT
- WHOPES-certified for indoor use

The MOH may choose to use DDT again for several reasons. First, DDT continues to be effective on *An. funestus* (Ratovonjato et al. 2003). Second, the MOH wants to alternate IRS pesticides to manage vector resistance. Third, Madagascar is committed to eliminating malaria and intends to use IRS in endemic areas on the east coast, where DDT is most appropriate in terms of its lengthy residual effect on household walls.

**C. The Extent to Which the Proposed Pesticide Use is Part of an Integrated Vector Management Program**

The proposed insecticide use is part of an integrated management strategy including IRS, ITNs and LLINs, and larviciding. The MOH has a commitment to all three, although currently larviciding is only being implemented as a pilot project. Environmental management is not used as a strategy by the MOH, as rice fields provide the primary breeding ground for malaria vectors, but communities are encouraged to “manage their environment to abate malaria transmission risks” (MOH 2005).

**D. The Proposed Method or Methods of Application, Including Availability of Appropriate Application and Safety Equipment**

The proposed method of application is Indoor Residual Spraying, or IRS. IRS is a commonly used malaria vector control method that is particularly effective in preventing malaria epidemics. It is implemented by the application of residual insecticides, to which *Anopheles* female mosquitoes have been demonstrated to be susceptible, to the interior walls of houses and other structures. The insecticide remains on treated surfaces upon which mosquitoes will rest before or after taking a blood meal. Several formulations of insecticides are available for this purpose. The residual effect of the insecticide is sufficient to kill resting mosquitoes for a period ranging from three to twelve months, depending on the insecticide, the surface on which it is applied, and local conditions. The objective of the IRS Campaign is to reduce the mean life-span of the female mosquito population below the duration required for development of the parasite life phases that

occur in the mosquito and, thereby, to substantially reduce the population’s ability to sustain malaria transmission. IRS is most effective in areas with seasonal malaria transmission. It is typically implemented by teams of spray operators who spray houses in at-risk localities prior to the rainy season, because heavy rains prompt increases in the *Anopheles* vector population. To be effective, IRS must attain coverage rates of at least 85% of the houses in a target area.

The spray operators who implement IRS use compression sprayers to apply a measured amount of insecticide on the interior walls of houses and structures. Insecticides that are applied to house walls in smaller doses, such as alpha-cypermethrin, are packaged in water-soluble sachets that are dropped directly into the spray can. The sprayer is pressurized, and the insecticide is then applied to the interior walls of targeted houses and structures. After the day’s spraying is complete, spray operators must clean the sprayer following the manufacturer’s recommendations to ensure the sprayer’s proper operation.

The logistical needs to implement IRS are immense; however, the Madagascar MOH has an excellent system in place for planning, implementing and evaluating IRS Campaigns, as well as adapting the program to changing needs for malaria control. The activities conducted by the MOH for IRS are shown in Table 5.

**Table 5. Madagascar Ministry of Health IRS Planning and Implementation Activities**

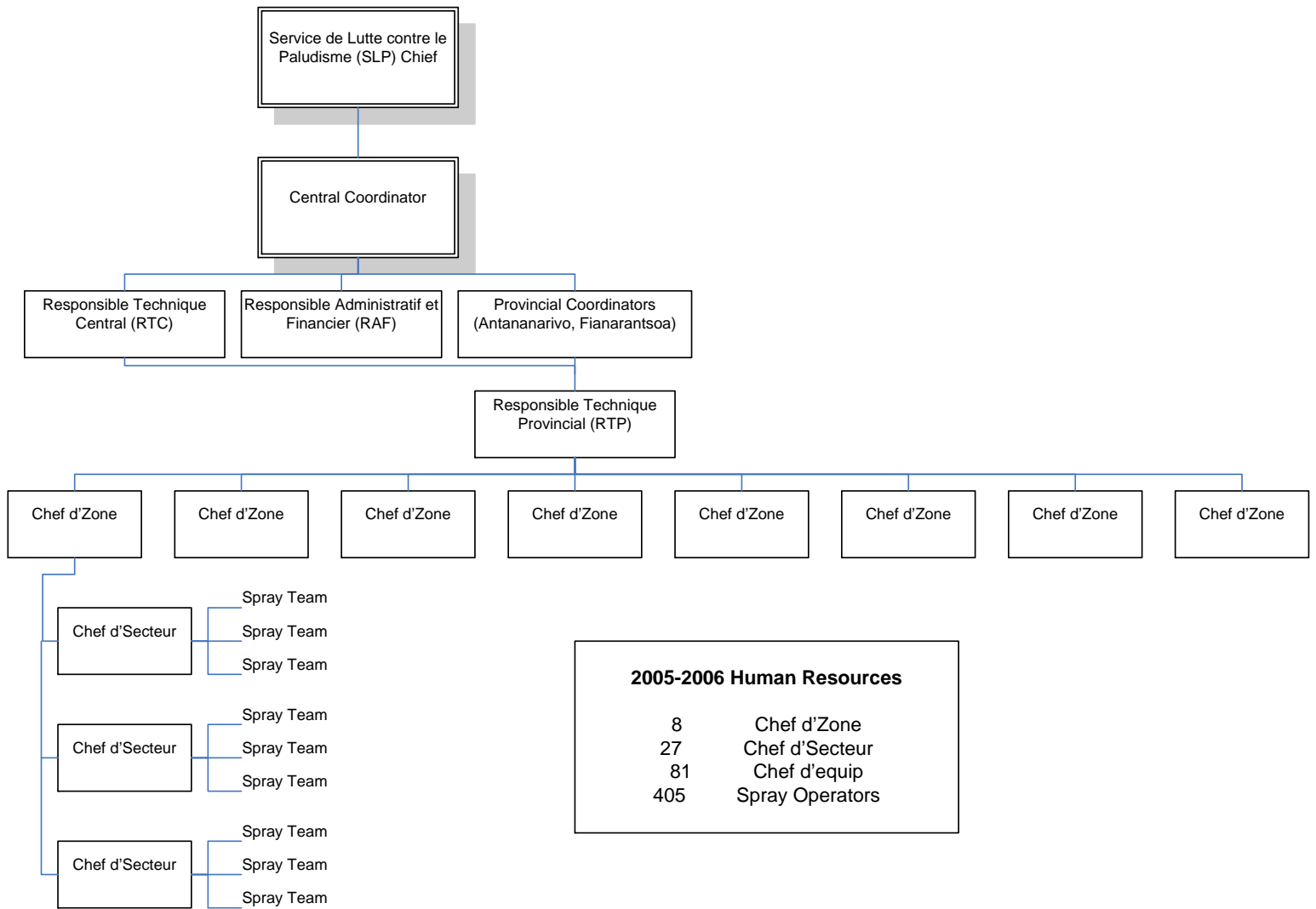
Pre-operational phase*	Operational Phase	Post-operational phase
<ul style="list-style-type: none"> <li>• Geographical reconnaissance</li> </ul>	<ul style="list-style-type: none"> <li>• Hiring of spray operators and team leaders</li> </ul>	<ul style="list-style-type: none"> <li>• Collecting remaining insecticide</li> </ul>
<ul style="list-style-type: none"> <li>• Assessment of needs/sensitization of administrative authorities and traditional leaders</li> </ul>	<ul style="list-style-type: none"> <li>• Training of spray operators and team leaders</li> </ul>	<ul style="list-style-type: none"> <li>• Packaging treatment</li> </ul>
<ul style="list-style-type: none"> <li>• Identification of storage</li> </ul>	<ul style="list-style-type: none"> <li>• Coordination and supervision</li> </ul>	<ul style="list-style-type: none"> <li>• Inventory and storing of equipment</li> </ul>
<ul style="list-style-type: none"> <li>• Mobilization of field agents (Chef d’ Zone, Chef d’ Secteur...)</li> </ul>	<ul style="list-style-type: none"> <li>• Performance evaluation</li> </ul>	<ul style="list-style-type: none"> <li>• Final performance evaluation</li> </ul>
<ul style="list-style-type: none"> <li>• Timeline</li> </ul>		<ul style="list-style-type: none"> <li>• Report</li> </ul>
<ul style="list-style-type: none"> <li>• Distribution of insecticides</li> </ul>		
<ul style="list-style-type: none"> <li>• Preparing agents training</li> </ul>		

\* Note that, to receive USAID support for this operation, health workers in targeted Zones and Secteurs must be trained in the treatment of pesticide poisoning, and that pesticide poisoning medications must be procured and distributed during the pre-operational phase.



Through solid planning and evaluation, the Ministry of Health has ensured that spraying is completed in specific areas of need, at the appropriate time, and with very high household coverage (refusal rates for DDT were 6.4%). In this way, the Ministry has very effectively reduced *both* the malaria case load *and* insecticide use. The Ministry of Health used DDT in IRS from 1993 to 2003 (with no IRS implementation in the period of 2000-2002) and alpha-cypermethrin exclusively since 2003 (Rakotoson 2006).

**Figure 4. Current IRS Program Structure in Madagascar**



Ministry of Health staff at the central and provincial levels was trained in the implementation of IRS in 1987 by WHO; Avima has also provided more recent training. Ministry of Health staff then train Chef d' Zones and Chef d' Secteurs, who in turn train spray operators and Chef d' equip (team leaders) each year. The Chef d'equip are trained

for 5 days, and spray operators are trained for 3 days. There are no women on the spray teams.

During training, spray operators are instructed to take a shower after each day's spraying. Washing in lakes, pools, and rivers is forbidden. Spray operators are also instructed to wash their overalls one to three times per week (depending on their dirtiness), far from houses and water sources. Currently, spray operators wash their personal protective equipment in their own buckets.

Spray operators are also trained to use water from rivers and creeks to fill the spray tanks, but to keep away from rivers and creeks during the cleaning of sprayers. They are told to dispose of sprayer rinse-water in on the ground far from water sources or in a hole dug especially for that purpose.

The spray equipment used for the IRS program is Hudson X-Pert<sup>®</sup> sprayers, which are manufactured following WHO specifications for compression sprayers for IRS operations. Each spray operator is provided with the safety equipment, which is currently not in accordance with WHO specifications; close-toed shoes or boots are not purchased for or worn by spray operators, as they prefer to wear sandals. The safety equipment purchased by the Ministry of Health for spray operators includes:

- Overalls (one pair)
- Hat
- Gloves
- Goggles
- Dust mask
- Piece of soap with which to wash overalls

At the end of each IRS Campaign, the spray operators are allowed to keep the overalls and the hats, while the gloves are burned. New personal protective equipment is purchased for each spray campaign (with the exception of goggles), as spray operators disdain wearing equipment used by a different spray operator in the previous year.

The spray operator's workday lasts from 6:00 to 15:00 or 16:00 hours. Spray operators are forbidden from eating until the end of the workday. During the duration of the campaign, spray operators must travel far from their homes (maximum 72 km), and stay as guests in the homes of community members. While working in these communities, the spray operators are guided by community agents who advise them on how to travel to each house in the community. These community agents also introduce spray operators to the families whose homes are being sprayed.

Using a spray card, spray operators document the location, number of rooms and households sprayed, and number of charges (amount of insecticide) used during the day (see **Annex 6**). The Chef d'équip collects spray cards from the spray operators and turns them in to the Chef d'Secteur.

In addition to filling out a spray card, the spray operator marks the door of each house with chalk to confirm that the house has been sprayed. So that supervisors can identify who conducted the spraying for each particular house, the mark reveals the Zone, Secteur, Team, and Spray Operator, using the system described in Table 9.

**Table 6. House Marking System for IRS Campaigns**

IRS Management Unit	Zone	Secteur	Spray Team	Spray Operator
<b>Code</b>	Capital Letter	Roman Numeral	Number	Number
<b>Example</b>	A	1	1	1

On the house, the chalk mark would read “A111.”

Occasionally, spray operators encounter homes where a resident is ill and bed-ridden. When DDT was used, the spray operator would request that the sick person be taken out of the house. If family members could not move the sick person out of the residence, the spray operator would spray the entire house except for the sick person’s room. When alpha-cypermethrin is used, however, the spray operator will spray the entire house even if the sick person has not been evacuated. According to the MOH, this is accepted by the communities because they believe that alpha-cypermethrin is a stronger chemical that will help control pests. The practice of spraying rooms with individuals still inside must be stopped immediately.

In addition to residences, any additional roofed structures are sprayed during the campaign. These include:

- Outside kitchens
- Latrines
- Animal shelters/pens
- Schools
- Shops

Any structure without a roof is not sprayed.

Spray operators are recruited based on the following criteria:

- Literacy
- Seriousness
- Health
- Industriousness
- Ability to communicate with the community

Spray operators are evaluated on these criteria by supervisors by the Chef d’Secteur and the Chef d’ Zone through use of an IRS Campaign Oversight Checklist, called a “Grille

de Supervision.” The Grille de Supervision is used to identify and address widespread problems during the current campaign, as well as to help plan for the next year’s IRS Campaign (**Annex 5**). The most common problems seen during spraying include forgetting to spray a part of the house and improper spray technique due to a lack of practice at the beginning of the campaign. The spray operators can be dismissed at any time, since spray operator contracts are signed on a daily basis. The IRS National Coordinators is in charge of these dismissals, basing them on Chef de Secteur and Zone reports.

Central level MOH staff feel that supervision of the spray teams is adequate. The Regional Coordinator and Provincial Coordinator are in the field during the campaign to supervise. Although the Chiefs of the Health Districts are supposed to assist the program as additional supervisors, these individuals are usually preoccupied with other responsibilities that accompany their positions.

The duration of the campaign lasts approximately 1 to 1.5 months. Communities are involved in transporting all the equipment and insecticide. Some community members request pesticide from spray operators for their crops; program managers believe this is the source of any pilferage that occurs. In one zone during the 2004-2005 IRS Campaign, spray operators were caught selling insecticides (MOH Evaluation 2005).

***E. Any Acute and Long-Term Toxicological Hazards, Either Human or Environmental, Associated with the Proposed Use and Measures Available to Minimize Such Hazards***

Possible acute and long-term toxicological hazards have been discussed previously in this PERSUAP under *Unavoidable Adverse Effects*. For acute and long-term toxicological hazards, see the PEA for IVM Toxicological Profiles for alpha-cypermethrin in **Annex 2** of this PERSUAP.

Residential Exposure. The proposed pesticide use, the measures currently used to mitigate occupational hazards associated with IRS, and the recommendations for further mitigation of occupational risk are mentioned in the preceding section. Although occupational exposure to the insecticide is a concern, the risk of residential exposure is also present and needs to be addressed. Typically, residential exposure is addressed by carrying out IEC) campaigns to inform communities about their roles and responsibilities during the spray campaign.

IEC campaigns for IRS in Madagascar begin 20 days prior to the start of spraying and continue during the campaign. Local authorities are sent a notice about the campaign, and are asked to organize community meetings on IRS. The MOH also uses local radio to announce the spray campaign. Through the IEC campaigns, communities are told that the spray campaign will be commencing to target and kill mosquitoes, that they must take foodstuffs and water out of their houses, that they should accept spray operators into their homes both for spraying and as houseguests during the campaign, and that they should

not touch or paint their walls after the spraying has been completed. Community members are provided information similar to that given spray operators during training.

In addition to the contents of the current IEC campaigns, MOH's IEC messages should also instruct IRS target community residents to do the following:

- If furniture cannot be moved out of the home, then it should be moved to the center of the room, if possible
- Stay outside the home during spraying and for one hour after spraying, and move sick or pregnant residents outside the home during this time.
- Move and keep all animals outside the home during spraying and for one hour after spraying
- Sweep floors free of any residual insecticide that may remain from the spraying, while keeping children and animals outside
- Keep using bednets for protection against malaria.

Pesticide Poisoning. The MOH must assure that spray operators are trained to identify the signs and symptoms of poisoning and to use emergency first aid techniques. Because the treatment for poisoning is specific to each pesticide, country-specific treatment and referral guidelines must be developed based on the specific insecticides being used and the local capacity for poisoning treatment. To assure that appropriate treatment is available in the event of poisoning, the program must assure that country-specific exposure treatment guidelines are developed. Country-specific guidelines should include:

- General principles in the management of acute pesticide poisoning
- First-aid procedures and training strategy for spray operators
- Identification of appropriate treatment facilities and assurance that treatment drugs are available, provide training to local medical staff to assure that the capability to provide appropriate treatment is established, procure appropriate treatment drugs if not available, and prepare treatment guidelines for the specific country setting and pesticides being used
- Determination of referral process (transportation of exposure victim, communication with facilities)

In addition, the program should assure financial support for any medical costs incurred in managing or treating the toxic effects of exposure to insecticides used in the program.

The Ministry of Health will be responsible for an evaluation of the capacity of local facilities to treat poisoning by the pesticides being used, including identification of a referral hospital if treatment for exposure cannot be adequately provided for by local health clinics. Health workers in Madagascar's district health facilities have already been instructed in treatment for pesticide poisoning.

If needed, guidelines for treatment of poisoning from alpha-cypermethrin exposure are located in **Annex 3** of this PERSUAP . These guidelines are adapted from EPA's

*Recognition and Management of Pesticide Poisonings* and WHO's report, *Malaria Vector Control: Insecticides for Indoor Residual Spraying*.

Safe Pesticide Transport. In Madagascar, drivers are informed on the danger of transporting insecticide, but there are no guidelines for their training. During the 2004-2005 IRS Campaign, two vehicles had accidents, but no spills were reported. There are no vehicles designated specifically for insecticide; whatever vehicle is available is used.

Prior to long-distance transport of the insecticide from the customs warehouse/central storage facility to a district, drivers should be informed about general issues surrounding the insecticide and how to handle emergency situations (e.g., road accidents). Training for long-distance transport must include the following information:

- For what use the insecticide is intended
- Toxicity of the insecticide
- Understanding security issues and implications of insecticide use outside public health
- Handling an accident or emergency (according to the FAO Pesticide Storage and Stock Control Manual)
- Combustibility and combustion byproducts of insecticide.

Drivers hired specifically for the two-month spray campaign period must receive the following:

- Training provided to spray operators (with the exception of sprayer operation and spray practice)
- Training on handling an accident or emergency (according to the FAO Pesticide Storage and Stock Control Manual)
- Training on handling vehicle contamination (see paragraph below).

Because vehicles are not dedicated exclusively to the IRS program, it is important to ensure that pesticide contamination in the vehicle does not have negative impacts when the vehicle is subsequently used for another purpose (e.g., food transport). Drivers will be responsible for taking care that any cloth vehicle seats are covered to prevent contamination from transportation of spray operators. To prevent pesticide runoff from vehicle washing, drivers will also be responsible for wiping the vehicle bed with a damp cloth prior to washing the exterior of the vehicle. Finally, drivers will be responsible for cleaning and decontaminating the interior of the vehicle and exterior bed at the end of the spray campaign. Drivers will be provided with gloves to wear for cleaning the vehicle.

#### **F. The Effectiveness of the Requested Pesticide for the Proposed Use**

Susceptibility studies conducted by the Institut Pasteur de Madagascar in 2003 indicate that *Anopheles funestus* is susceptible to pyrethroids and DDT. Although these susceptibility studies did not include alpha-cypermethrin, other pyrethroids were included—deltamethrin, lambda-cyhalothrin and cyfluthrin. *An. funestus* was

susceptible to all three pyrethroids, indicating that the vector is also susceptible to alpha-cypermethrin (Ratovonjato et al. 2003).

### **G. Compatibility of the Proposed Pesticide with Target and Nontarget Ecosystems**

Alpha-cypermethrin should be compatible with its intended use in communes of the central highlands of Madagascar, with the exceptions noted in *Environmental Consequences—Unavoidable Adverse Effects*. The following paragraphs indicate the compatibility of the proposed pesticide with nontarget ecosystems.

Alpha-cypermethrin is toxic to bees, and fish and other aquatic organisms. Thus the primary concern in alpha-cyhalothrin use for IRS would be the following scenarios:

- **Release of sprayer rinse-water into water bodies.** Spray operators are instructed to either to dig a hole for sprayer rinse-water or pour the sprayer rinse-water on the ground, far from water sources; however, there are no assurances that the spray operators abide by this rule.
- **Release of overall/PPE wash-water into water bodies.** Spray operators are instructed to wash their overalls once to three times per week in a place far from the household in which they are staying and far from water bodies. The operators are told specifically to dig a hole, dump the wash water in the hole, and cover it up; however, there are no assurances that the spray operators carry out this process.
- **Spray operators washing themselves in water bodies.** Spray operators are forbidden from washing themselves in lakes, pools or rivers; however, there are no assurances that the spray operators abide by this rule.
- **Accidental spraying of apiaries (beehives).** Accidental spraying of apiaries would kill bees residing therein.

According to United States Code of Federal Regulations Title 22 Section 216, “to the extent feasible and relevant, projects and programs for which Environmental Impact Statements or Environmental Assessments have been prepared should be designed to include measurement of any changes in environmental quality, positive or negative, during their implementation.” Monitoring of changes in environmental quality as a result of this IRS activity is not relevant for the following reasons:

- Alpha-cypermethrin does not bioaccumulate or persist in the environment.
- Alpha-cypermethrin will not be sprayed on agricultural fields or in the environment, and substantial releases of the pesticide into the environment as a result of project activities are improbable.
- Impacts of alpha-cypermethrin on non-target organisms are acute and transitory.
- No area within the targeted Zones has been defined as a national park or conservation area.

**H. The Conditions Under Which the Pesticide is to be Used, Including Climate, Flora, Fauna, Geography, Hydrology, and Soils**

Table 10 describes the temperature and precipitation patterns in central Madagascar throughout the year.

**Table 7. Average Monthly Temperature and Precipitation in Antananarivo, Madagascar**

	Years on Record	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Temperature °C	18	18 (avg)	21	21	21	20	18	16	15	16	17	19	20	21
Average Precipitation mm	110	1369 (total)	287	261	193	58	17	7	7	10	15	60	152	289

Source: WashingtonPost.com Historical Weather Data for Antananarivo, accessed July 7, 2006.

A list of the endangered species present in Madagascar can be found in **Annex 4** of this PERSUAP .

No spraying will be conducted inside the boundaries of protected areas or sensitive ecosystems, and no outdoor spraying will be conducted. Additionally, efforts made to mitigate these potential environmental impacts, including the following:

- Securing storage areas to prevent pilferage
- Supervision of spray teams to ensure proper insecticide handling and prevent pilferage
- Counting used insecticide sachets to account for proper use of the insecticide
- Reporting on compliance

**I. The Availability and Effectiveness of Other Pesticides or Non-Chemical Control Methods**

Other Pesticides. Other WHO-approved adulticides that could be used for indoor residual house spraying include:

- bendiocarb
- bifenthrin
- cyfluthrin
- DDT
- deltamethrin
- etofenprox
- fenitrothion
- lambda-cyhalothrin



- malathion
- pirimiphos-methyl
- propoxur.

Non-Chemical Control Methods. WHO and GEF are funding a 5-year 3-district larvicide pilot program in Madagascar, with the goal of reducing use of DDT. The Ministry of Health has not pursued Environmental Management as a malaria vector control strategy because breeding occurs primarily in rice fields, making elimination of breeding sites difficult.

***J. The Requesting Country's Ability to Regulate or Control the Distribution, Storage, Use, and Disposal of the Requested Pesticide***

Distribution. The insecticides are transported by truck to target districts.

Storage.

In several ways, the central pesticide warehouse currently does not comply with Malagasy pesticide regulations. The Ministry of Health should endeavor to renovate its central pesticide warehouse to comply with the following standards set forth in Malagasy pesticide regulations (*Arrêté n° 7452-92 règlementant le stockage et le reconditionnement des produits agropharmaceutiques*):

- A 'warehouse' is defined as a vast premises where agro-pharmaceutical products are stored in relatively large quantities by importers, producers, packagers or suppliers.
- Warehouses should be located at a certain distance from residential areas or villages, factories dealing with human or animal produce, and also from water sources or water pipes. It must be built in an area that is free from flooding and that is easily accessible by car. The ground of the warehouse must be built with waterproof and solid material, preferably made of concrete. The walls must be built with waterproof material with a minimum of 60 cm from ground level.
- The warehouse must have an inclined or sloping pipe in concrete that is at least 15 cm under the level of the floorboards, and that is the circumference of the warehouse, to permit the evacuation of any eventual leaks.
- End users can purchase pesticides directly from shops. The premises where the agro-pharmaceutical products are sold or housed must be equipped with fire extinguishers. Moreover, the premises must be dry and ventilated properly.
- These products must be stored separately and far from other merchandise, particularly produce; to prevent any contamination or confusion.
- It is forbidden to store the products in a kitchen or in a room reserved for guests.
- The products must be stored on shelves or on ranges for those that have to be piled up on the ground.
- The height on a range should not exceed 1.50 meters.

- Distances between shelves or ranges should be at least 1 meter.
- All shops or warehouses must have a bucket full of lime or sawdust, empty jars and shovels, as well as water for cleaning in case of accidental loss.
- A warning sign that states ‘Danger- Smoking forbidden, Drinking or Eating’ must be placed where it can be seen clearly. A drawing of min. 20cm high representing a dead head should be included on the sign. The letters must be written in dark red on a white background.
- The managers of shops and warehouse must keep an account of all agro-pharm. products received, stored, bought or destroyed.
- For products subject to restrictions, it is important to write explicitly the date of purchase, the name and address, phone number and quality.
- The first aid kit should have instructions that include the name, address and contact information in case of an emergency and should be placed in a visible location in the warehouse.
- The shop or warehouse should be well secured and have security equipment and a first aid kit.
- Products must be kept in their original package and stored separately by category (insecticide, herbicide, fungicide etc.). Repackaging for sale is strictly forbidden.
- The products can not be stored in bottles and other containers for food or drink.
- The product should not be sold if the container is damaged or if the original label is illegible.

To comply with these regulations, the MOH needs to do the following with regards to its current pesticide storage facility:

- Relocate the warehouse to a location that is not within the MOH building if possible; if this is not possible, repair the ceiling to prevent all water flow, install vents to the outside of the building, and (if possible) renovate the space to include a sump to contain leaks.
- Never store any medical products in the same store as the insecticides.
- Ensure that a bucket full of lime or sawdust, empty jars and shovels, as well as water for cleaning is available in the warehouse.
- Ensure that a fire extinguisher is available in the warehouse.
- Put up a warning sign as indicated in Madagascar regulations.
- Ensure that a first aid kit with emergency information is located in a visible location in the warehouse.

At the community level, the Chef d’équip is in charge of pesticide storage, and keeps storehouse records to manage the inflow and outflow of insecticide. Storehouse records are kept to manage the in and out rate of insecticide. This is done at the community, regional and central levels as a tool of management. There are guards at every storage

facility. To date, there have been no storehouse fires to date. Neither drivers nor Chef d'équip are instructed in how to deal with accidents/spills. The following instructions should be provided to all drivers and Chef d'équip in the event of a spill:

*In the event of a leak or spill of wettable powder, the Chef d'équip should put on nitrile rubber protective gloves and a face mask. He should then dampen an adequate amount of absorbent sawdust, sand, or dry soil and apply it with a shovel over the area of the spill. The damp sawdust, sand, or soil containing spillage material should be swept or shoveled up carefully and placed in a marked container for disposal. After sweeping, which should be conducted more than once if necessary, a scrubbing brush at the end of a stick should be used to scrub down the area of the spill with water and strong soap or detergent.*

FAO 1996

In areas where IRS is being conducted, the local fire brigade should be informed as to the location of insecticide stores and the hazards involved.

Disposal. In past IRS Campaigns, insecticide sachets and packaging, gloves and dust masks have been burned far from communities, water bodies, and rice fields. USAID requests that non-contaminated insecticide packaging (e.g., boxes, paper) be disposed of locally—WHO recommends that this packaging be returned to a supervisor for “safe” disposal, and FAO recommends disposal at a landfill or “recycling” the packaging as fuel for a cement kiln or power plant (WHO 2002; Thompson 2004). FAO’s *Draft Guidance Document on the Selection of Waste Management Options for the Disposal of Obsolete Pesticides and Contaminated Materials* says that, “The materials, from which the containers and packaging are constructed, is generally environmentally harmless in itself and is suitable for recycling or disposal within the country. The degree of residual pesticide contamination within the materials is the only issue that may prevent this from occurring” (Thompson 2004:60). Any packaging or personal protective equipment that has been heavily contaminated should be triple-rinsed, shredded or punctured, and taken to a hazardous waste facility.

Spray operators are instructed to take their sprayer, overalls and other PPE to their household (or the community in which they are staying as a guest) and to wash themselves far from lakes, pools or rivers. They are also instructed to use available water for rinsing their sprayers, but to dig a hole for sprayer rinse-water or dump the rinse-water on the ground far from water sources. Finally, they are instructed to wash their overalls in a washtub using the soap provided with their PPE kit, and to dig a hole and dump the wash-water in the hole. Despite this instruction, there are no assurances that the spray operators carry out these activities as instructed.

#### **K. The Provisions Made for Training of Users and Applicators**

Provisions made for training of users and applicators are described under *Pesticide Procedures D. The Proposed Method or Methods of Application*. Training should be

observed to ensure that it is conducted according to WHO's *Manual for Indoor Residual Spraying: Application of Residual Sprays for Vector Control* (WHO, 2002).

#### **L. The Provisions Made for Monitoring the Use and Effectiveness of the Pesticide**

MOH monitoring during the IRS Campaign involves:

- Ensuring coverage targets are achieved by deadline for spray completion
- Assuring hiring and retention of an adequate workforce conduct spraying
- Ensuring the volume of insecticide is adequate to achieve desired coverage
- Progress reports (submitted by teams to Chef d'Secteur)
- Spot-checks for mitigation monitoring purposes

Spot-checks for mitigation monitoring purposes will be conducted using the IRS Campaign Oversight Checklist shown in **Annex 5** of this PERSUAP. This will allow for easy analysis of data on mitigation practices, which will then be used to address any divergence (e.g., individual and program-wide) from best practices. It is recommended that, in the near future, this checklist be revisited and revised based on the operational recommendations found in this Environmental Assessment.

USAID/Madagascar will supervise and report on safety and environmental procedures during the spray campaign, ensuring that best professional practices are implemented.

## **Preparation Methodology**

The contents of this PERSUAP are based on direct communication with USAID/Madagascar, the Madagascar MOH, World Bank CRESAN II, the Institut Pasteur de Madagascar, the non-governmental organization Voarisoa, IRS Campaign district, secteur, and zone staff. Individuals from these institutions graciously provided information on pesticide and vector control practices currently being conducted in Madagascar to a team consisting of:

Ms. Melanie Biscoe	Environmental Scientist, RTI International
Dr. Noe Rakotondrajaona	Public Health Specialist, USAID/Madagascar
Raharimalala Vololontsoa	Program Assistant, USAID/Madagascar

Research for this PERSUAP was conducted over a 4-day period from April 18 to April 21, 2006. Additionally, government documents and journal articles concerning pesticide use, the environment, and malaria control were reviewed and incorporated into this PERSUAP.

## Bibliography

Brutus, L. ; le Goff, G. ; Rasoloniaina, L. ; Rajaonarivelo, V. ; Raveloson, A. ; and Cot, M. 2001. Lutte contre de paludisme dans le moyen-ouest de Madagascar : comparaison de l'efficacité de la lambda-cyhalothrine et du DDT en aspersions intra-domiciliaires. I – Étude entomologique. *Parasite*. 8 ; 297-308

Cot, M. ; Brutus, L. ; le Goff, G. ; Rajaonarivelo, V. ; and Raveloson, A. 2001. Lutte contre de paludisme dans le moyen-ouest de Madagascar : comparaison de l'efficacité de la lambda-cyhalothrine et du DDT en aspersions intra-domiciliaires. II – Étude parasitologique et clinique. *Parasite*. 8; 309-316.

Curtis, C. 2002. Restoration of Malaria Control in the Madagascar Highlands by DDT Spraying. *American Journal of Tropical Medicine and Hygiene*. 66:1; 1

Food and Agriculture Organization of the United Nations (FAO). 2004. Draft Guidance Document: *The Selection of Waste Management Options for the Disposal of Obsolete Pesticides and Contaminated Materials*.

Food and Agriculture Organization of the United Nations (FAO). 1999. *Pesticide Storage and Stock Control Manual*.

Guillet, P. and Govere, J. 2006. La résistance des vecteurs du paludisme aux insecticides: propositions pour la mise en place d'un suivi et d'une politique de gestion à Madagascar: Rapport de mission (7-19/11/2005). Vector Biology and Control, WHO Regional Office for Africa.

International Programme on Chemical Safety (IPCS). 1990. *Health and Safety Guide No. 38: Cyhalothrin and Lambda-cyhalothrin Health and Safety Guide*. (UNEP/ILO/WHO).

IUCN 2006. 2006 IUCN Red List of Threatened Species. <[www.iucnredlist.org](http://www.iucnredlist.org)>. Downloaded on 28 August 2006.

Government of Madagascar. 1992. *Arrêté n° 7452-92 règlementant le stockage et le reconditionnement des produits agropharmaceutiques*.

Madagascar Ministry of Health and Family Planning, Directorate of Emergencies and Communicable Disease Control, Malaria Control Department. 2005. *2005-2009 Strategic Plan*.

Madagascar Ministry of Health and Family Planning, Directorate of Emergencies and Communicable Disease Control, Malaria Control Department. 2005. *Evaluation of the 2004-2005 IRS Campaign*.

Najera, J. and M. Zaim. 2002. *Malaria Vector Control: Decision Making Criteria and Procedures for Judicious Use of Insecticides*. World Health Organization Pesticide Evaluation Scheme (WHOPES).

Rakotoson, J. 2006. Indoor Residual Spray Campaign (IRS) in the central highlands (CHL) of Madagascar. Power point presentation given on April 18, 2006.

Ratovonjato, J.; Le Goff, G.; Rajaonarivelo, E. ; Rakotondraibe, E. ; and Robert, V. 2003. [Recent observations on the sensitivity to pyrethroids and DDT of *Anopheles arabiensis* and *Anopheles funestus* in the central Highlands of Madagascar; preliminary results on the absence of the kdr mutation in *An. arabiensis*] Article in French. *Arch. Institut Pasteur de Madagascar*. 69:1-2; 63-69

Thompson, R. 2004. *Draft Guidance Document: The Selection of Waste Management Options for the Disposal of Obsolete Pesticides and Contaminated Materials*. Food and Agriculture Organization of the United Nations.

United Kingdom National Poisons Information Service. *UK PID Monograph: Alpha-cypermethrin*. Accessed on International Programme on Chemical Safety (IPCS) INTOX Database July 7, 2006.

World Health Organization (WHO). 2002. *Manual for Indoor Residual Spraying: Application of Residual Sprays for Vector Control* (WHO/CDS/WHOPES/GCDPP/2000.3).

# Annex 1: Required Mitigation Activities for IRS Program

Pre-Campaign	During Campaign	Post-Campaign
<p><b>Prohibit spraying of rooms</b> where sick or pregnant persons lie and cannot be moved out of the house during spraying and for one hour post-spraying.</p>	<p><b>Prohibit spraying of rooms</b> where sick or pregnant persons lie and cannot be moved out of the house during spraying and for one hour post-spraying.</p>	<p>USAID requests that <b>non-contaminated insecticide packaging (e.g., boxes, paper) be disposed of locally</b>—WHO recommends that this packaging be returned to a supervisor for “safe” disposal, and FAO recommends disposal at a landfill or “recycling” the packaging as fuel for a cement kiln or power plant (WHO 2002; Thompson 2004). <b>Any packaging or personal protective equipment that has been heavily contaminated should be triple-rinsed, shredded or punctured, and taken to a hazardous waste facility.</b></p>
<p><b>Train storekeepers and drivers</b> in accordance with the guidance provided in this PERSUAP and FAO’s Pesticide Storage and Stock Control Manual.</p>	<p><b>Reduce environmental contamination</b> through strict auditing of insecticide sachets, supervision of pesticide use, and thorough instruction on daily spray operator hygiene, rinsing and maintenance of sprayers, and washing of Personal Protective Equipment (PPE) in accordance with WHO guidelines.</p>	<p><b>Provide post- IRS Campaign evaluation</b> to USAID/Madagascar, including records on insecticide used and results from spot-checking.</p>
<p><b>As needed, train health workers</b> in insecticide poisoning treatment, and <b>ensure treatment medicines</b> for insecticide exposure are available in districts targeted for IRS.</p>	<p><b>Reduce household exposure</b> by covering furniture that cannot be moved with cloths prior to spraying.</p>	
<p><b>Train spray operators, team leaders, and supervisors according to best practices</b>, as outlined by the WHO and this PERSUAP, particularly integrating training on recognition of pesticide poisoning symptoms, advised actions when symptoms occur, and referral options.</p>	<p><b>Restrict IRS activities to the Central Highlands, and prohibit IRS in sensitive areas</b>, including protected areas and sensitive ecosystems. Spray with care in areas where beekeeping occurs.</p>	
<p><b>Procure close-toed shoes or boots</b> for spray operators as part of their Personal Protective Equipment (PPE) in accordance with WHO guidelines;</p>		

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discourage wearing of sandals.

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**Educate target communities** through an Information, Education, and Communication (IEC) campaign, citing importance of removing all food, water and utensils from house prior to spraying, moving furniture to the center of the room or outside, staying out of the house during and 1 hour after spraying, not allowing children or animals in the house until floor residue is swept outside.

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**Inform fire brigades** of the location and contents of storage facilities.

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**Revise IRS Oversight Checklist (Grille de Supervision)** to address only the use of Fendona (as opposed to DDT).

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**It is recommended (not required) that a new MOH pesticide storage facility be constructed** according to the Food and Agriculture Organization of the United Nations's (FAO's) Pesticide Storage and Stock Control Manual, to decrease risk of spillage, protect pesticide products from rainfall, and decrease risk of exposure to employees working in MOH headquarters.

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**The MOH must provide official notice to the National Environment Office** of the planned IRS activities including information on the area where IRS will take place, pesticide use practices, the education of workers and beneficiaries, and the USAID PERSUAP requirements.

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If necessary, **request temporary registration for Fendona** from the Ministry of Agriculture. In the past, alpha-cypermethrin has been temporarily registered for use in IRS activities. If this temporary registration has expired, the MOH must request an additional temporary registration of alpha-cypermethrin from the Ministry of

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Agriculture.

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**USAID will discuss importance of an environmental assessment** for any pesticides used in IRS will be discussed with MOH and Department of Environment staff-- online resource for conducting assessments will be provided (<http://www.encapafrika.org/>)

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**The MOH and USAID will develop a Memorandum of Understanding (MOU)** to establish MOH responsibilities for compliance with the PERSUAP. The MOU will also establish USAID, Research Triangle Institute (RTI) International, Ministry of Agriculture and Department of Environment responsibilities for monitoring MOH compliance with the PERSUAP, as appropriate. According to USAID's Automated Directives System (ADS) 204.5.4, the USAID Mission Strategic Objective (SO) team is required to actively monitor ongoing activities for compliance with the requirements and recommendations in this assessment.

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## Annex 2: Toxicological Profile for Alpha-Cypermethrin, IVM PEA

CAS Registry Number 67375-30-8

### *Summary of Insecticide*

#### *Chemical History*

Alpha-cypermethrin is a highly active synthetic pyrethroid insecticide used to control a wide variety of pests in agricultural and public health applications. It is similar to the natural insecticide pyrethrum, which comes from chrysanthemums; however, it is more effective and longer lasting (ATSDR, 2003; IPCS, 1992). Alpha-cypermethrin is available in technical grade formulation, emulsifiable concentrate, ultra-low-volume formulation, suspension concentrate, and in mixtures with other insecticides (HSDB, 2005; IPCS, 1992). For mosquito control, it is used in bed nets and other materials that are dipped in alpha-cypermethrin to protect the user (WHO, 1997, 1998). It is considered one of the best insecticides for impregnation of traps and screens (WHO, 1997). Alpha-cypermethrin is not currently registered for use in the United States (HSDB, 2005), but cypermethrin is.

Alpha-cypermethrin is of low risk to humans when used at levels recommended for its designed purpose (HSDB, 2005; ATSDR, 2003). However, as a synthetic pyrethroid, alpha-cypermethrin exhibits its toxic effects by interfering with the way the nerves and brain normally function (HSDB, 2005; ATSDR, 2003). It has moderate acute toxicity and is a suspected endocrine disruptor but does not inhibit cholinesterase (PAN, 2005). Typical symptoms of acute exposure are irritation of skin and eyes, headaches, dizziness, nausea, vomiting, diarrhea, and excessive salivation and fatigue. Inhaled alpha-cypermethrin has been shown to cause cutaneous paraesthesias or a burning, tingling, or stinging. However, these effects are generally reversible and disappear within a day of removal from exposure (HSDB, 2005; ATSDR, 2003; PAN, 2005). Alpha-cypermethrin is harmful if swallowed (MSDS, n.d.). Inhalation and dermal exposure are the most likely human exposure routes (HSDB, 2005). Environmental levels of significance are unlikely if alpha-cypermethrin is applied at recommended rates (IPCS, 1992).

#### *Description of Data Quality and Quantity*

Comprehensive reviews on the toxicity of alpha-cypermethrin are not widely available but include the following:

- Toxicological Profile for Pyrethrin and Pyrethroids (ATSDR, 2003)
- Environmental Health Criteria 142: Alpha- Cypermethrin (IPCS, 1992)

EPA and ATSDR have developed quantitative oral human health benchmarks (EPA's chronic RfD and ATSDR's acute oral MRL) for cypermethrin. Alpha-cypermethrin makes up one quarter of the racemic mixture cypermethrin and has a similar mode of action. Alpha-cypermethrin is also similar to cypermethrin with regard to the signs of intoxication, target organs effects, and metabolic pathways (IPCS, 1992).

### Summary Table

Duration	Route	Benchmark Value	Units	Endpoint	Reference
Acute, Intermediate, Chronic	Inhalation	4	mg/kg/day	Inhalation NOAEL in rats with UF of 100 applied	
Acute	Oral	0.02	mg/kg/day	Acute oral MRL for cypermethrin based on neurological effects in rats with UF of 1000 applied	ATSDR (2003)
Intermediate	Oral	0.01	mg/kg/day	Adopt chronic RfD as intermediate duration	
Chronic	Oral	0.01	mg/kg/day	Chronic oral RfD for cypermethrin based on neurological effects in dogs with UF of 100 applied	U.S. EPA (2005)
Acute, Intermediate, Chronic	Dermal	5	mg/kg/day	Dermal NOAEL in rats with UF of 100 applied	

For inhalation exposure, a NOAEL of 400 mg/m<sup>3</sup> (447 mg/kg/day)<sup>1</sup> was identified for neurological and respiratory effects in rats exposed to alpha-cypermethrin via inhalation for 4 hours (IPCS, 1992). An uncertainty factor of 100 to account for intra- and interspecies variation was applied, for an inhalation benchmark of 4 mg/kg/day. This value is appropriate for all exposure durations.

Due to limited low-dose oral data for alpha-cypermethrin, health benchmarks for cypermethrin were used and are expected to be protective of human health. The acute oral MRL for cypermethrin of 0.02 mg/kg/day is based on a LOAEL of 20 mg/kg for neurological effects (altered gait and decreased motor activity) in rats with an uncertainty factor of 1,000 applied. Long-Evans rats were given single gavage doses of up to 120 mg/kg cypermethrin. Motor activity and FOB were assessed at 2 and 4 hours post-dosing. A NOAEL was not identified (ATSDR, 2003). The chronic oral RfD for cypermethrin of 0.01 mg/kg/day is based on a NOEL of 1 mg/kg/day for systemic effects with an uncertainty factor of 100 applied. Beagle dogs were dosed with up to 15 mg/kg/day cypermethrin in corn oil for 52 weeks. During the first week, increased vomiting was observed in dogs at all dose levels. Additionally, throughout the study all

<sup>1</sup> Conversion between mg/m<sup>3</sup> and mg/kg/day assumes, for Fischer-344 rats, an average body weight of 0.152 kg and inhalation rate of 0.17 m<sup>3</sup>/day (U.S. EPA, 1988).

dogs passed liquid feces; however, the incidence was 10- and 30-fold higher in the 5 and 15 mg/kg/day groups, respectively. The NOEL identified for this study was 1 mg/kg/day (U.S. EPA, 2005).

For dermal exposure, a NOAEL of 500 mg/kg/day was identified in rats dermally exposed to alpha-cypermethrin once for 24 hours (IPCS, 1992). An uncertainty factor of 100 to account for intra- and interspecies variation was applied, for a dermal benchmark value of 5 mg/kg/day. This value is appropriate for all exposure durations.

### *Insecticide Background*

CASRN: 67375-30-8

Synonyms: alfamethrin, alphamethrin, alphacypermethrin, alpha-cypermethrin, alfa-cipermetrina, alfacypermetrin, alfa cipremetrin, [1 alpha(S\*),3alpha]-(+ -)-Cyano(3-phenoxyphenyl)methyl 3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropanecarboxylate, (1R cis S) and (1S cis R) Enantiomeric isomer pair of alpha-cyano-3-phenoxybenzyl-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropane carboxylate, Pesticide Code 209600(S)-alpha-cyano-3-phenoxybenzyl-(1R)-cis-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate and (R)-alpha-cyano-3-phenoxybenzyl-(1S)-cis-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate, WL 85871, cyano(3-phenoxyphenyl)methyl 3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate (+)-cis isomer, alphametrin, numerous other systematic and non-systematic names (HSDB, 2005; PAN 2005; ATSDR, 2003; MSDS, n.d.)

Chemical Group: pyrethroid (PAN, 2005)

Registered Trade Names: Bestox, Fastac, Concord, Dominex, Fendona, Fendona 1.5 SC, Fendona 10 SC, Fendonal WP, Renegade (HSDB, 2005, IPCS, 1992, WHO, 2002), Tenopa SC (alphacypermethrin + flufenoxuron) (HSDB, 2005; PAN 2005; ATSDR, 2003; MSDS, n.d.)

### *Usage*

Alpha-cypermethrin is a pyrethroid insecticide used to combat a wide variety of chewing and sucking insects on field crops, fruits and vegetables, and in forestry uses. It may be applied to crops as either a curative or preventative treatment. Alpha-cypermethrin is also used in public health applications to control mosquitoes, flies, and other pests. For animal husbandry it is used as an ectoparasiticide and to control flies (HSDB, 2005; IPCS, 1992). Alpha-cypermethrin belongs to the pyrethroid class of insecticides, which have

long been used to control mosquitoes, human lice, beetles, and flies (ATSDR, 2003). For mosquito protection, it is used in bed nets and other materials that are dipped into the alpha-cypermethrin to protect the user. Alpha-cypermethrin has been available since 1983 (IPCS, 1992); however, it not currently registered for use in the United States (HSDB, 2005).

#### *Formulations and Concentrations*

Alpha-cypermethrin is available in technical grade, emulsifiable concentrates, wettable powder, suspension concentrates, ultra-low-volume liquids, tablets, and in mixtures with other insecticides (HSDB, 2005; IPCS, 1992). Technical grade alpha-cypermethrin is greater than 90 percent pure (HSDB, 2005). Common formulations of alpha-cypermethrin include Fastac, which is available as an emulsifiable concentrate (20–100 g/L), a wettable powder (50 g/kg), a suspension concentrate (15–250 g/L), and an ultra-low-volume liquid (6–15 g/L); and Fendona and Renegade, which are available as an emulsifiable concentrate (50 or 100 g/L), a suspension concentrate (250 g/L), and a wettable powder (50 g/kg). Alpha-cypermethrin is combined with other active ingredients to form other products (IPCS, 1992). WHO has indicated that the content of alpha-cypermethrin in the formulated products must be declared and shall not exceed the listed standards. Technical grade alpha-cypermethrin must have no less than 910 g/kg alphacypermethrin cis 2 ([IR cis] S and [IS cis] R isomers), and the combined content of the cis and trans isomers of alpha-cyano-3-phenoxybenzyl-2,2-dimethyl-3-(2,2-dichlorovinyl-) cyclopropanecarboxylate must be at least 975 g/kg. No more than 1 g/kg of volatile hydrocarbon solvent and 1 mg/kg of triethylamine is permitted. The aqueous suspension concentrate should contain alphacypermethrin cis 2 ([IR cis] S and [IS cis] R isomers) as follows: up to 25 g/kg,  $\pm$  15 percent of the declared content; 25 to 100 g/kg,  $\pm$  10 percent of the declared content. The alphacypermethrin cis 1:cis 2 isomer ratio must be lower than 5:95 (WHO, 1999).

#### *Shelf Life*

Alpha-cypermethrin is stable in acidic and neutral environments. However, it hydrolyses at pH 12–13 and decomposes at temperatures greater than 220 °C. For practical purposes, field studies have indicated that it is stable to sunlight (IPCS, 1992). It is not compatible with strong oxidizing agents (MSDS, n.d.).

#### *Degradation Products*

Based on its structure, alpha-cypermethrin is expected to readily biodegrade in the environment. However, in two tests it did not degrade and therefore cannot be considered readily biodegradable. One of the major transformation products in the microbial transformation of technical alpha-cypermethrin is 3-phenoxybenzoic acid, which is then transformed to 4-hydroxy-3-phenoxybenzoic acid (IPCS, 1992).

## *Environmental Behavior*

### **Fate and Transport in Terrestrial Systems**

Based on its Koc value, alpha-cypermethrin binds tightly to soil, making it almost immobile in most soil types. In moist soil, volatilization is expected to be the major fate process; however its bond to soil lessens this effect. Volatilization is not a major fate process for dry soil. Biodegradation by environmental organisms in non-sterile soil and by sunlight is expected (HSDB, 2005; IPCS, 1992). Studies have shown that within 2 weeks of treatment with 0.5 kg ai/ha (active ingredient per hectare) of a diluted alpha-cypermethrin emulsifiable concentrate formulation in sandy-clay soil, residues of alpha-cypermethrin were 50 percent less. After 1 year, they were below detection or < 0.01 mg/kg. Similar results were seen after a second and third application to the site indicating that alpha-cypermethrin did not build up in the surface soil. Additionally, no leaching to subsurface soils was observed. Alpha-cypermethrin also does not build up in peat soils (IPCS, 1992).

### **Fate and Transport in Aquatic Systems**

Alpha-cypermethrin binds tightly to suspended solids and sediments in water. It is expected to volatilize from water; however, volatilization is lessened by alpha-cypermethrin's bond with soil. Reported volatilization half-lives are 8 days for a river models and 65 days for a lake model. If adsorption is taken into consideration, the estimated volatilization half-life in a pond model is 125 years. Estimated hydrolysis half-lives are 36 and 4 years at pH 7 and 8 respectively. Alpha-cypermethrin is also expected to undergo photodecomposition. Based on its bioconcentration factor, alpha-cypermethrin has a high potential to bioconcentrate in aquatic organism; however, its potential may actually be lower than this suggests because of the ability of aquatic organisms to rapidly metabolize alpha-cypermethrin (HSDB, 2005).

## *Human Health Effects*

### **Acute Exposure**

#### ***Effects/Symptoms***

Limited data exist on the acute toxicity of alpha-cypermethrin in humans (IPCS, 1992; HSDB, 2005). Occupationally exposed workers reported only mild skin irritation (IPCS, 1992). The main effects reported from acute exposure to alpha-cypermethrin in humans include skin rashes, eye irritation, itching and burning sensation on exposed skin, and paraesthesia. Acute inhalation exposures may cause upper and lower respiratory tract irritation. Ingestion of alpha-cypermethrin is also harmful (HSDB, 2005; MSDS, n.d.). No acute poisonings have been reported (IPCS, 1992).

In rodents, alpha-cypermethrin has moderate to high oral toxicity (HSDB, 2005; IPCS, 1992). Oral LD<sub>50</sub> values in rats and mice vary greatly and depend on the formulation, concentration, and the vehicle (IPCS, 1992). Acute oral LD<sub>50</sub> values for technical alpha-cypermethrin range from 79 to 400 mg/kg (in corn oil) in rats (HSDB, 2005; IPCS, 1992;

MSDS, n.d.). Although the LD<sub>50</sub> of 80 mg/kg is considered representative, higher values have been reported. In mice, the reported acute oral LD<sub>50</sub> of technical alpha-cypermethrin is 35 mg/kg (in corn oil). Oral LD<sub>50</sub> values for formulated alpha-cypermethrin in rats range from 101 to 174 mg/kg for an emulsifiable concentrate formulation (100 g/L), while 1,804 mg/kg was reported for a suspension concentrate formulation (100 mg/L) and 5,838 mg/kg for an ultra-low-volume liquid formulation (15 g/L) (IPCS, 1992). Clinical signs reported in orally exposed animals are associated with central nervous system activity and included ataxia; gait abnormalities; choreoathetosis; “tip-toe” walk; and increased salivation, lacrimation, piloerection, tremor, and clonic convulsions. Acute dermal exposures are minimally irritating to the skin and eyes of rabbit skin. However, some formulations can cause severe eye irritation that includes corneal opacity and iris damage. Stimulation of the sensory-nerve endings of the skin has been observed in guinea pigs. Reported dermal LD<sub>50</sub> values of greater than 2,000 mg tech/kg are reported for rats and rabbits (HSDB, 2005; IPCS, 1992). No mortality or signs of toxicity were observed in rats or mice after single dermal applications of up to 500 mg/kg or 4-hour inhalation exposure of mice to 400 mg/m<sup>3</sup>. Alpha-cypermethrin is not a dermal sensitizer in guinea pigs (IPCS, 1992).

### ***Treatment***

Pyrethroid insecticides and their metabolites can be detected in blood and urine; however, the methods are not practical to use given how quickly these compounds are broken down in the body (ATSDR, 2003). Alpha-cypermethrin poisoning should be treated the same as a pyrethroid poisoning. There are no antidotes for alpha-cypermethrin exposure. Treatment is supportive and depends on the symptoms of the exposed person. Decontamination is all that is necessary for most exposures. If a person exhibits signs of typical pyrethroid toxicity following alpha-cypermethrin exposure (nausea, vomiting, shortness of breath, tremors, hypersensitivity, weakness, burning, or itching), they should immediately remove any contaminated clothing. Any liquid contaminant on the skin should be soaked up and the affected skin areas cleaned with alkaline soap and warm water. The application of topical vitamin E helps to relieve the symptoms of paraesthesia. Eye exposures should be treated by rinsing with copious amounts of saline or room temperature water for at least 15 minutes. Contact lenses should be removed. Medical attention should be sought if irritation, pain, swelling, lacrimation, or photophobia persists. The treatment of ingestion exposures is mostly symptomatic and supportive. Care should be taken to monitor for the development of hypersensitivity reactions with respiratory distress. Gastric decontamination is recommended if large amounts have been very recently ingested, and oral administration of activated charcoal and cathartic are recommend for ingestion of small amounts or if treatment has been delayed. Vomiting should not be induced following ingestion exposures, but the mouth should be rinsed. The person should be kept calm and medical attention should be sought as quickly as possible. For inhalation exposures, removal to fresh air and monitoring for breathing

difficulties, respiratory tract irritation, bronchitis, and pneumonitis are recommended. Oxygen should be administered as necessary (PAN, 2005; HSDB, 2005).

### *Chronic Exposure*

#### **Noncancer Endpoints**

Little data are available for humans following chronic exposures to alpha-cypermethrin. Chronic exposure to pyrethrins may cause hypersensitivity pneumonitis characterized by chest pain, cough, dyspnea, and bronchospasm. Because alpha-cypermethrin belongs to this class of chemicals, similar effects may be expected (HSDB, 2005).

Chronic toxicity data are also lacking in animals. No animal data are available for long-term toxicity, reproductive toxicity, teratogenicity, or immunotoxicity (HSDB, 2005; IPCS, 1992). However, chronic toxicity data are available for cypermethrin, including rodent multigenerational reproduction, embryotoxicity, and teratogenicity studies. At doses that produced systemic toxicity, no effects on reproductive parameters or fetal development were observed. Therefore, it is likely that alpha-cypermethrin would also cause no reproductive or developmental effects in rodents because it is a component of cypermethrin. Available data do not indicate that alpha-cypermethrin is mutagenic (IPCS, 1992).

#### **Cancer Endpoints**

No data are available on the carcinogenic potential of alpha-cypermethrin (IPCS, 1992).

### *Toxicokinetics*

Like other pyrethroid insecticides, orally administered alpha-cypermethrin, is absorbed via the intestinal tract of mammals, and dermally applied doses are absorbed through intact skin. Little or none is absorbed by inhalation exposures (HSDB, 2005). Most pyrethroids are rapidly broken down by liver enzymes and their metabolites are quickly excreted (HSDB, 2005). The metabolism of synthetic pyrethroids in mammals is generally through hydrolysis, oxidation, and conjugation. Metabolism of alpha-cypermethrin occurs by the cleavage of the ester bond. Studies in rats show that the phenoxybenzyl alcohol and cyclopropane carboxylic acid parts of the molecule are conjugated with sulfate and glucuronide, respectively, before being excreted in urine. Esteric hydrolysis and oxidative pathways occur in rats, rabbits, and humans with esteric hydrolysis being the predominant pathway in humans and rabbits (IPCS, 1992). Within 24 hours of an oral dose of 0.25–0.75 mg in humans, 43 percent was excreted in the urine as free of conjugated cis-cyclopropane carboxylic acid (HSDB, 2005; IPCS, 1992). Orally administered alpha-cypermethrin is eliminated in the urine of rats as the sulfate conjugate of 3-(4-hydroxyphenoxy) benzoic acid. In the faces it is eliminated partly as unchanged compound. Alpha-cypermethrin levels in tissues are low except for fatty tissues. The reported half-life for elimination from fat is 2.5 days for the first phase of elimination and 17 to 26 days for the second phase (IPCS, 1992).



## *Ecological Effects*

### **Acute Exposure**

#### ***Toxicity in Non-Targeted Terrestrial Organisms***

Alpha-cypermethrin, like other pyrethroids, is very unlikely to harm terrestrial organisms other than its targets (e.g., mosquitoes and other pests). No toxicity data are available for alpha-cypermethrin in birds. However, cypermethrin has a very low toxicity in birds with acute oral LD<sub>50</sub> values of greater than 2,000 mg/kg body weight. In feed, the reported LC<sub>50</sub> values are greater than 10,000 mg/kg diet (IPCS, 1992). As with other pyrethroid insecticides, alpha-cypermethrin is extremely toxic to honey bees. The reported 24-hour oral LD<sub>50</sub> for alpha-cypermethrin emulsifiable concentrate is 0.13 µg/bee and the 24-hour oral LD<sub>50</sub> for alpha-cypermethrin in acetone was 0.06 µg/bee. The reported dermal LD<sub>50</sub>s are 0.03 µg/bee for technical alpha-cypermethrin and 0.11 µg/bee for emulsifiable concentrate (IPCS, 1992). The very high toxicity in bees was not observed in the field, likely as a result of the repellent effect of alpha-cypermethrin, which would limit exposure (IPCS, 1992; HSDB, 2005). Mortality was seen in only 15 percent of honey bees exposed to flowers treated with an emulsifiable concentrate formulation within 48 hours. Other studies using oil-enhanced suspension concentrate formulations showed similarly low toxicity. Additionally, a similar pattern of toxicity was seen in leaf-cutting bees. The toxicity of alpha-cypermethrin to earthworms, Carabid beetles, Syrphid larvae and neuropteran larvae is low while it is relatively high for Linyphiid spiders and Coccinellids (IPCS, 1992).

#### ***Toxicity in Non-Targeted Aquatic Systems***

Alpha-cypermethrin is very toxic to fish under laboratory conditions, with emulsifiable concentrate formulations being the most toxic (IPCS, 1992); however, these effects are not seen in field studies. Therefore, the hazard to fish from contamination of waterbodies due to overspraying and drift is negligible (IPCS, 1992). Depending on the formulation, the reported 96-hour LC<sub>50</sub> values range from 0.7 to 350 µg/L (IPCS, 1992). For rainbow trout, the reported 96-hour LC<sub>50</sub> values range from 2.8 to 350 µg/L (HSDB, 2005; IPCS, 1992). The emulsifiable concentrate formulation is 10 to 70 times more toxic to rainbow trout than the wettable powder or suspension concentrate formulations. However, in field studies, the 14-day LC<sub>50</sub> for rainbow trout was just 29 g ai/ha for emulsifiable concentrate formulations and greater than 1,000 g ai/ha for suspension concentrate, wettable powder, and micro-encapsulated formulations. For fathead minnows, the reported 96-hour LC<sub>50</sub> value for technical alpha-cypermethrin was 0.93 µg/L, while the reported 96-hour LC<sub>50</sub> values for carp range from 0.8 to 11 µg/L depending on the formulation. For fish in the early stages of life, alpha-cypermethrin and cypermethrin toxicity are similar (IPCS, 1992). Alpha-cypermethrin has the potential to accumulate in fish, with a bioconcentration factor of 990 (HSDB, 2005). It has also been shown to be highly toxic to some aquatic invertebrates and aquatic insects (IPCS, 1992).

### **Chronic Exposure**

Due to low rate of application and low persistence of alpha-cypermethrin in both terrestrial and aquatic environments, serious adverse effects are not anticipated from chronic exposures (HSDB, 2005). The hazard of alpha-cypermethrin to fish and aquatic invertebrates is in its acute toxicity. There is no evidence of chronic exposure causing cumulative effects (IPCS, 1992).

#### *References*

- ATSDR (Agency for Toxic Substances and Disease Registry). 2003. Toxicological Profile for Pyrethrin and Pyrethroids. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. Available at <http://www.atsdr.cdc.gov/toxprofiles/tp155.html>.
- HSDB (Hazardous Substance Databank). 2005. Alphacypermethrin. National Library of Medicine, National Toxicology Program. Available at <http://toxnet.nlm.nih.gov/cgi-bin/sis/search/f?./temp/~Qubkyc:1>.
- IPCS (International Programme on Chemical Safety). 1992. Environmental Health Criteria 142. Alpha-Cypermethrin. Geneva: World Health Organization. Available at <http://www.inchem.org/documents/ehc/ehc/ehc142.htm>.
- MSDS (Material Safety Data Sheet). n.d. Alpha Cypermethrin. Available at [http://physchem.ox.ac.uk/MSDS/CY/alpha\\_cypermethrin.html](http://physchem.ox.ac.uk/MSDS/CY/alpha_cypermethrin.html).
- PAN (Pesticide Action Network). 2005. PAN Pesticides Database (Version 6) – Alpha-Cypermethrin. Updated April 2005. Available at [http://www.pesticideinfo.org/Detail\\_Chemical.jsp?Rec\\_Id=PC37663](http://www.pesticideinfo.org/Detail_Chemical.jsp?Rec_Id=PC37663).
- U.S. EPA (Environmental Protection Agency). 1988. Recommendations for and Documentation of Biological Values for Use in Risk Assessment. Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Office of Research and Development, Cincinnati, OH. EPA/600/6-87/008.
- U.S. EPA (Environmental Protection Agency). 2005. Integrated Risk Information System (IRIS): Cypermethrin. National Center for Environmental Assessment, Office of Research and Development, Washington, DC. Available at <http://www.epa.gov/iris/subst/0380.htm>.
- WHO (World Health Organization). 1997. Vector Control - Methods for Use by Individuals and Communities. Available at [http://www.who.int/docstore/water\\_sanitation\\_health/vectcontrol/ch15.htm](http://www.who.int/docstore/water_sanitation_health/vectcontrol/ch15.htm).
- WHO (World Health Organization). 1998. Report of the Second WHOPES Working Group Meeting: Review of Alphacypermethrin 10% and SC 5% and Cyfluthrin 5% EW and 10% WP. June 22–23, 1998. Available at [http://whqlibdoc.who.int/hq/1998/CTD\\_WHOPES\\_98.10.pdf](http://whqlibdoc.who.int/hq/1998/CTD_WHOPES_98.10.pdf).

WHO (World Health Organization). 1999. Specifications for Alpha Cypermethrin.  
Available at <http://www.who.int/whopes/quality/en/Alphacypermethrin1.pdf>.

WHO (World Health Organization). 2002. FPA List of Household Pesticides. Available  
at <http://www.wpro.who.int/hse/pages/householdlist.html>.

## **Annex 3: Exposure Treatment Guidelines\***

### **Pyrethroids**

These modern synthetic insecticides are similar chemically to natural pyrethrins, but modified to increase stability in the natural environment. They are now widely used in agriculture, in homes and gardens, and to treat ectoparasitic disease.

Pyrethroids are formulated as emulsifiable concentrates, wettable powders, granules, and concentrates for ultra low volume application. They may be combined with additional pesticides (sometimes highly toxic) in the technical product or tank-mixed with other pesticides at the time of application.

#### *Toxicology*

Certain pyrethroids exhibit striking neurotoxicity in laboratory animals when administered by intravenous injection, and some are toxic when ingested orally. However, systemic toxicity by inhalation and dermal absorption is low. Although limited absorption may account for the low toxicity of some pyrethroids, rapid biodegradation by mammalian liver enzymes (ester hydrolysis and oxidation) is probably the major factor responsible for this phenomenon. Most pyrethroid metabolites are promptly excreted (at least in part) by the kidney. Fatalities have occurred rarely after pyrethroid exposure, usually following ingestion (He et al., 1989).

The most severe toxicity is to the central nervous system, although more uncommon. Seizures have been reported in severe cases of pyrethroid intoxication. Seizures are more common with exposure to the more toxic cyano-pyrethroids, which include fenvalerate, flucythrinate, cypermethrin, deltamethrin, and fluvalinate. There are no reports in the literature of seizures in humans from exposure to permethrin.

Apart from central nervous system toxicity, some pyrethroids do cause distressing paresthesia when liquid or volatilized materials contact human skin. Again, these symptoms are more common with exposure to the pyrethroids whose structures include cyano-groups. Sensations are described as stinging, burning, itching, and tingling, progressing to numbness. The skin of the face seems to be most commonly affected, but the hands, forearms, and neck are sometimes involved. Sweating, exposure to sun or heat, and applying water increase the disagreeable sensations. Sometimes the effect is noted within minutes of exposure, but a 1-2 hour delay in the appearance of symptoms is more common. Sensations rarely persist more than 24 hours. Little or no inflammatory reaction is apparent where the paresthesia is reported; the effect is presumed to result from pyrethroid contact with sensory nerve endings in the skin. The paraesthesia is not allergic

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\* US Agency for International Development. Draft 4. Integrated Vector Management Programs for Malaria Vector Control: Programmatic Environmental Assessment. March 2006. Prepared by RTI International. Contract GHS-I-01-03-00028-000-1. Prepared for Bureau for Global Health, USAID.

in nature, although sensitization and allergic responses have been reported as an independent phenomenon with pyrethroid exposure. Race, skin type, or disposition to allergic disease does not affect the likelihood or severity of the reaction.

Persons treated with permethrin for lice or flea infestations sometimes experience itching and burning at the site of application, but this is chiefly an exacerbation of sensations caused by the parasites themselves, and is not typical of the paraesthesia described above.

Other signs and symptoms of toxicity include abnormal facial sensations, dizziness, salivation, headache, fatigue, vomiting, diarrhea, and irritability to sound and touch. In more severe cases, pulmonary edema and muscle fasciculations can develop. Due to the inclusion of unique solvent ingredients, certain formulations of fluvalinate are corrosive to the eyes. Pyrethroids are not cholinesterase inhibitors. However, there have been some cases in which pyrethroid poisoning has been misdiagnosed as organophosphate poisoning, due to some of the similar presenting signs, and some patients have died from atropine toxicity.

### ***Alpha-cypermethrin***

Alpha-cypermethrin is a synthetic pyrethroid.

#### *Toxicology*

Absorption may occur to some extent after inhalation or dermal exposure but, as with other pyrethroids, alpha-cypermethrin is rapidly metabolized and excreted from the body.

Mode of action: Neurotoxicity through disruption of nerve fiber impulse transmission.

#### *Symptoms of poisoning*

In normal use, only local skin reactions have been reported. Any pyrethroid reaching the systemic circulation will be metabolized rapidly to much less toxic metabolites. The risk of toxicity of any kind to humans exposed by the usual routes is extremely remote, even with frequent exposure to the low concentrations used for malaria control. Systemic toxicity has not been seen in users, except on very rare occasions when few precautions were taken during packaging of pyrethroids and the victim's whole body was subjected to repeated and often prolonged exposure through soaked clothing.

Nevertheless, if ingested, these products may produce nausea, vomiting, cough, respiratory distress, and convulsions.

The field use of pyrethroids in the recommended concentrations, accompanied by the normal precautions for insecticide use, poses little or no hazard to applicators. Skin reactions such as pruritus, tautness and reddening of the facial skin, partial facial paraesthesia, and signs of irritation in the oropharyngeal cavity or coughing, especially when combined with increased sensitivity to touch stimuli, may be signs of dermal contact or inhalative exposure. These dermal sensations are direct and transitory effects on sensory nerve endings and are not the result of a primary skin irritation.

Toxicologically, these are useful characteristics, as they provide an early indication of exposure.

After breathing in the insecticide spray mist, there may be irritation of respiratory mucous membranes with coughing and sneezing.

### **Treatment by Medical Professional**

1. **Skin decontamination.** Wash skin promptly with soap and water. If irritant or paresthesia occurs, obtain treatment by a physician. Because volatilization of pyrethroids apparently accounts for paresthesia affecting the face, strenuous measures should be taken (ventilation, protective face mask and hood) to avoid vapor contact with the face and eyes. Vitamin E oil preparations (dL-alpha tocopheryl acetate) are uniquely effective in preventing and stopping the paresthesia. They are safe to apply to the skin under field conditions. Corn oil is somewhat effective, but possible side effects with continuing use make it less suitable. Vaseline is less effective than corn oil. Zinc oxide actually makes the reaction worse.

2. **Eye contamination.** Some pyrethroid compounds can be very corrosive to the eyes. Extraordinary measures should be taken to avoid eye contamination. The eye should be treated immediately by prolonged flushing of the eye with copious amounts of clean water or saline. If irritation persists, obtain professional ophthalmologic care.

3. **Gastrointestinal decontamination.** If large amounts of pyrethroids, especially the cyano-pyrethroids, have been ingested and the patient is seen soon after exposure, consider gastrointestinal decontamination. Based on observations in laboratory animals and humans, large ingestions of allethrin, cismethrin, fluvalinate, fenvalerate, or would be the most likely to generate neurotoxic manifestations.

If only small amounts of pyrethroid have been ingested, or if treatment has been delayed, oral administration of activated charcoal and cathartic probably represents optimal management. Do not give cathartic if patient has diarrhea or an ileus.

4. **Other treatments.** Several drugs are effective in relieving the pyrethroid neurotoxic manifestations observed in deliberately poisoned laboratory animals, but none has been tested in human poisonings. Therefore, neither efficacy nor safety under these circumstances is known. Furthermore, moderate neurotoxic symptoms and signs are likely to resolve spontaneously if they do occur.

5. **Seizures.** Any seizures should be treated as outlined in the general principles for management of acute poisoning.

## **General Principles in the Management of Acute Pesticide Poisonings**

### ***Skin Decontamination***

Decontamination must proceed concurrently with whatever resuscitative and antidotal measures are necessary to preserve life. Shower patient with soap and water, and shampoo hair to remove chemicals from skin and hair. If there are any indications of weakness, ataxia, or other neurologic impairment, remove the victim's clothing, have the victim lie down, and give the victim a complete bath and shampoo using copious

amounts of soap and water. Check for pesticide sequestered under fingernails or in skin folds and wash these areas.

Flush contaminating chemicals from eyes with copious amounts of clean water for 10-15 minutes. If eye irritation is present after decontamination, ophthalmologic consultation is appropriate.

Persons attending the victim should avoid direct contact with heavily contaminated clothing and vomitus. Contaminated clothing should be promptly removed, bagged, and laundered before returning to the patient. Shoes and other leather items cannot usually be decontaminated and should be discarded. Note that pesticides can contaminate the inside surfaces of gloves, boots, and headgear. Decontamination should especially be considered for emergency personnel (such as ambulance drivers) at the site of a spill or contamination. Wear rubber gloves while washing pesticide from skin and hair of patient. Latex and other surgical or precautionary gloves usually do not provide adequate protection from pesticide contamination.

### ***Airway Protection***

Ensure that a clear airway exists. Suction any oral secretions using a large bore suction device if necessary. Intubate the trachea if the patient has respiratory depression or if the patient appears obtunded or otherwise neurologically impaired. Administer oxygen as necessary to maintain adequate tissue oxygenation. In severe poisonings, mechanically supporting pulmonary ventilation for several days may be necessary.

**Note on Specific Pesticides:** There are several special considerations with regard to certain pesticides. In **organophosphate** and **carbamate** poisoning, adequate tissue oxygenation is essential prior to administering atropine.

### ***Gastrointestinal Decontamination***

A joint position statement has recently been released by the American Academy of Clinical Toxicology and the European Association of Poisons Centres and Clinical Toxicologists on various methods of gastrointestinal decontamination. A summary of the position statement accompanies the description of each procedure.

1. **1. Gastric Lavage.** If the patient presents within 60 minutes of ingestion, lavage may be **considered**. Insert an orogastric tube and follow with fluid, usually normal saline. Aspirate back the fluid in an attempt to remove any toxicant. If the patient is neurologically impaired, airway protection with a cuffed endotracheal tube is indicated prior to gastric lavage. Lavage performed more than 60 minutes after ingestion has not proven to be beneficial and runs the risk of inducing bleeding, perforation, or scarring due to additional trauma to already traumatized tissues. It is almost always necessary first to control seizures before attempting gastric lavage or any other method of GI decontamination. Studies of poison recovery have been performed mainly with solid material such as pills. There are no controlled studies of pesticide recovery by these methods. Reported recovery of material at 60 minutes in several studies

was 8 percent to 32 percent. There is further evidence that lavage may propel the material into the small bowel, thus increasing absorption.

**Note on Specific Pesticides:** Lavage is contraindicated in hydrocarbon ingestion, a common vehicle in many pesticide formulations.

**Position Statement:** Gastric lavage should not be routinely used in the management of poisons. Lavage is indicated only when a patient has ingested a potentially life-threatening amount of poison and the procedure can be done within 60 minutes of ingestion. Even then, clinical benefit has not been confirmed in controlled studies.

2. **Activated Charcoal Adsorption.** Activated charcoal is an effective absorbent for many poisonings. Volunteer studies suggest that it will reduce the amount of poison absorbed if given within 60 minutes. There are insufficient data to support or exclude its use if time from ingestion is prolonged, although some poisons that are less soluble may be adsorbed beyond 60 minutes. Clinical trials with charcoal have been done with poisons other than pesticides. There is some evidence that paraquat is well adsorbed by activated charcoal. Charcoal has been anecdotally successful with other pesticides.

Dosage of Activated Charcoal:

- **Adults and children over 12 years: 25-100 g in 300-800 mL water.**
- **Children under 12 years: 25-50 g per dose.**
- **Infants and toddlers under 20 kg: 1 g per kg body weight.**

Many activated charcoal formulations come premixed with sorbitol. Avoid giving more than one dose of sorbitol as a cathartic in infants and children due to the risk of rapid shifts of intravascular fluid. Encourage the victim to swallow the adsorbent even though spontaneous vomiting continues. Antiemetic therapy may help control vomiting in adults or older children. As an alternative, activated charcoal may be administered through an orogastric tube or diluted with water and administered slowly through a nasogastric tube. Repeated administration of charcoal or other absorbent every 2-4 hours may be beneficial in both children and adults, but use of a cathartic such as sorbitol should be avoided after the first dose. Repeated doses of activated charcoal should not be administered if the gut is atonic. The use of charcoal without airway protection is contraindicated in the neurologically impaired patient.

**Note on Specific Pesticides:** The use of charcoal without airway protection should be used with caution in poisons such as organophosphates, carbamates, and organochlorines if they are prepared in a hydrocarbon solution.

**Position Statement:** Single-dose activated charcoal should not be used routinely in the management of poisoned patients. Charcoal appears to be most effective within 60 minutes of ingestion and may be considered for use for this time period. Although it may be considered 60 minutes after ingestion, there is insufficient evidence to support or deny



its use for this time period. Despite improved binding of poisons within 60 minutes, only one study suggests that there is improved clinical outcome. Activated charcoal is contraindicated in an unprotected airway, a GI tract not anatomically intact, and when charcoal therapy may increase the risk of **aspiration** of a hydrocarbon-based pesticide.

**Seizures:** Lorazepam is increasingly being recognized as the drug of choice for status epilepticus, although there are few reports of its use with certain pesticides. Emergency personnel must be prepared to assist ventilation with lorazepam and any other medication used to control seizures. See dosage table below. For organochlorine compounds, use of lorazepam has not been reported in the literature. Diazepam is often used for this, and is still used in other pesticide poisonings.

Dosage of Diazepam:

- **Adults:** 5-10 mg IV and repeat every 5-10 minutes to maximum of 30 mg.
- **Children:** 0.2 to 0.5 mg/kg every 5 minutes to maximum of 10 mg in children over 5 years, and maximum of 5 mg in children under 5 years.

Dosage of Lorazepam:

- **Adults:** 2-4 mg/dose given IV over 2-5 minutes. Repeat if necessary to a maximum of 8 mg in a 12 hour period.
- **Adolescents:** Same as adult dose, except maximum dose is 4 mg.
- **Children under 12 years:** 0.05-0.10 mg/kg IV over 2-5 minutes. Repeat if necessary .05 mg/kg 10-15 minutes after first dose, with a maximum dose of 4 mg.

**Caution:** Be prepared to assist pulmonary ventilation mechanically if respiration is depressed, to intubate the trachea if laryngospasm occurs, and to counteract hypotensive reactions.

Phenobarbital is an additional treatment option for seizure control. Dosage for **infants, children, and adults** is 15-20 mg/kg as an IV loading dose. An additional 5 mg/kg IV may be given every 15-30 minutes to a maximum of 30 mg/kg. The drug should be pushed no faster than 1 mg/kg/minute.

For seizure management, most patients respond well to usual management consisting of benzodiazepines, or phenytoin and phenobarbital.

## Annex 4: Terrestrial and Freshwater Endangered Species of Madagascar

Scientific Name	Common Name (English)	Common Name (French)	Class	Population Trend
<i>Haliaeetus vociferoides</i>	MADAGASCAR FISH-EAGLE	PYGARGUE DE MADAGASCAR	CR	D
<i>Mantella aurantiaca</i>	GOLDEN FROG, GOLDEN MANTELLA	MANTELLE DORÉE	CR	D
<i>Boophis williamsi</i>			CR	D
<i>Mantella cowanii</i>	COWAN'S MANTELLA		CR	D
<i>Mantella expectata</i>	BLUE-LEGGED MANTELLA		CR	D
<i>Mantella milotympanum</i>	BLACK-EARED MANTELLA		CR	D
<i>Mantella viridis</i>	GREEN MANTELLA		CR	D
<i>Mantidactylus pauliani</i>			CR	D
<i>Scaphiophryne gottlebei</i>			CR	D
<i>Erymnochelys madagascariensis</i>	MADAGASCAR BIG-HEADED TURTLE, MADAGASCAR SIDENECK TURTLE	PODOCNÉMIDE DE MADAGASCAR	EN	
<i>Aglyptodactylus laticeps</i>			EN	D
<i>Mantella bernhardi</i>	BERNHARD'S MANTELLA		EN	D
<i>Mantella crocea</i>	YELLOW MANTELLA		EN	D
<i>Mantidactylus brunae</i>			EN	D
<i>Mantidactylus corvus</i>			EN	D
<i>Mantidactylus madecassus</i>			EN	D
<i>Mantidactylus microtis</i>			EN	D
<i>Mantidactylus microtympanum</i>			EN	D
<i>Mantidactylus silvanus</i>			EN	D
<i>Mantidactylus webbi</i>			EN	D
<i>Scaphiophryne boribory</i>			EN	D
<i>Dyscophus antongilii</i>	TOMATO FROG	CRAPAUD ROUGE DE MADAGASCAR	NT	U
<i>Limosa limosa</i>	BLACK-TAILED GODWIT		NT	D
<i>Heterixalus carbonei</i>			NT	D
<i>Heterixalus rutenbergi</i>			NT	D
<i>Boophis majori</i>			NT	D
<i>Boophis occidentalis</i>			NT	D
<i>Boophis rhodoscelis</i>			NT	D
<i>Boophis rufiocularis</i>			NT	D

Scientific Name	Common Name (English)	Common Name (French)	Class	Population Trend
Mantidactylus bertini			NT	D
Scaphiophryne madagascariensis			NT	D
Ravenea musicalis			VU	
Teinobasis alluaudi	SEYCHELLES FINELINER		VU	U
Boophis andreonei			VU	D
Boophis blommersae			VU	D
Boophis haematopus			VU	D
Boophis jaegeri			VU	D
Mantella haraldmeieri	HARALDMEIER'S MANTELLA		VU	D
Mantella madagascariensis	MADAGASCAN MANTELLA		VU	D
Mantella pulchra	BEAUTIFUL MANTELLA		VU	D
Mantidactylus elegans			VU	D
Mantidactylus massorum			VU	D
Mantidactylus striatus			VU	D
Mantidactylus tandroka			VU	S
Scaphiophryne marmorata			VU	D
Haliaeetus vociferoides	MADAGASCAR FISH-EAGLE	PYGARGUE DE MADAGASCAR	CR	D
Mantella aurantiaca	GOLDEN FROG, GOLDEN MANTELLA	MANTELLE DORÉE	CR	D
Boophis williamsi			CR	D
Mantella cowanii	COWAN'S MANTELLA		CR	D
Mantella expectata	BLUE-LEGGED MANTELLA		CR	D
Mantella milotympanum	BLACK-EARED MANTELLA		CR	D
Mantella viridis	GREEN MANTELLA		CR	D
Mantidactylus pauliani			CR	D
Scaphiophryne gottlebei			CR	D
Erymnochelys madagascariensis	MADAGASCAR BIG-HEADED TURTLE, MADAGASCAR SIDENECK TURTLE	PODOCNÉMIDE DE MADAGASCAR	EN	
Aglyptodactylus laticeps			EN	D
Mantella bernhardi	BERNHARD'S MANTELLA		EN	D
Mantella crocea	YELLOW MANTELLA		EN	D
Mantidactylus brunae			EN	D
Mantidactylus corvus			EN	D
Mantidactylus madecassus			EN	D
Mantidactylus microtis			EN	D
Mantidactylus microtympanum			EN	D
Mantidactylus silvanus			EN	D

Scientific Name	Common Name (English)	Common Name (French)	Class	Population Trend
Mantidactylus webbi			EN	D
Scaphiophryne boribory			EN	D
Dyscophus antongilii	TOMATO FROG	CRAPAUD ROUGE DE MADAGASCAR	NT	U
Limosa limosa	BLACK-TAILED GODWIT		NT	D
Heterixalus carbonei			NT	D
Heterixalus rutenbergi			NT	D
Boophis majori			NT	D
Boophis occidentalis			NT	D
Boophis rhodoscelis			NT	D
Boophis rufiocularis			NT	D
Mantidactylus bertini			NT	D
Scaphiophryne madagascariensis			NT	D
Ravenea musicalis			VU	
Teinobasis alluaudi	SEYCHELLES FINELINER		VU	U
Boophis andreonei			VU	D
Boophis blommersae			VU	D
Boophis haematopus			VU	D
Boophis jaegeri			VU	D
Mantella haraldmeieri	HARALDMEIER'S MANTELLA		VU	D
Mantella madagascariensis	MADAGASCAN MANTELLA		VU	D
Mantella pulchra	BEAUTIFUL MANTELLA		VU	D
Mantidactylus elegans			VU	D
Mantidactylus massorum			VU	D
Mantidactylus striatus			VU	D
Mantidactylus tandroka			VU	S
Scaphiophryne marmorata			VU	D
Haliaeetus vociferoides	MADAGASCAR FISH-EAGLE	PYGARGUE DE MADAGASCAR	CR	D
Mantella aurantiaca	GOLDEN FROG, GOLDEN MANTELLA	MANTELLE DORÉE	CR	D
Boophis williamsi			CR	D
Mantella cowanii	COWAN'S MANTELLA		CR	D
Mantella expectata	BLUE-LEGGED MANTELLA		CR	D
Mantella milotympanum	BLACK-EARED MANTELLA		CR	D
Mantella viridis	GREEN MANTELLA		CR	D
Mantidactylus pauliani			CR	D
Scaphiophryne gottlebei			CR	D
Erymnochelys madagascariensis	MADAGASCAR BIG-HEADED TURTLE,	PODOCNÉMIDE DE MADAGASCAR	EN	

Scientific Name	Common Name (English)	Common Name (French)	Class	Population Trend
	MADAGASCAR SIDENECK TURTLE			
<i>Aglyptodactylus laticeps</i>			EN	D
<i>Mantella bernhardi</i>	BERNHARD'S MANTELLA		EN	D
<i>Mantella crocea</i>	YELLOW MANTELLA		EN	D
<i>Mantidactylus brunae</i>			EN	D
<i>Mantidactylus corvus</i>			EN	D
<i>Mantidactylus madecassus</i>			EN	D
<i>Mantidactylus microtis</i>			EN	D
<i>Mantidactylus microtypanum</i>			EN	D
<i>Mantidactylus silvanus</i>			EN	D
<i>Mantidactylus webbi</i>			EN	D
<i>Scaphiophryne boribory</i>			EN	D
<i>Dyscophus antongilii</i>	TOMATO FROG	CRAPAUD ROUGE DE MADAGASCAR	NT	U
<i>Limosa limosa</i>	BLACK-TAILED GODWIT		NT	D
<i>Heterixalus carbonei</i>			NT	D
<i>Heterixalus rutenbergi</i>			NT	D
<i>Boophis majori</i>			NT	D
<i>Boophis occidentalis</i>			NT	D
<i>Boophis rhodoscelis</i>			NT	D
<i>Boophis rufioculis</i>			NT	D
<i>Mantidactylus bertini</i>			NT	D
<i>Scaphiophryne madagascariensis</i>			NT	D
<i>Ravenea musicalis</i>			VU	
<i>Teinobasis alluaudi</i>	SEYCHELLES FINELINER		VU	U
<i>Boophis andreonei</i>			VU	D

Key	
CR	Critically Endangered
EN	Endangered
LR/cd	Low Risk: Conservation Dependent
LR/nt	Near Threatened
NT	Near Threatened
VU	Vulnerable
I	Increasing
D	Decreasing



**Visé par les Autorités :**                    /\_\_\_/                    /\_\_\_/

**A.1.4 Autorités informés de la venue de l'équipe :**                    /\_\_\_/                    /\_\_\_/

**A.2 Ressources matérielles**

**A.2.1 Protection :**

- Port de combinaison :
- Port de chapeau :
- Port de masque :
- Port de gants :
- Port de kiranyl :
- Lunettes :

Oui

Non

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**A.2.2 Appareils de pulvérisation :**

En bon état :

Bien entretenu :

Oui

Non

/\_\_\_/

/\_\_\_/

/\_\_\_/

/\_\_\_/

## ASPECT TECHNIQUE

### B.1 Liés aux produits (DDT)

Oui

Non

- en sécurité /\_\_\_/
- respect du mélange (DDT/Eau) : 2 fois 5 litres : /\_\_\_/ /\_\_\_/
- /\_\_\_/
- existence de déchets au sol après mélange : /\_\_\_/
- /\_\_\_/

### B.2 Liés aux agents (Aspergeurs)

Oui

Non

- respect de la distance (lance/mur : 45 cm) : /\_\_\_/
- /\_\_\_/
- respect de la pression ( 55/25 PSI) : /\_\_\_/
- /\_\_\_/

### B.3 Liés à l'habitation

Oui

Non

- maison bien dégagées : /\_\_\_/
- /\_\_\_/
- aspersion de murs : /\_\_\_/
- /\_\_\_/
- aspersion des plafonds : /\_\_\_/
- /\_\_\_/
- aspersion des auvents : /\_\_\_/
- /\_\_\_/
- existence de ruissellements /\_\_\_/
- /\_\_\_/

## ASPECT SOCIAL

(à recueillir auprès de la population ou des autorités) :

Oui

Non

- existence d'une participation communautaire : /\_\_\_/
- /\_\_\_/
- si oui : quel
- . hébergement : /\_\_\_/
- /\_\_\_/
- . transport des insecticides : /\_\_\_/
- /\_\_\_/
- . approvisionnement en eau : /\_\_\_/
- /\_\_\_/

. autres (à préciser) :

.....



REMARQUES GENERALES :

1. Renseignements concernant les comportements :

Chef de Zone : .....

.....

Chef de Secteur : .....

.....

Chef d'Equipe : .....

.....

Aspergeurs : .....

.....

2. Autres problèmes rencontrés et solutions préconisées :

.....

.....

Signature

A remettre lors du passage du Superviseur Central



# Annex 7: Pesticide Storage and Stock Control Manual, FAO

## *Foreword*

This manual was prepared by the Food and Agriculture Organization of the United Nations (FAO) under project GCP/INT/572/NET: "Prevention and disposal of obsolete and unwanted pesticide stocks in Africa and the Near East", funded by the Government of the Netherlands. It was written by the National Resources Institute (NRI), Chatham, United Kingdom, with added and editorial input from the FAO Plant Protection Service (AGPP). All the drawings were contributed by an NRI graphic artist.

Despite the limited geographical scope of the project, the manual is considered applicable and useful in many countries particularly in the management and stock control of stored pesticides.

It has been published for distribution to Member Countries of FAO. In view of the fundamental importance of pesticide management, it would be useful to have feedback that could be used in future revisions of this manual. Reference should also be made to FAO's Provisional guidelines: prevention of accumulation of obsolete pesticide stocks, published at the end of 1995, and Technical guidelines on disposal of bulk quantities of obsolete pesticides in developing countries, a joint FAO/UNEP/WHO publication expected in 1996. Comments or suggestions may be addressed to:

Chief, Plant Protection Service  
Plant Production and Protection Division  
FAO  
Viale delle Terme di Caracalla  
00100 Rome, Italy  
Telex 610181 FAO I  
Fax (39-6) 52256347

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## **Abbreviations**

- DLCOE-<sub>A</sub>** Desert Locust Control Organization for Eastern Africa
- ec** emulsifiable concentrate
- FAO** Food and Agriculture Organization of the United Nations
- GIFAP** International Group of National Associations of Agrochemical Manufacturers
- ILO** International Labour Organisation
- LD50** the dose of a substance that causes death in 50 percent of a sample of test animals
- NRI** Natural Resources Institute
- OP** organophosphate
- PVC** polyvinyl chloride
- UNEP** United Nations Environment Programme
- WHO** World Health Organization
- wp** Wettable powder
- 

## **Introduction**

Most pesticides are chemicals that are used to kill pests. Among these are insecticides, fungicides, herbicides, nematicides, rodenticides, acaricides and molluscicides, which are used to kill, respectively, insect pests, fungal diseases, weeds, nematodes, rats and mice, mites and ticks and snail disease vectors. They may also kill other organisms, and most are poisonous to humans.

The World Health Organization estimated (WHO, 1986) that 1 million people are affected by insecticide poisoning every year and that 20 000 die as a result of being unaware of the risks involved in handling insecticides. Pesticides are classified by WHO on the basis of their oral or dermal lethal dose (LD). A measurement called the LD50 is calculated by measuring the number of milligrams of active ingredient per kilogram of body weight required to kill 50 percent of a test sample of animals - often rats. Each insecticide is then put into one of four classifications: Class Ia is extremely hazardous; Ib, highly hazardous; II, moderately hazardous; and III, slightly hazardous.

Pesticides usually have to be stored before use. The following account illustrates how essential careful pesticide storage practice and stock control are, especially when extremely hazardous

chemicals are involved.

The incident was recounted in 1978 by a storekeeper. He had heard that metal drums of the pesticide dieldrin (a very dangerous organochlorine which is no longer used because of its detrimental effect on the environment), had been kept for some years in a pesticide store with a leaking roof. The drum lids had partially rusted and corroded. When, in order to inspect outdated drums at the rear of the store, a storekeeper's assistant climbed up and jumped across the drums at the front, the lid of one gave way as he landed on it. The assistant plunged down into the dieldrin solution which came up to his waist. Within a few hours he had died of poisoning as a result of pesticide inhalation and absorption through the skin.

## **Pesticide Stores**

### **Choice of site**

The site for a new pesticide store should not be close to dwellings or to hospitals, schools, shops, food markets, animal feed depots and general stores (Figure 1).

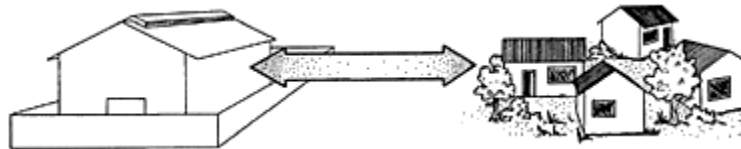


FIGURE 1 - The pesticide store should be located far from human dwellings

It should be faraway from water courses, wells and other supplies of water for domestic and stock animal use because these could be contaminated by spillage and leaks from the store (Figure 2).

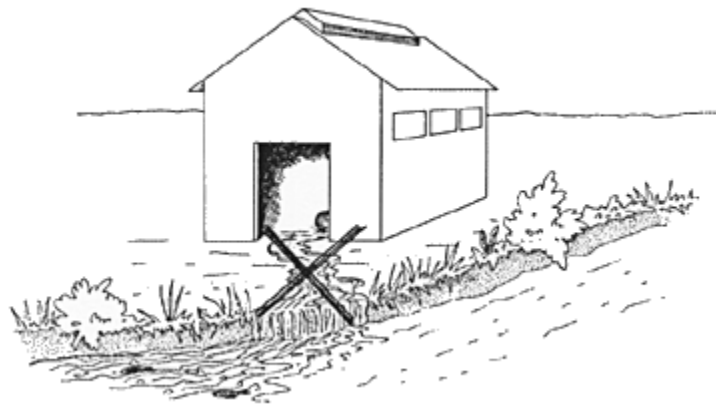


FIGURE 2 - The pesticide store should be sited far from rivers and bodies of water, to prevent chemical contamination from entering and poisoning the water

The site should not be in an area with high groundwater levels, which may be subject to seasonal flooding (Figure 3), nor should it be adjacent to a seasonal flood course.



FIGURE 3 - The pesticide store should not be sited in an area subject to flooding, especially during seasonal rains

There should be easy access for pesticide delivery vehicles. Ideally, there should be access on at least three sides of the building for fire-fighting vehicles and equipment in case of emergency (Figure 4).



FIGURE 4 - The pesticide store should have three sides free to allow access to fire-fighting equipment in an emergency

## Design and structure of buildings

### General principles

The store should be large enough to accommodate the quantities of pesticides planned for storage. A further 15 percent capacity should be included to allow for stock movement and possible future needs, in addition to space for dispensing and repacking insecticides and for empty containers. It should also be well ventilated, to prevent the buildup of pesticide vapour and to stop temperatures getting too high, especially in tropical and subtropical countries with a normally high daytime air temperature. The floors should be of smooth, impermeable concrete to avoid absorption of spillages and to allow easy cleaning (Figure 5).

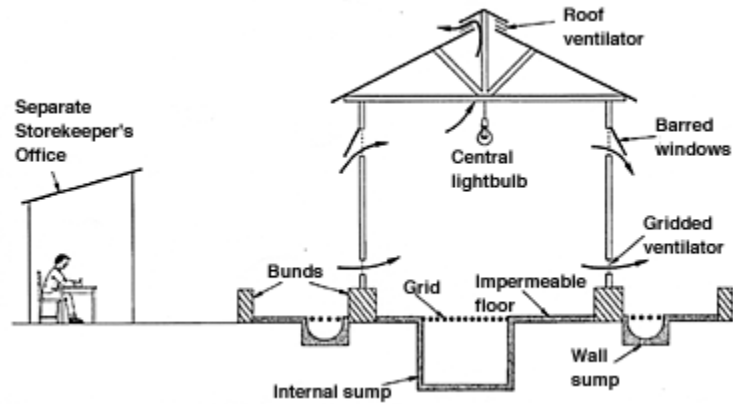


FIGURE 5 - Diagram of a pesticide store showing building features, with storekeeper's office separate from the store (not to scale)

## Layout

The layout (Figure 6) should allow for:

- minimum handling of pesticide containers to avoid causing leaks and spills;
- direct access to the outside without passing through another building;
- a well-lit and ventilated working area for dispensing and repacking pesticides some distance from the store entrance;
- space for storing empty containers and out-of-date stock awaiting disposal.



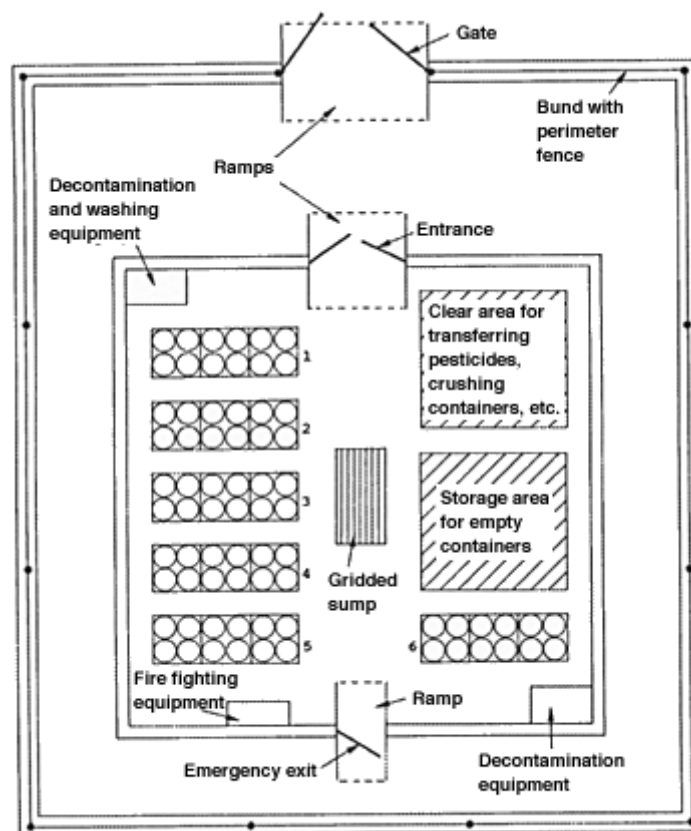


FIGURE 6 - Store layout to show arrangement of facilities (not to scale)

The storekeeper's office should be separate from the storage area. Washing facilities should be provided, with alternative arrangements if there is no piped water supply. Protective clothing should be stored separately from pesticides.

Herbicides should not be stored together with insecticides or other pesticides such as rodenticides and fungicides (Figure 7) so that those that are not poisonous to humans are not contaminated by hazardous chemicals.

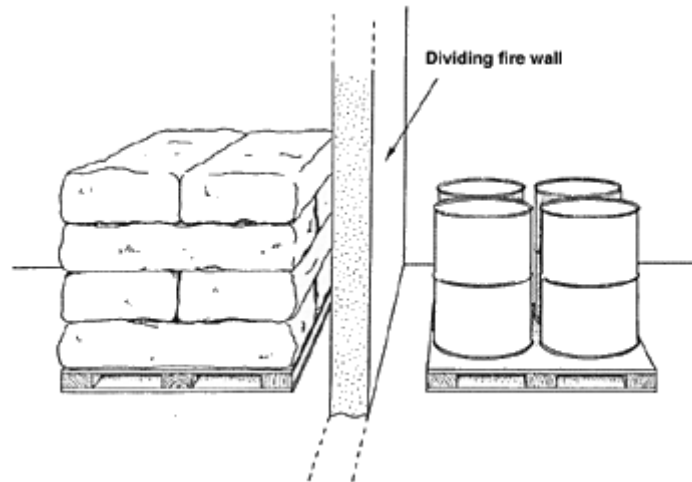


FIGURE 7 - Store dividing wall separating different types of pesticides and acting as an internal fire-break

## Structure

Ideally, the roof should be of light material, such as asbestos substitute or glass fibre, which collapses in the event of fire to allow smoke and fumes to get out and to avoid explosions. The material should not be so flimsy, however, that it is blown away during severe seasonal storms or cyclones.

The store walls should have outside sills that direct spilled chemicals into a sump.

Internal walls should be smooth and free from cracks and ledges to allow easy cleaning.

Windows should not be built if there are alternative means of ventilation and lighting; otherwise they should be shaded (to prevent sunlight from heating the chemicals and causing them to degrade) and barred against unauthorized entry.

The store should be well lit with natural or electric lighting (200 lux) to permit container labels to be read easily.

As sparks can cause fires, electrical fittings should be mineral insulated or armoured cable should be used with flame/dust-proof fittings.

The floor should be made of impervious material or of slats over a concrete-lined sump into which chemical spills can drain to be neutralized. The floor area should be slightly raised at the edges to prevent spills from leaking out of the building and floodwater from getting in. Store walls should be set on bunds, lined to a height of 14 cm with impervious material. A bund around the whole area to contain the store contents is desirable as a further precaution to reduce the risk of gross environmental contamination. Store and perimeter fence bunds should be fitted with concrete ramps to allow vehicle access (Figure 8).

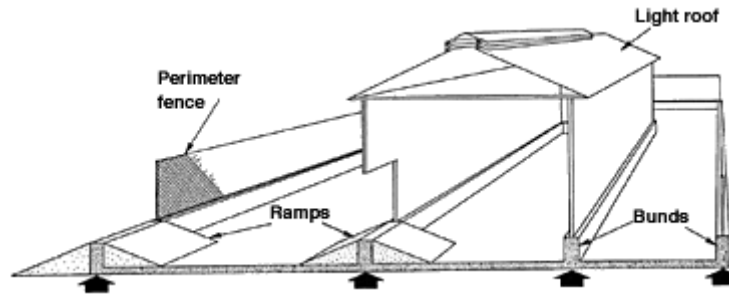


FIGURE 8 - Pesticide store with bunding of walls and perimeter fence including ramps

A static or piped water supply, with soap, should be available for hand and face washing and for decontamination of personnel accidentally splashed by chemicals.

There should be a concrete-lined exterior sump into which spills and leaks can be directed for neutralization and removal. Contaminated water should not be allowed to enter the main drainage system or water courses, but should be directed by sills into sumps.

There should be walls between sections to act as fire-breaks (Figure 9).

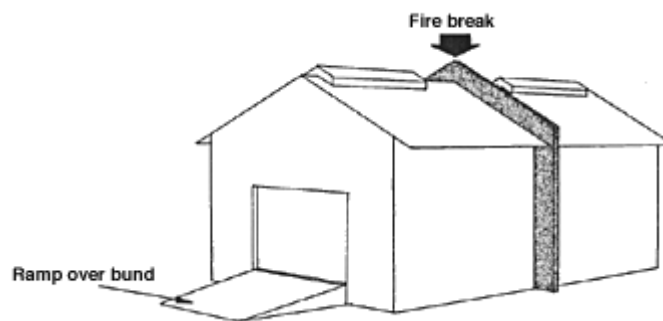


FIGURE 9 - Fire-break in a pesticide store

There should be an emergency exit in addition to the entrance doors, preferably at the other end of the store.

Ventilation is one of the most important requirements within the store as it prevents the buildup of vapours. Toxic vapours may affect the health of store-workers and inflammable vapours are a fire risk. Ventilation also keeps the store as cool as possible. This is important as pesticides deteriorate more slowly and therefore last longer in a cooler environment. Many pesticides are destabilized by high temperatures, which in exceptional cases may even cause explosions.

The ventilation area should be equivalent to 1/150 of the floor area, or outside doors should be open for at least six hours per week. Exhaust fans should be fitted to large stores, preferably on a time switch. Roof- and floor-level ventilation (gridded to prevent the entry of birds and rats) is required to extract light fumes, hot air and heavy vapours.

## Temporary storage





Temporary storage of pesticides away from a main store may be required during certain operations such as locust control. The basic principles still apply: keep the pesticides secure (fenced-in or locked inside a vehicle); store them indoors or under a roof to avoid direct sunlight

exposure; keep them dry, cool and well-ventilated, especially when they are stored in a vehicle which may become hot if left in the sun.

## Notices

A notice should be displayed on the outside of the store in the local language(s) with a skull and crossbones sign. The notice should read: "Danger pesticides. Authorized entry only". Strategically placed signs should be visually obvious and placed on the inside and outside of pesticide stores. These should read: "No smoking; no naked or half-dressed flame".

There should also be a list of colour codes on display in the store and on containers. Sticky labels for placing on metal and plastic containers are available. The lists in Figure 10 are included with GIFAP (1988a).

Hazard Label	Hazard Class	Method of storage
	2 (In)flammable gas (red background)	Segregate; explosion-proof equipment or open-air storage needed
	3 (In)flammable liquids; flashpoint 55°C or lower (red background)  (3 Combustible liquids; flashpoint over 55°C)	Not exceed 250 tonnes unless fire-protected  Recommended not to exceed 250 tonnes
	4.1 (In)flammable solids (vertical red and white background)	Recommended not to exceed 250 tonnes
	4.2 Spontaneously combustible (lower half red, upper half white)	Segregate, open-air storage recommended






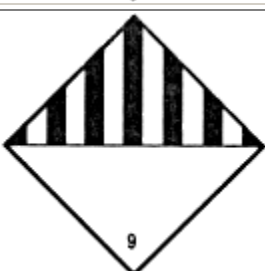
	<p>4.3 Dangerous when wet (blue background)</p>	<p>Segregate; no sprinkler! protect from rain</p>
	<p>5 Oxidizing substances (yellow background)</p>	<p>Separate from flammables or combustibles</p>
	<p>6.1 Poisonous substances (white background)</p>	<p>Legal requirements may demand segregation if highly toxic (LD<sub>50</sub> oral &lt; 25 mg/kg)</p>
	<p>8 Corrosives (white and black background)</p>	<p>Separate from pesticides packed in metal</p>
	<p>(white background) Various dangerous substances</p>	
	<p>(white and black background)</p>	<p>No limit; if non-combustible, use as a barrier for separation</p>

FIGURE 10 - Warning signs for display in stores and on containers

*Notes*

Inflammable and flammable have the same meaning (British and American usage).

Segregation means storing apart in different rooms with a fire-wall as barrier. Separation means storing apart in different parts of the same room.

After GIFAP, 1988

### **Storage of Pesticides**

As a general principle, systems of storage should be flexible and adaptable.

#### **Stacking positions and heights**

Stock should be arranged to use the oldest first ("first in first out" principle) and to prevent obsolete stock from accumulating. Containers should be arranged to minimize handling and thus avoid mechanical damage giving rise to leaks. Floor spaces should be uncluttered, with marked, 1-m wide, gangways between shelves or stacks (Figure 11) that permit easy inspection and allow free air flow (Figure 12). This also enables immediate clean-up in the event of any leakage or spills, which can be seen quickly. Climbing on pesticide containers to reach other containers should not be necessary - damaged or corroded metal drums can easily give way under a person's weight and this leads to potentially fatal gross contamination with pesticide.

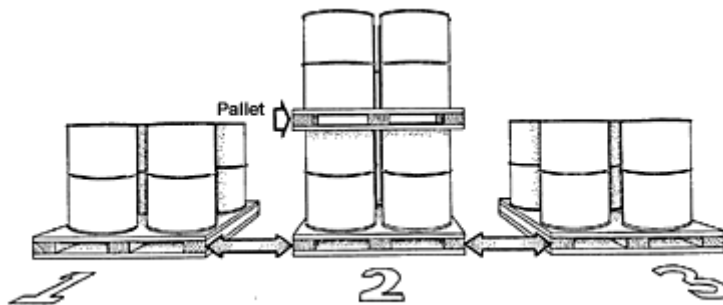


FIGURE 11 - Marked and numbered rows of stacked metal containers of pesticides with pallets below



FIGURE 12 - Aisle space to allow free air flow and access between rows of stacked pesticides

Dunnage (timber and bricks) should be used so containers are not placed directly on the floor. Stacked containers should be on pallets (Figure 13). Corrosion resulting from rising damp or leaking chemicals should be promptly observed and dealt with appropriately.

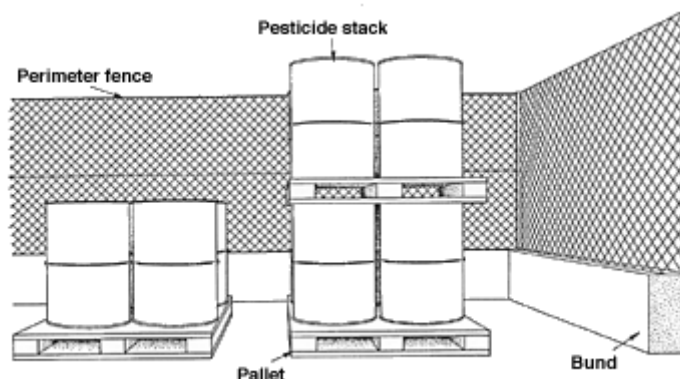


FIGURE 13 - Outside storage (temporary) of pesticides with perimeter fence and arrangement of pallets similar to that inside

Dust, granule and wettable powder formulations should be kept in cartons during storage to avoid caking. Concentrate formulations, especially those in glass bottles, should also be kept in cartons to avoid breakage.

Storage shelves should not exceed a height of 2 m to avoid the use of ladders.

Containers should not exceed a height of 107 cm on each pallet. Containers and cartons should be stacked at safe heights ensuring that they are stable (Figure 14). The safe height depends on container material (Table 1).

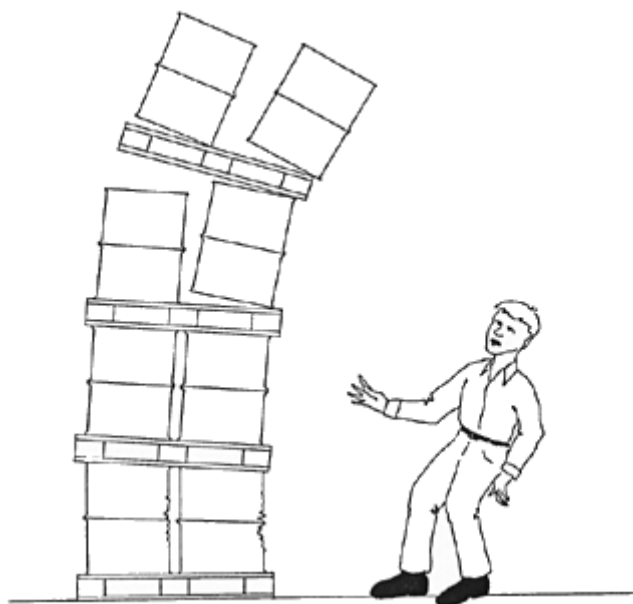


FIGURE 14 - Stacks that are too high become unwieldy and containers lower down are crushed

**TABLE 1**  
**Maximum stacking of containers on top of each other**

<b>Package type</b>	<b>Number of layers on basal pallet</b>	<b>Palletized: number of packages on each pallet</b>
Steel drums (200 l)	1	3-4
Steel drums (smaller than 200 l)	2	3-4
Fibre drums (200 l)	1	3
Fibre drums (smaller than 200 l)	2	3
Plastic drums (200 l)	1	2
Plastic drums (smaller than 200 l)	2	2
Paper sacks	4-5	3
Plastic sacks	4-5	3
Fibre case containing tins	4-6	3-4
Fibre case containing soft packages (plastic bottles, sachets)	4-6	2
Wooden cases	2-4	3-4

### ***Pesticide shelf-life***

The biological efficacy of pesticides gradually decreases with time. The pesticide shelf-life is the period of time that a pesticide can be stored before it deteriorates. Nearly all pesticides have a limited shelf-life. As part of modern pesticide formulation technology, packing methods and storage practice aim to prolong shelf-life as much as possible. Manufacturers indicate the shelf-life of the pesticide on the container, but many pesticides may still be usable long after the indicated shelf-life has expired. Most pesticides have an indicated shelf-life of at least two years from the time of manufacture, but shelf-life will be shortened if pesticides are not stored properly (e.g. if they are stored at high temperatures). Stock turnover organization needs to take into account the time that pesticides may have been in transit between manufacture and reaching the store.

Pesticides in sealed containers may change over time in two main ways:

- The active ingredient may change chemically and break down into products that may no longer have pesticidal properties, thus decreasing the concentration of the original active ingredient.
- The formulation of the pesticide may break down and a precipitate of flakes, crystals or sludges may form, making it impossible to mix or use in sprayers.

An organochlorine such as endosulfan is chemically very stable, but some formulations may break down more rapidly. Organophosphates are much less stable and therefore generally have a shorter shelf-life. Dust and wettable powder formulations tend to break down and cake together,



as a result of high temperature, high humidity, strong sunlight or compaction under pressure, more than liquids in sealed containers.

## Pesticide ordering and shelf-life

The shelf-life and rate of use must be taken into account when ordering pesticides (Figure 15). Do not order more than one year's requirement. The date of manufacture and shelf-life should be on the outside of the container. If a larger quantity is ordered than can be used during the period of shelf-life, outdated stocks will accumulate and present disposal problems, as well as financial loss.

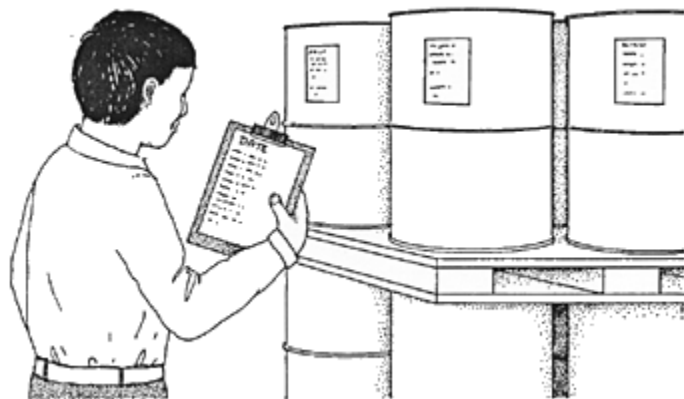


FIGURE 15 - Storekeeper checking dates from labels on containers in a pesticide store

## Stock inspection and shelf-life

Stocks in a pesticide store should be inspected regularly for signs of deterioration, such as caking of powders, sedimentation or gelling of liquids and discoloration through oxidation. Shelf-life declines rapidly after containers have been opened and left partially empty. Stock turnover must be organized to ensure that the contents of a container are used as quickly as possible once the container has been opened. Unsealed containers of dusts and wettable powders should not be kept for more than one year.

Containers are not only subject to deterioration caused by external factors (climatic, biological and mechanical), but can also be corroded internally through the action of the pesticides they contain. Emulsifiable concentrate formulations are particularly likely to affect weak spots, especially along seams (Figure 16) or where there are imperfections on the internal coating of the container. Some pesticides increase in acidity during storage and this makes them more likely to corrode containers from within. Discoloration of pesticide is a sign of corrosion of this type and should be looked for during stock inspections.

## Outdated pesticide stocks

Often there is no information on shelf-life on the pesticide container label. When this is the case, a two-year shelf-life should be assumed, unless more precise information can be obtained from the manufacturer or distributor at the time of purchase.

Outdated stocks may still be usable if the formulation has not broken down. The only way that

this can be verified is by having a sample of the product analysed by the manufacturer or at an independent laboratory and the dose measured accordingly. The date of the test must be attached to the drums after samples have been analysed. Trial and error methods that assess the pesticide's efficacy by using more concentrated doses or higher application rates are not recommended.

### Disposal of outdated and unusable pesticides

The main aim of good storekeeping is to minimize the need to dispose of stocks since the disposal of pesticides presents many problems. However, on occasion, it will be necessary to dispose of old stock. Store accounting procedures should allow for old stocks to be written off, that is there should be some system by which unusable pesticides can be removed from the store. Unfortunately the storekeeper does not always have the authority to do this and stock tends to remain on record whether it is usable or not. If there is no system whereby pesticides can be written off and subsequently disposed of, old pesticides soon present hazards as their containers deteriorate and start to leak. The disposal of unwanted pesticides is considered later on.

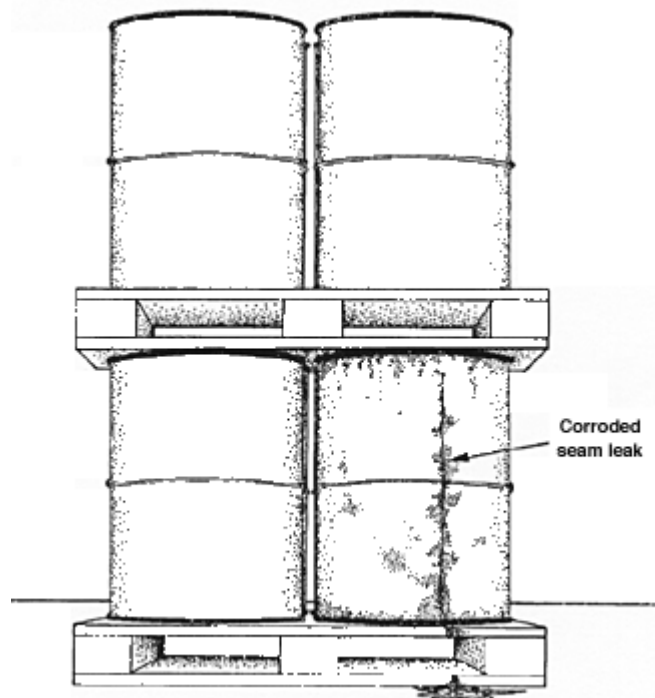


FIGURE 16 - Pesticide container corroded and leaking from a side seam

### ***Pesticide stock planning and recording systems***

Pesticide stores should have a proper system of stock planning and should keep records of stocks received, held and issued. No more pesticide should be ordered than is required or than can be stored in an appropriate way. Major problems have been caused where there was no

system or where the storekeeper had not been trained in, or failed to use, an existing system. Without a record system, orders for excessive quantities of pesticide can be made and the most recently received stock tends to be issued first because older stock is less accessible or the customer wants "fresh" pesticide.

As pesticides have a limited shelf-life, it is essential that only sufficient pesticide is ordered for requirements and that issues are made on a "first in -first out" basis. If such a procedure is not followed, old, out-of-date stocks of pesticide accumulate in deteriorating containers, particularly in dark recesses of the store.

Not only do these stocks represent a financial loss to the store-owner (government, marketing board, agricultural cooperative, pesticide wholesaler or retailer or individual farmer), but they also constitute a hazard to personnel working in the store and present an environmental problem when they are eventually disposed of. The movement of chemicals into and out of the store must be carefully recorded. This information may also be required for emergency services, such as the fire brigade, in the event of a disaster so that the volume of pesticides involved can be assessed.

## Record systems

The record system adopted will depend on the size and function of the store and on the accounting requirements of the store-owner. Records should be kept separate from the pesticide store.

### Small store

No elaborate system is required or usually possible at the minimum level of, for example, a small-scale farmer storing only a few pesticides. But even the small-scale farmer should adhere to the following practices, which are essential in all pesticide stores of whatever size:

- The date of purchase or arrival should be written on each container as it is deposited in the store.
- Ensure that all containers have proper labels and that these remain attached to the containers and are clean and readable; labels in poor condition should be replaced.

In addition, the small-scale farmer should keep invoices, delivery notes or receipts obtained in connection with pesticide purchases separate from the store. This will enable the farmer to contact the pesticide supplier in the event of an emergency or if further advice is needed. The farmer should also have a supply of material safety data sheets, which the supplier or manufacturer can provide.

### Large store

Any store above the size of a small-scale farmer's will require some sort of formal records system. The system adopted depends on circumstances. Records should be kept separate from the pesticide stock so that they are not destroyed in the event of a major disaster (such as fire, flood, earthquake, hurricane or destruction during civil unrest).

Records may be kept as sheets in a ledger or in card index form. Duplicate records adjacent to the stock itself may also be required, perhaps in simplified form. Again, a supply of material safety data sheets should be requested from the supplier or manufacturer.

Records should be accurate and sufficiently detailed to enable a replacement storekeeper to take over responsibility without needing to refer to the previous storekeeper.

Pesticides have a limited shelf-life, and stock batches bought at different times may vary in formulation and packaging. It is important that a completely separate record be allocated to each consignment of different pesticides as it is received by the store.

The national authority responsible for the procurement of pesticides needs to be regularly updated on stocks kept in various locations in the country and stores should be able to supply this information.

A possible layout for a pesticide store record sheet is given below. The store record sheet allows the progress of each consignment of a particular pesticide to be followed from receipt, through inspections, stocktaking and checking to issues, analysis of stock after the shelf-life has expired and disposal when deterioration has been established.

Well-kept records are the sign of a properly run store and are essential for minimizing wastage of stock or damage caused by accidents. The store supervisor should ensure that there is an adequate system being followed by the storekeeper at all times. The storekeeper should be trained in the use of the records system and must be responsible for its upkeep.

### Sample pesticide store stock record sheet

<b>Pesticide group</b>	<i>Insecticide OP</i>
<b>Ref. no.</b>	<i>Inv 29/5[R3]</i>
<b>Common name</b>	<i>Chlorpyrifos</i>
<b>Trade name</b>	<i>Dursban</i>
<b>Formulation/concentration</b>	<i>% ec, 400 g/litre</i>
<b>Manufacturer/supplier</b>	<i>Dow Elanco, USA</i>
<b>Quantity</b> ( <i>agreed issuing quantity/package</i> )	<i>1 000 2.5-litre plastic containers</i>
<b>Primary packaging quantity</b>	<i>Four containers of 250 cartons</i>
<b>Date received</b>	<i>20 December 1994</i>
<b>Use-by date</b>	<i>1 December 1996</i>
<b>Notes</b> ( <i>shelf-life; special storage conditions; inspection frequency</i> )	<i>Two-year shelf-life; keep cartons sealed; inspect every six months; look out for breakdown of plastic containers</i>

<b>Date</b>	<b>Quantity issued</b> (litres)	<b>Balance in stock</b> (litres)	<b>Notes</b> ( <i>stock inspection: notes on condition etc. storekeeper's initials</i> )
<i>25 December 1994</i>	<i>650</i>	<i>1 850</i>	
<i>6 June 1995</i>			<i>Stock inspected; no damage. MRKL</i>
<i>10 June 1995</i>	<i>1 300</i>	<i>550</i>	<i>Stock check. MRKL</i>
<i>10 September 1995</i>		<i>548</i>	<i>Stock inspected; two containers leaking; disposed of. MRKL</i>
<i>30 September</i>	<i>548</i>	<i>nil</i>	

1995			
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**Record of disposal of outdated stock**      *Leak absorbed by sawdust and burnt, split containers relocated to store II and contents transferred*

*(MRKL are the storekeeper's initials)*

### Notes on the sample record sheet

**Reference number** Cross-reference should be made to the invoice or delivery note; location of the pesticide in the store (bin, shelf or row number).

**Identification of the pesticide** Pesticide group, common and trade names with details of formulation and concentration should all be recorded.

**Source of the pesticide** Where possible information on primary manufacturer or formulator, as well as local source, should be recorded (with local telephone number where available in case of emergency). Where the pesticide came from should also be recorded since many stocks are shifted around.

**Packaging and issuing units** These may differ; the pesticide may be in 200-litre metal drums or in 1-litre cans packed in boxes of 20 with sales or issues being made in units of the 1-litre can.

**Date received** Possibly the most important item of information; it is essential that this should be documented. It must also be recorded on the actual pesticide containers together with the use-by date (Figure 17).

**Notes** Information should be obtained from the supplier on shelf-life (use-by date), any special storage requirements, particular hazards and other details, which should be incorporated as instructions to the storekeeper on the record form.

**Stock operation and management** Details of receipts and issues must be meticulously recorded and records of periodic stock inspections should be kept initialled by the inspector. Careful notes should be made on the state of containers and contents at the time of inspection.

**Disposal** When outdated stock is eventually disposed of it should be recorded, with notes on the method of disposal of the pesticide and its containers, the location of dumps, etc.

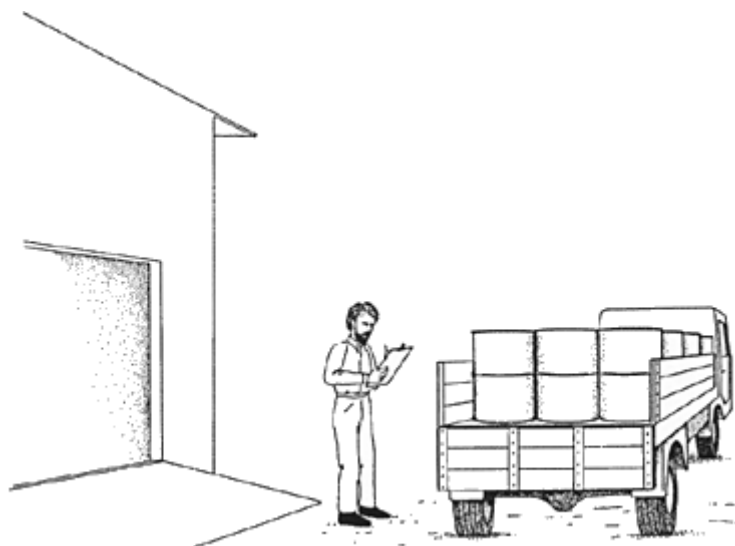


FIGURE 17 - Storekeeper recording date of arrival and inspecting condition of new stocks of pesticides, clipboard in hand

### ***Local transport of pesticides***

Severe cases of poisoning have been caused by the transportation of pesticides with other commodities.

Containers of pesticides have leaked during movements, contaminating foodstuffs such as flour and rice packed in sacks and carried in the same truck. People have eaten the food after it has arrived at its destination and have become ill; thousands of deaths have resulted from poisoning in this way. There are several basic points to be remembered:

- Food, animal feed or general consumer goods should not be transported in the same truck as pesticides (Figure 18).
- Open or leaking containers of pesticides should never be transported.
- If pesticide containers must be transported with other goods, they must be separated in sealed partitions and securely fixed with straps or rope.
- Pesticide containers should be loaded in such a way that they will not be damaged during transport, that their labels will not be rubbed off and that they will not shift and fall off the truck on rough road surfaces (the load must be securely fixed).
- The truck driver or railway officials should be informed that the load consists of toxic pesticides and should be given instructions on what action to take in the event of an emergency (crash, fire, spillage). Material safety data sheets should be provided if possible.
- The pesticide load should be checked at intervals during transportation and any leakage, spills or other contamination should be cleaned up immediately. In the event of leakage while the means of transport is moving, the vehicle should be

brought to a halt immediately to stop the leakage and the leaked product should be cleaned up.

- With a major spill, people should be kept away and the spill covered with earth, sand, etc. (Figure 19); no attempt should be made to wash away the spill with water or other substances.
- The truck, including tarpaulins and other goods, should be checked for evidence of spills or leaks after the pesticides have been unloaded, and then decontaminated of pesticide before it next departs.
- Pesticide containers should be loaded and unloaded carefully (Figure 20); most leaks from containers in storage are caused by damage during transportation and handling.
- Newly arrived consignments should be checked for leaks and loose lids, and repacked immediately if necessary. Replace torn or unreadable labels. A supply of empty new containers should be available for repacking from damaged ones.

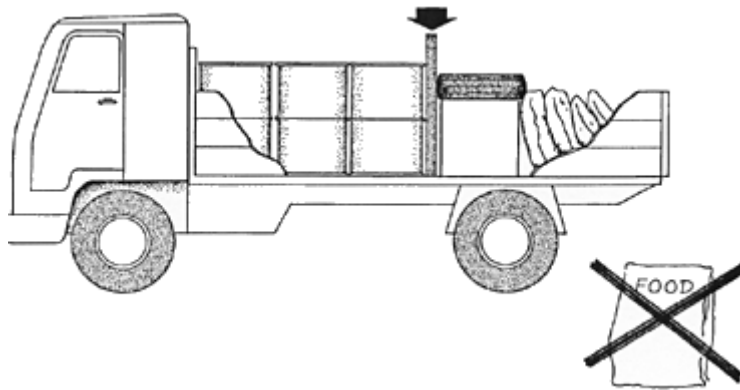


FIGURE 18 - Local transport of pesticide on a goods vehicle - other materials are partitioned off but food must not be carried



FIGURE 19 - Spill, caused by a pesticide drum falling off a vehicle, being covered by soil - people are kept away from the spill



FIGURE 20 - Careful unloading of pesticides from a delivery vehicle to avoid leaks resulting from damage to containers;  
the storekeeper is examining the delivery note

## ***Spills, leaks and disposal of containers and chemicals***

Pesticides are biologically active materials and potentially hazardous to human health and the environment. Complete decontamination and effective disposal are often very difficult to achieve. One of the most important objectives of good store management is therefore to minimize the occurrence of leaks, spills and outdated stock.

### **Spills**

There will occasionally be spills, even in the best run stores, especially where concentrates are repacked and transferred into other containers. Spills must be cleaned up immediately. Always have two people working when handling severe spills.

Untreated spills may corrode other containers, become trodden in and contaminate store personnel and may produce toxic or inflammable fumes. If not removed quickly, the spilled chemicals may be absorbed by the floor. Floors therefore need to be made of impermeable (sealed) concrete or other non-absorbent material - removing the contaminated part and replacing it may be the only way to decontaminate absorbent brick, earth or wooden floors.

### **Liquid spills**

The spill should not be hosed down as this merely disperses the pesticide over a wider area. A supply of absorbent sawdust, sand or dry soil should be kept in a container in the store. Nitrile rubber protective gloves and face-mask should be worn.

Sawdust, sand or dry soil should be scattered over the area of the spill and left for a few minutes to soak up the chemical.



The sawdust, sand or dry soil containing absorbed spilled chemical should be swept or shovelled up and placed in a marked container for disposal (Figure 21).



FIGURE 21 - Spill soaked up by sand or sawdust being carefully swept up by the storekeeper and placed in a container to be collected and taken for central disposal by the national authority

After sweeping, more than once if necessary, a scrubbing brush at the end of a stick should be used to scrub down the area of the spill with water and strong soap or detergent. Excess soapy water should be removed with a rough floor cloth and not hosed down.

## Solid spills

Dusts, wettable powders or granules can create dust when swept up without the use of an absorbent material. A supply of absorbent sawdust, sand or dry soil should be kept in a container in the store where they can easily be reached for use in an emergency .

Nitrile rubber protective gloves and face-mask should be worn.

The sawdust, sand or dry soil should be dampened and applied with a shovel over the area of the spill.

The damp sawdust, sand or soil containing spillage material should be swept or shovelled up carefully and placed in a marked container for disposal (Figure 21).

After sweeping, more than once if necessary, a scrubbing brush at the end of a stick should be used to scrub down the area of the spill with water and strong soap or detergent. Excess soapy water should be removed with a rough floor cloth and not hosed down.

## Leaks

Leakage from containers is a major problem in the storage and transport of pesticides (Figure 22). The main cause is rough handling which dents drums, weakens or splits seams and weakens closures (lids, caps and stoppers). Other causes of mechanical damage are puncturing or abrasion during transport when packages and containers rub against one another or against the sides of the truck travelling over uneven surfaces and rough roads.

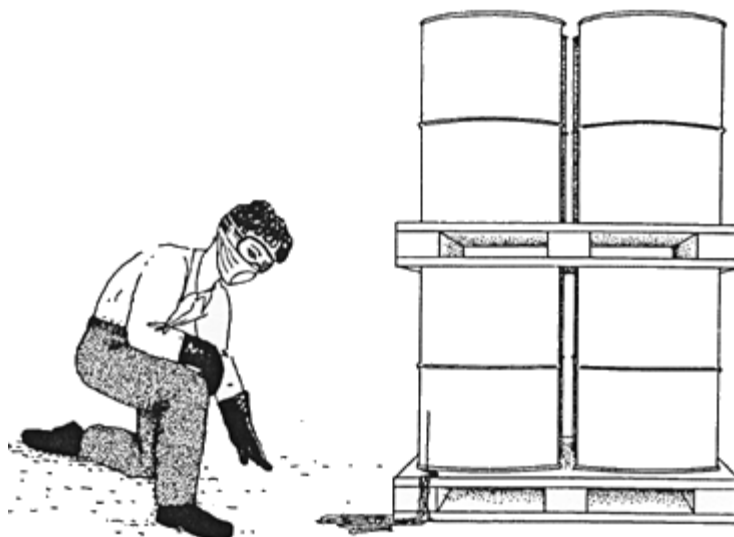


FIGURE 22 - Storekeeper inspecting a leak from a pesticide container

Leaks also result from corrosion of the container, which may be accelerated by mechanical damage (dents may rupture drum linings, for example). Corrosion may start internally, the pesticide itself or its breakdown products being the primary cause. Alternatively, corrosion may begin externally, as a result of rusting in damp storage conditions or contamination from pesticide leaking from nearby containers. Many emulsifiable concentrate (ec) formulations are very corrosive. Some, including monocrotophos, dicrotophos, dichlorvos and phosphamidon are incompatible with steel, so they should be packed in plastic or aluminium containers or in steel containers lined with inner coatings. Some pesticides are dissolved in organic solvents that cannot always be packed in plastic drums.

Containers may leak for other reasons; for example, strong sunlight can degrade some plastic containers, including bottles and plastic sacks. Rodents may damage paper, board or fibre containers. Termites may attack paper and card.

Stores should be inspected regularly, at least every two months. Old, rotting and leaking containers are extremely difficult to move safely, so any leaking containers should be dealt with immediately.

Usually, the only way to deal with a leak is to repack the material in a sound container. New containers are preferable, if available, but old containers of various types and sizes may be used for this purpose (old containers are also useful for temporarily storing the products of spills). They must have been thoroughly decontaminated (see next section) and their old labels completely removed.

Pesticides should be repacked in containers made of the same materials as the original containers as some chemicals are not compatible with different materials. Ideally a drum that contained the same product should be used. If unavailable, the container must have been properly cleaned of previous contents to avoid cross-contamination. New labels must be written out immediately with all the information on the old label and fastened securely to the new container. Write the date of repacking (and the date of the original receipt) on the replacement container and ensure that the repacked material is used first.

## Disposal

### Disposing of pesticide containers

Many accidents have been caused by empty pesticide containers being used to store water and food. An empty pesticide container can never be cleaned completely of pesticide and should be disposed of in a way that ensures it cannot be used for other purposes. It is, however, wise to retain samples of various types of container, which have been carefully cleaned, in the pesticide store for use in repacking the contents of damaged containers and storing cleaned up leaks and spills prior to final disposal.

Empty containers awaiting disposal should be stored in a special, secure area in the pesticide store to ensure that they are not stolen and used for other purposes.

Empty containers should always be cleaned out, as far as is practicable, before disposal to minimize both hazard and waste of residual pesticide. Containers that have contained ec or wettable powder (wp) formulations should be rinsed with water several times and the rinsings added to the spray tank before it is topped up to the required volume. Following this, containers can be washed out with a mixture of water, detergent and caustic soda (Figure 23). Containers of liquid formulations may be cleaned with kerosene (paraffin) or diesel fuel and the washings (small quantities of about 5 litres) collected for sending later to a central location for disposal by the national authority in a safe and environmentally sound manner.



FIGURE 23 - Decontamination of a pesticide container - the inside and outside are being cleaned with detergent and water -  
highly contaminated rinsings should be saved for disposal with other major toxic waste

As long as they are not heavily contaminated paper, cardboard and fibreboard containers should be burnt on a fire in the open (Figure 24). However, cartons that have contained phenoxy acid herbicides should not be burnt because the combustion products can damage crops at long distances. Highly contaminated cardboard, paper and jute materials should be collected and sent to the central disposal centres along with other toxic waste.



FIGURE 24 - Disposal of lightly contaminated cardboard pesticide container on a fire, ensuring that fumes travel away from personnel

Containers rendered unusable, the products of decontamination procedures, leaks and spills, and container rinsings (where these have not been added to the spray tank) should all be collected for sending later to a central location for disposal by the national authority.

Glass containers should be smashed and steel drums and metal and plastic containers punctured (Figure 25) and crushed (do not puncture aerosol containers) before being sent to a central location for disposal by the national authority.



FIGURE 25 - Metal container being crushed so that it cannot be reused - it will be collected for central disposal by the national authority

## Disposing of unwanted pesticides

Using pesticides for their intended purposes according to label instructions is the most satisfactory means of disposing of them. For this reason, no more than one year's requirement of pesticides should be ordered and stored, so that none will remain at the end of the product's shelf-life of two years. Only as much pesticide as can be used in a day's operations should be withdrawn from the store and only as much as will go into the sprayer tank should be mixed.

Occasions will arise when it will be necessary to dispose of pesticide concentrates, either because the stock is outdated and has been found to be unusable or because the product is no

longer registered for the original purpose. Where very large quantities are to be disposed of, professional advice must be sought from the suppliers and national authority.

If only a few kilograms or litres of pesticide are involved, they should be collected for sending later to a central location for disposal by the national authority. Larger quantities of pesticides are best disposed of by burning in a special incinerator (at 1 200°C) - this does not mean that it would be safe to burn them at a lower temperature on a fire. Incineration requires special equipment with provision for "scrubbing" the combustion products, but this is beyond the capacity of pesticide storekeepers and should be referred to the relevant national authority.

Other means of disposal are to return the pesticide to the supplier or pass it on to a specialist disposal agent elected by the national authority.

Returning the pesticide to the supplier or to the national authority is the safest means of disposal. Disposal involves chemical methods such as alkaline and acid hydrolysis. Oxidation, reduction and spraying on to the ground or allowing to escape into the atmosphere may also be employed, but require specialist skills. The end product in most cases is still toxic. Storekeepers should not become directly involved with pesticide disposal and should refer to the relevant national authority.

## ***Decontamination***

### **Personnel**

Pesticides coming into contact with the skin can rapidly enter the body. Successful decontamination of body surfaces requires:

- prompt action and rapid application of plenty of soap and water;
- extremely thorough washing.

Anyone contaminated with pesticide should strip off their clothing and quickly and thoroughly scrub the affected part of their body with soap and water. This should be followed by careful rinsing and towelling dry (Figure 26).



FIGURE 26 - Storekeeper decontaminating himself by washing thoroughly with soap and water - his protective clothing, washed separately, is hanging out to dry in full sunshine

## Protective clothing

Contaminated protective clothing should be thoroughly washed using industrial grade detergent followed by several rinsings. Protective clothing should not be washed with the family wash. Gloves should be worn when washing protective clothing. Hot water should be used when available. Washed clothes should be hung to dry in full sunshine.

Where there is a large patch of fabric that has been contaminated by toxic concentrates and replacement clothing is available, it is best to destroy the affected clothing by burning.

## Stores and vehicles

When dealing with leaks and spills, water, soap or detergent are usually the most readily available materials for decontamination. However, other chemicals sold for domestic or common commercial purposes may be useful too.

Organophosphorus compounds can be treated by sodium hypochlorite (bleach) and sodium carbonate (washing soda), which are useful for decontamination and can be applied following initial scrubbing with soap and water.

Organochlorine compounds are persistent chemicals and household ammonia and washing soda can be used, but the main method is to scrub with water and detergent. Carbamates should be scrubbed with washing soda or strong soap.

Transport vehicles should be decontaminated thoroughly as soon as spills or leaks are seen, otherwise there is a danger that when used subsequently for other goods, including foodstuffs, the goods could become contaminated (Figure 27). Spills are cleaned up in the same way that they are in stores. The contaminated washings from the vehicle should be absorbed by sawdust, sand or dry soil and placed in a container for collection and central disposal by the national authority.



FIGURE 27 - Scrubbing the back of a delivery truck using detergent and water to decontaminate it of pesticides

## **Major emergencies**

Major emergencies are a far greater risk for pesticide stores than they are elsewhere.

### **Fire**

The primary objective in the design and management of pesticide stores is to reduce the risk of fire. Prevention is better than cure!

Pesticides, especially those formulated as liquids, present major fire hazards because the solvents used in formulations (oils and petroleum distillates) have low flashpoints and may be readily vaporized at normal temperatures. In poorly ventilated stores heavy vapours may accumulate near the floor if drums are left open or if leaks and spills are not cleared up. An electrical spark, naked flame or even the sun's rays concentrated by a glass container may cause an explosion followed by the spread of fire.

Some wettable powders are suspected of starting fires through spontaneous combustion, while sodium chlorate (used as a herbicide, defoliant, desiccant and soil sterilant) is a powerful oxidizing agent that easily catches fire and should only be supplied with a fire suppressant in the formulation (once sodium chlorate containers have been opened their entire contents should be used immediately).

The outside of pesticide stores should bear prominently displayed warning notices stating "Danger pesticides: authorized persons only" and "No smoking: no naked flame" as well as symbols. These rules should be strictly followed.

Fire extinguishers (powder or carbon dioxide, not water) should be available in the store and should be regularly checked. Static or running water (required, together with soap, for decontamination purposes anyway) should also be available and buckets of sand or earth (also required for absorbing any liquid pesticide spills or leaks) are useful for putting out small fires (Figure 28).



FIGURE 28 - Extinguishing a small fire in a pesticide store using shovelfuls of sand or earth from a container

The local fire brigade should be informed of the store's existence and the hazards involved. It is very useful to place a notice on the outside of the store giving names and addresses of those responsible for the store (including key holders) who can be contacted in an emergency.

In the event of a fire it is essential to try to contain the pesticides that leak from burning and exploding containers in the store. Hence the need for bunding of some kind to be provided when the store is built; bunds also prevent the water used to fight the fire, which inevitably becomes contaminated with pesticides, from contaminating the neighbourhood and thus the environment generally.

Contamination of the environment from combustion products such as smoke and fumes cannot be prevented. A light roof designed to collapse easily in a fire will at least permit the fumes to be carried upwards away from the fire-fighters (Figure 29).

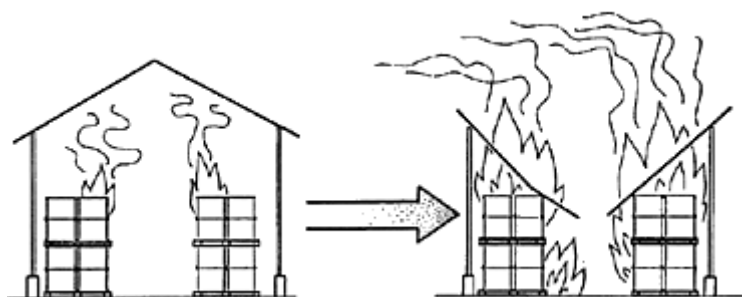


FIGURE 29 - Pesticide store in flames - the light roof has collapsed thus preventing an explosion

Fires in pesticide stores that contain organophosphorus compounds and carbamates can be extremely dangerous to fire-fighters, who should never go downwind of the fire and should always wear breathing apparatus.

Solid water streams from fire-fighting hoses should be avoided since they can disperse the pesticide, especially powder formulations, over a wide area. Care should also be taken to avoid dragging fire hoses through contaminated water.

Protective clothing and equipment used by fire-fighters should be thoroughly decontaminated after the fire.



## Flooding

Flooding during seasonal rains is a common event in tropical countries. Flooded pesticide stores are subject to special hazards.

Cardboard or paper containers in which many pesticides are packed lose strength and may leak or burst open when wet. Other containers, especially partially empty drums of liquid, may be swept away with a flood. Environmental contamination over a wide area may result from either of these events; water supplies may become polluted and pesticide containers may present a hazard to people who find them.

## Destruction

Dangers from fire, flooding and destruction during civil disturbances emphasize the value of keeping records of stocks in a place where they will be safe in an emergency. Records of the quantities and types of pesticide involved prove invaluable in subsequent efforts to clean up, trace missing containers and assess the environmental risk and financial loss caused by the emergency.

### ***Personal safety and protective clothing***

When working with pesticides, do not eat, drink or smoke. Wash hands and face thoroughly with soap and water before smoking or eating. Also wash your hands before using the toilet. Some form of protective clothing is required when handling and transferring pesticides in stores. In warm, humid tropical climates, wearing additional protective clothing may be uncomfortable. Ideally, therefore, only pesticide types and formulations which do not require additional protective clothing should be stored. This is unlikely to be possible in most cases however.

## General body protection

The garments worn should have long sleeves and covering for the lower body and legs. Footwear (boots or shoes) and some kind of head covering should also be worn. Many kinds of normal clothing in tropical and subtropical countries provide good general body protection in any case, but work clothing should be in a good state of repair and should not have tears or worn areas through which pesticides can enter and contaminate the skin. Work clothing, including footwear, must be washed in water with soap or other detergent after each day's use, separately from other clothing.

## Hand protection

When pouring and otherwise transferring pesticides from one container to another, chemical-resistant gloves should be worn (Figure 30). They must fit the hands comfortably and be flexible enough to grip pesticide containers firmly. They must be long enough at least to cover the wrists.



FIGURE 30 - Storekeeper wearing mask, eye protection, gloves and apron over shirt and trousers to protect himself from splashes while transferring pesticide concentrate

Gloves made of nitrile rubber or neoprene offer good protection against a wide range of pesticide products, especially those dissolved or suspended in water, granules or dusts. Gloves made of natural rubber do not provide sufficient protection against products such as emulsifiable concentrates and ultra-low-volume pesticides.

The outside of gloves should be rinsed with water before removal and the gloves should be washed inside and out and allowed to dry after each day's use. They should be examined for signs of wear and tear, particularly between the fingers.

### Footwear

Calf-length rubber boots give protection against a wide range of dilute pesticide products. Leather footwear is unsuitable because it absorbs some pesticide products and cannot be decontaminated. Trousers should be worn outside the boots so that spills and splashes do not fall into them.

### Eye protection

Goggles or face shields are used to protect the eyes from splashes (Figure 30) and when transferring dusts. Face shields are cooler to wear in hot, humid climates and do not mist over as easily as goggles. Although they provide less satisfactory eye protection, the use of safety spectacles is preferable to no protection.

Wash after use to remove any contamination. An eyewash set should also be available.

### Protection against inhalation

There should be a sufficient stock of lightweight disposable masks that cover the mouth and nose when handling dusts. The masks must be discarded after use. Vapour masks or half-face respirators with organic vapour cartridges should also be available.

## Apron covering

Aprons are useful additional protective items for loading operations, handling concentrated formulations and cleaning out containers before disposal. Aprons made of PVC, nitrile rubber or neoprene, or disposable ones made of polyethylene materials, provide adequate additional protection for operations of this kind. The apron should cover the front of the body up to the neck and down to the knees. As with other protective equipment, aprons must be washed after use and inspected regularly for signs of damage.

If items of protective clothing are not available, the national authority responsible for supplying or distributing pesticides should ensure that they are provided. Donors and suppliers of pesticides should be asked to provide them.

## Annexes

### Essential equipment within a pesticide store

**Thick polyethylene sheeting on floor** (if surface is not concrete or otherwise impermeable)

**Floor dunnage** (bricks, timber)

**Wooden pallets**

**Ramps at entrance to contain leakage**

**Entrance door with lock to prevent unauthorized entry**

**Bars across windows and ventilators to prevent unauthorized entry**

**Container of absorbent sand, sawdust or dry soil**

**Shovel**

**Long-handled brush with stiff bristles**

**Short-handled brush and pan**

**Water supply, or container of water, with soap**

**Detergent solution**

**Drum spanners**

**Metal funnels**

**Fire-fighting equipment:**

fire extinguisher

fireproof blanket

**Protective clothing:**

helmet or cloth cap

safety spectacles, goggles or face shield (attached to helmet)

dust or light fume masks

emergency vapour masks or half-face respirators with organic vapour cartridges

nitrile rubber or neoprene gloves or gauntlets

overalls

nitrile rubber or neoprene aprons

strong rubber or neoprene boots

**Empty pesticide containers** (preferably salvage drums that can contain a whole 200-litre drum)

**Empty bags to repack heavily damaged or leaking containers**

**Self-adhesive warning labels for marking drums**

**Emergency first aid equipment:**

- first aid box
- stretcher and blanket
- eyewash set

**Stock record sheets**

## **Routine pesticide store management procedures**

1. The storekeeper should put on essential protective clothing (overalls and boots) upon arrival at the pesticide store.
2. There should be a quick daily inspection of drums and containers to ensure that there have been no overnight spills or leaks.
3. Spilled and leaked pesticide must be cleaned up immediately, using the methods described in section ["Spills, leaks and disposal of containers and chemicals"](#).
4. Drums and containers should be thoroughly inspected monthly for leaking seals, split seams and corrosion.
5. Leaking or old drums should be removed and their contents transferred to empty containers. Appropriate protective clothing should be worn and precautions taken as described in section ["Personal safety and protective clothing"](#). Replacement containers should be sealed and relabelled.
6. Transfer of chemicals to new containers should be recorded on the stock record sheet.
7. Dates on labels of containers in the store should be checked monthly and outdated stock separated for disposal. Any labels in poor condition should be replaced.

Arrival of a consignment of pesticides at the store:

1. The back of the transport vehicle should be checked for spills and the containers for leaks or broken seals; the vehicle should be decontaminated of any spills. Chemicals from containers with leaks or split seams should be transferred to empty containers in good condition and relabelled.
2. Pesticide containers should be carefully unloaded from the delivery vehicle. The delivery note should be examined and check-list of chemicals arriving at the store should be prepared on a stock record sheet.
3. Containers of chemicals placed in the store should be set on floor dunnage and stacked using wooden pallets as necessary.
4. The location of chemical containers in the store should be recorded on the stock record list.

Taking pesticides from the store for pest control purposes

1. The condition of the transport vehicle should be checked before placing containers of pesticides in it. It should also be ensured that no foodstuffs are to be carried on the same vehicle.
2. The removal of pesticides from the store should be recorded on the stock record sheet.
3. The stock first deposited in the store should be the first to be taken out.
4. Pesticide containers should be carefully loaded on to the despatch vehicle and the driver provided with a delivery note.

### Ten rules for proper pesticide storage and stock management

1. Pesticide stores should not be located in or near densely populated urban areas or near water bodies.
2. The storage capacity (total storage surface) should be sufficient to store the total stock of pesticides at any time.
3. Each store should have at least the following:
  - sufficient ventilation openings to avoid unnecessarily high temperatures;
  - floors made of, or covered by, impermeable concrete or cement (as a temporary measure, floors may be covered by a large and thick polyethylene sheet);
  - ramps at entrances to contain any major leakage within the store;
  - doors that are lockable and bars across ventilation holes and windows to prevent unauthorized entry.
4. The floor of the store should have a layout of separate blocks with aisles between them. Ideally the outline of the blocks should be painted on the floor. Each block should contain only one product. There should be sufficient space between blocks to move containers freely, enable the inspection of containers and treat leakages. Drums should be stacked in such a way that each can be inspected from the aisles between the blocks. Drums and bags should be stored on pallets. The number of containers stacked on top of each other should not exceed the stacking recommendations for the type of container concerned. Overstacking may lead to rupture of containers lower down and reduces access to containers.
5. Pesticide stores should only contain pesticides. All other goods or objects should be removed.
6. Obsolete pesticides should be separated from operational stocks.
7. Each store should have the following for dealing with emergencies:
  - a few bags of sawdust and/or sand to absorb leaked or spilled pesticides;
  - a number of empty containers (preferably salvage drums that can contain a whole 200-litre drum) and empty bags to repack heavily damaged or leaking containers;
  - spade and brush;
  - fire extinguisher;
  - protective gear for staff to enable them to deal with emergencies (nitrile rubber or neoprene gloves, rubber boots, overalls, goggles, vapour masks or half-face respirators with organic vapour cartridges)

- water supply from a tap, or a container of water, to wash hands and face if these become contaminated;
  - eyewash set.
8. The contents of leaking or heavily damaged containers should be repacked in appropriate replacement containers. Repacked pesticides should be labelled immediately. Stores should be inspected regularly. Any leakage or contamination should be cleaned up immediately.
  9. Storekeepers should keep a record of the stocks in their custody and a separate record of stocks in the country should be kept centrally. Recorded data should include: for incoming pesticides, the arrival date, formulation, quantity, unit size, date of manufacture, supplier and origin; for outgoing pesticides, the date, formulation, quantity, unit size and destination. Records should be updated regularly.
  10. A "first in - first out" principle should be applied consistently. In other words, always finish old consignments before using newly arrived consignments.

## References

- FAO. 1985. Guidelines for the packaging and storage of pesticides. Rome, FAO.
- GIFAP. 1984. Guidelines for emergency measures in cases of pesticide poisoning. Brussels, International Group of National Associations of Manufacturers of Agrochemical Products (GIFAP).
- GIFAP. 1985. Options for ensuring quality in stored pesticide products. Technical Monograph No. 10. Brussels, GIFAP.
- GIFAP. 1987. Guidelines for the safe transport of pesticides. Brussels, GIFAP.
- GIFAP. 1987. Guidelines for the avoidance, limitation and disposal of pesticide waste on the farm. Brussels, GIFAP.
- GIFAP. 1988a. Guidelines for safe warehousing of pesticides. Brussels, GIFAP.
- GIFAP. 1988b. Pictograms for agrochemical labels: an aid to the safe handling of pesticides. Brussels, GIFAP.
- GIFAP. 1989. Guidelines for personal protection when using pesticides in hot climates. Brussels, GIFAP.
- ILO. 1991. Safety and health in the use of agrochemicals: a guide. Geneva, International Labour Organisation (ILO).
- NRI. 1994. Training supplements, Pesticide Management Training Course. Chatham, UK, Pest Management Department, Natural Resources Institute (NRI).
- Shell International Chemical Company Limited. 1982. Pesticides: a safety guide. London, Shell.
- UKASTA. 1979. Agrochemicals storage handbook. London, United Kingdom Agricultural Supplies and Trade Association (UKASTA).
- UNEP. 1990. Storage of hazardous materials: a technical guide for safe warehousing of hazardous materials. Technical Report Series No. 3. Paris, Industry and Environment Office, United Nations Environment Programme (UNEP).

- WHO. 1986. Informal consultation on planning strategy for the prevention of pesticide poisoning. 25 to 29 November 1985, Geneva. Unpublished World Health Organization (WHO) document WHO/VBC/86.926.