Environmental Assessment for IRS Using Bendiocarb, DDT and Lambda-Cyhalothrin for Malaria Control in Mozambique

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February 5, 2007

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Prepared for
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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.

ENVIRONMENTAL ASSESSMENT FOR
IRS USING DDT FOR MALARIA CONTROL IN MOZAMBIQUE

PROGRAM/ACTIVITY DATA:

Program/Activity Number:	656-0008
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Program/Activity Title:	SO8: Integrated Health Sector (HIS) Strategic Objective Agreement (SOAG)
Sub-Activity:	IRS Using DDT for Malaria Control in Mozambique

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ENVIRONMENTAL ACTION RECOMMENDED: (Place X where applicable)

Categorical Exclusion: ____ Negative Determination: ____
Positive Determination: _X__ Deferral: ____

ADDITIONAL ELEMENTS: (Place X where applicable)

CONDITIONS: ____ PVO/NGO: ____

SUMMARY OF FINDINGS:

This program is associated with the U.S. President's Malaria Initiative (PMI) in Africa, which seeks to reduce malaria mortality by 50% in up to 15 countries in sub-Saharan Africa by 2010. The United States will work in partnership with host governments and build on existing national malaria control plans, policies, and resources. The PMI will support and complement the efforts of the Global Fund, the World Bank, and other members of the Roll Back Malaria Partnership. Mozambique is one of four second-year countries to be selected for PMI.

The Initial Environmental Examination in 2005 of the United States Agency for International Development (USAID)/Mozambique's Strategic Objective (SO) 8, Integrated Health Sector (HIS) Strategic Objective Agreement (SOAG) identified distribution, re-treatment, and use of re-treatable Insecticide Treated Nets (ITNs) and Long-Lasting Insecticidal Nets (LLINs) as a major intervention for malaria control, for

which a Negative Determination with conditions was recommended. The conditions to be met were listed in the Safer Use Action Plan (SUAP), and based on recommendations from the Programmatic Environmental Assessment for Insecticide-Treated Materials in USAID Activities in Sub-Saharan Africa (ITM PEA).

As part of a new malaria control program under the PMI, USAID proposes to implement an Indoor Residual Spraying (IRS) program in Mozambique from September/October through November using dichloro-diphenyl-trichloroethane (DDT) for malaria vector control. Mozambique is characterized by perennial malaria transmission, and IRS would be used reduce malaria incidence in the seasons of highest transmission. Another aspect of malaria vector control supported by the Ministry of Health (Ministerio de Saude, henceforth referred to as MISAU) includes ITNs and LLINs. In the long-term, larviciding and environmental management should be pursued to provide an integrated malaria vector control strategy, although these interventions are not covered by this Environmental Assessment (EA).

A **Positive Determination** is recommended for this program, per 22CFR216.3(a)(ii)(3), because of the potential for the pesticides proposed for use to have a significant impact on the environment, and per 22CFR216.3(b)(iii)(b) because the U.S. registration of two of the chemicals proposed for use – DDT and bendiocarb– were cancelled by USEPA. 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 MISAU and MICOA, with as much assistance from USAID as necessary, will implement the risk reduction actions outlined in the Environmental Assessment (EA) and summarized here and in the section entitled REQUIRED AND RECOMMENDED MITIGATION MEASURES: The Safer Use Action Plan. An overview of conditions of the Environmental Assessment (EA) is detailed below.

1. *In support of subsequent IRS campaigns supported by USAID, this Environmental Assessment will be reviewed and revised* to ensure the USAID support remains consistent with stipulations in Annex B, Part II of the Stockholm Convention (http://www.pops.int), Mozambique's National Implementation Plan (NIP), and Stockholm Convention party reporting requirements for DDT use, which can be found at http://www.pops.int/ddt_info/default.htm.
2. *To re-examine the need for DDT and to identify the best choice for IRS chemicals* (considering safety, effectiveness and affordability in accordance with Annex B, Part II of the Stockholm Convention), USAID will work with MISAU and MICOA before the next spray season, and annually as needed. This document provides authorization for DDT use for one season only. Before USAID can support use of DDT for another spray season, this EA must be amended to reflect the continuing need, if appropriate, for that pesticide.

3. *USAID will assist MICOA and MISAU in completing activities necessary to fulfill Stockholm Convention reporting requirements.*
4. *The Safer Use Action Plan is to be implemented* with relevant partners as a management tool for dealing with and accomplishing the objectives.
5. *IRS supervisors, team leaders, and spray operators will be trained* according to WHO standards as well as MINAG standards. Insecticide poisoning management training will be provided to health workers. Pyrethroid, DDT and carbamate poisoning treatment medications will be provided to trained health workers by MISAU. Insecticide storage facility storekeepers will also be trained on proper stores management.
6. *Occupational exposure to insecticides will be minimized through personal protective equipment* (according to WHO specs). 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.
7. *Environmental contamination will be kept to a minimum through strict auditing, handling, washing and disposal practices.* Each insecticide sachet will be strictly accounted for, contaminated waste-water/rinse-water will be re-used in subsequent days of spraying (progressive rinsing); empty DDT sachets will be collected by the MOH and returned to the supplier (if possible).
8. *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 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 EA.

APPROVAL OF ENVIRONMENTAL ACTION RECOMMENDED:

CLEARANCE:
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Michael Zeilinger

CONCURRENCE:
Mission Director, USAID Mozambique: _____Date: _____
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Table of Contents

Page

List of Figures ix

List of Tables x

Acronyms xi

Summary and Context 1

Required and Recommended Mitigation Measures: The Safer Use Action Plan 2
- Requirements 2
- Policy Reqirements 4
- Recommendations 5

Background and Purpose 9
- Need for Action and the Preferred Alternative 9
- Human Health and Environmental Effects of Preferred Alternative 11

Affected Environment 12

Environmental Consequences 12
- Unavoidable Adverse Effects 12
- Irreversible or Irretrievable Commitments of Resources 13
- Environmental Impacts of the Proposed Action 14
- Direct and Indirect Effects and Their Significance 14
- Conflicts with Other Policies, Plans, or Controls for the Areas Under Consideration 14
- Pesticide Procedures 22

Preparation Methodology 40

Bibliography 41

Annex 1: Terms of Reference for Technical Committee on the Indoor Residual Spraying (IRS) Zanzibar 43

Annex 2: Recommended Mitigation Activities for IRS Program 47

Annex 3: Map of Mozambique, UN 50

Annex 4: Malaria Control Intervention Maps, UNICEF 51

Annex 5: RTI Toxicological Profiles 56

Annex 6: Exposure Treatment Guidelines 81

Annex 7: Endangered Species of Mozambique 95
Annex 8: EU MRLs for DDT.....102

List of Figures

Page

Figure 1. Alternatives Considered and Not Considered 11

Figure 2. EIA Process in Mozambique 18

Figure 3. Current IRS Program Structure in Zambezia 27

List of Tables

Page

Table 1. Mitigation Activities for IRS Program 6

Table 2. Administrative Divisions.....12

Table 3. Population Affected by IRS Program 12

Table 4. FAO Export Profile for Mozambique. Accessed 2006. 21

Table 5. Pesticide Registration.....22

Table 6. Toxicity Classes 22

Table 7. Non-Cancer Risk Results for IRS Exposures 23

Table 8. Average Monthly Temperature and Precipitation in Quelimane, Mozambique 34

Acronyms

ACTs	artemisinin-based combination therapies
ATSDR	Agency for Toxic Substances and Disease Registry
C	Celsius
CDC	US Centers for Disease Control and Prevention
DDT	Dichloro-diphenyl-trichloroethane
EA	Environmental Assessment
FAO	Food and Agriculture Organization
GFATM	The Global Fund to Fight AIDS, Tuberculosis, and Malaria (referenced as "Global Fund")
GIS	Geographic Information Systems
IEC	Information, Education and Communication
IEE	Initial Environmental Examination
IPCS	International Programme on Chemical Safety
IPT	intermittent preventive treatment
IRS	Indoor Residual Spraying
ITM PEA	Programmatic Environmental Assessment for Insecticide-Treated Materials in USAID Activities in Sub-Saharan Africa
ITNs	Insecticide Treated Nets
IVM	Integrated Vector Management
KAP	Knowledge, Attitudes and Practice
LLINs	Long-Lasting Insecticidal Nets
mm	millimeter
MICOA	Ministry for Coordination of Environmental Affairs
MINAG	Ministerio de Agriculture (Ministry of Agriculture)
MISAU	Ministerio de Saude (Ministry of Health)
MRC	Medical Research Council of South Africa
MRL	Minimal Risk Level
NGO	non-governmental organization
NMCP	National Malaria Control Program
PCV	Packed Cell Volume
PPE	Personal Protective Equipment
PMI	President's Initiative on Malaria
SOAG	Strategic Objective Agreement
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

This Indoor Residual Spraying (IRS) program is associated with the U.S. President's Malaria Initiative (PMI) in Africa, launched in 2005, which seeks to reduce malaria mortality by 50% in up to 15 countries. The PMI supports and complements the efforts of the Global Fund, the World Bank, and other members of the Roll Back Malaria Partnership. The PMI will include detailed reporting on inputs, outputs, and results. Angola, Tanzania, and Uganda were the first three countries selected for this Initiative, and in 2006, Mozambique, Malawi, Rwanda, and Senegal have been selected for the PMI.

As part of a new malaria control program, the Unites States Agency for International Development (USAID) proposes to implement an IRS program for malaria vector control in Mozambique from September/October through November using bendiocarb, dichloro-diphenyl-trichloroethane (DDT) or lambda-cyhalothrin. Mozambique is characterized by perennial malaria transmission, and IRS would be used to reduce malaria incidence in the season of highest transmission. USAID will work with MISAU and MICOA before the next spray season, and annually as needed, to re-examine the need for DDT and to identify the best choice for IRS chemicals (considering safety, effectiveness and affordability in accordance with Annex B, Part II of the Stockholm Convention). So long as DDT is used with USAID support for Mozambique's IRS program, USAID will assist MICOA and MISAU in completing Stockholm Convention reporting requirements.

Another aspect of malaria vector control supported by the Ministry of Health (Ministerio de Saude, henceforth referred to as the MISAU) includes Insecticide Treated Nets (ITNs) and Long Lasting Insecticidal Nets (LLINs). ITNs and LLINs are currently being distributed in Mozambique by USAID. In the long-term, larviciding and environmental management should be pursued to provide an integrated malaria vector control strategy, although these interventions are not covered by this EA.

USAID support would include an IRS program for malaria epidemic prevention in Mozambique with the following components:

- Purchase of insecticide (Bendiocarb 80% wettable powder [WP], DDT 75% WP, and/or lambda-cyhalothrin 10% WP), spraying equipment, and adequate amounts of personal protective clothing and personal protective equipment (PPE) for spray operators and, when possible, supervisors
- Financial support for trainers and spray teams
- Financial support for storage facility renovation
- Technical advisors to plan the program, train field staff, and supervise field operations

- Analysis to assess *Anopheles* susceptibility to bendiocarb, DDT and lambda-cyhalothrin in Mozambique, as well as residual efficacy on various types of houses
- Health education to raise public awareness and promote cooperation
- Additional human health and environmental safety components.

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 the insecticide(s) chosen. 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 include potential use of compression sprayers and storage facilities for chemicals or methods of spraying not sanctioned by USAID that could have harmful health and environmental effects.

Required and Recommended Mitigation Measures: The Safer Use Action Plan

The Safer Use Action Plan (SUAP) puts the conclusions reached in the EA into a plan of action, including assignment of responsibility to the appropriate parties connected with the pesticide program. Based on the specific situation of Mozambique's IRS program, there are eleven key components to the SUAP, which are listed below. These major components are integrated into a larger list of detailed components (**Table 1**) designed to mitigate and monitor human health and environmental impacts of the MISAU's IRS program.

Requirements

Provide interactive training on the logistics of IRS procurement and management. This training would involve IRS coordinators from the central and provincial levels and include training on insecticide selection, exercises on the actions and timing involved for IRS preparations, and adaptive management. Such training will serve to streamline IRS preparation activities in the MISAU, ensure timely and effective spraying, and prevent accumulation of obsolete stocks.

Prohibit women spray operators in operations using DDT. USAID does not prefer to support IRS operations where women participate in the spraying of DDT inside homes; however, USAID will support IRS operations where women are charged with supervisory duties and do not participate in the actual spraying of DDT.

Prohibit the practice of rinsing out the sprayer after each charge. Spray operators working for the MISAU in Zambezia Province have been trained to clean the sprayer after each charge by digging a hole, dumping the remainder of the charge into it, and covering it up. The coordinator of Lubombo Spatial Development Initiative (LSDI), Ms. Elizabeth Streat, indicated that this practice is unnecessary and that sprayers only

need to be dumped out/rinsed at the end of each day of spraying, not after each charge. This process must be made clear during the training of spray operators.

Improve the supervision capacity in MISAU IRS programs. Supervisory personnel are lacking. As there is only one Brigade Chief for five spray teams (as opposed to one spray team), the quality and coverage of IRS, safe use and handling of pesticides, and restriction of pesticides to use in IRS cannot be assured. In addition to improving supervisory capacity, a spot-check card should be used while supervising to record the practices used by spray operators to correct current practices and identify future training needs.

To every extent possible, take advantage of pesticide management expertise being developed through the FAO Africa Stockpiles Program in Mozambique. There are multiple opportunities to strengthen pesticide management-related IRS operations by working with the FAO, Ministry of Agriculture (Ministerio de Agriculture, henceforth referred to as MINAG), and the Ministry for Coordination of Environmental Affairs (MICOA). Thus, the following activities are recommended to the MISAU, with the support of USAID when appropriate:

- Work to ensure access to a pesticide quality control laboratory for IRS chemicals
- Follow guidelines developed by the MINAG's Phytosanitary Department (DSV) and MICOA on the appropriate management of empty pesticide containers
- Collaborate with the MINAG and FAO to carry out an assessment of minimum pesticide-storage requirements for the government
- Follow any MICOA guidelines for disposal of unused and unusable pesticides
- Carry out training of pesticide storekeepers in collaboration with DSV and CropLife International
- Participate in training provided to federal inspectors/master trainers on technical issues involved in pesticide inspection and control, in collaboration with FAO and CropLife International.
- Work with the MICOA and MINAG to draft interim guidelines or regulations defining acceptable disposal options for small quantities of unusable pesticides
- Follow National Directorate of Agriculture (DINA) *Guidelines for the Registration and Handling of Pesticides* (DINA, 2003) for renovating or constructing central MISAU storehouses (e.g., Maputo, Quelimane) and as a general guideline for smaller, district-level storehouses[1].

Account for insecticide sachets according to LSDI procedures.

Provide storekeepers with up-to-date training on storehouse management. Regardless of whether this training is provided in conjunction with FAO or not, storekeepers should be provided training on storehouse management, as described in DINA's *Guidelines for the Registration and Handling of Pesticides* (DINA, 2003).

[1] The DINA Guidelines as well as FAO's *Pesticide Storage and Stock Control Manual* need to be updated to be more suited to small-scale storage of pesticides (van der Valk 2006).

Keep sprayer rinse-water in barrels for use at the beginning of the next spray season. Currently, Zambezia Province health officials are awaiting directions on how to deal with the end-of-season sprayer rinse-water; however, it is recommended that the rinse-water be saved and used at the beginning of the following spray season.

Export empty DDT sachets to manufacturer or an internationally recognized incineration facility for disposal, if possible. In lieu of this, empty sachets would have to be securely stored for future export or triple-rinsed and disposed in a local hazardous waste facility.

Include measures to avoid exposure when washing overalls. Because spray operators wash their overalls in their home, the following instructions should be given:

a. Take gloves from PPE kit home; whoever washes the overalls should wear gloves during the washing
b. Dump leftover water in a pit latrine; if no pit latrine is available, dig a pit, pour the water in, and cover it up with dirt
c. Whatever tub is used for washing the overalls should be washed thoroughly with soap or dish detergent before being used for any other purpose.

Initiate monitoring of pesticides used in IRS to the extent feasible and relevant. 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." Technical assistance will be provided to MICOA to assess the impact of IRS activities on the environment to the extent "feasible" and "relevant."

Policy Reqirements

Before the next spray season and every three years as needed, USAID will assist MISAU in re-examining the need for DDT based upon the best available information and to identify the best choice for IRS chemicals (considering safety, effectiveness and affordability in accordance with Annex B, Part II of the Stockholm Convention). In the selection of alternatives or combination of alternatives for malaria control, human health risks and environmental implications must be considered. Viable alternatives to DDT should pose less risk to human health and the environment, be suitable for disease control based on Stockholm Convention Party-specific conditions, and be supported with monitoring data. USAID will work with MICOA and MISAU to compile and analyze available information to help inform the choice of IRS chemicals.

USAID will assist MICOA and MISAU as needed in ***completing Stockholm Convention reporting requirements***.

Prohibit IRS in sensitive areas, including protected areas and sensitive ecosystems. Spray with care in areas where beekeeping occurs, particularly when using pyrethroids.

Avoid DDT use in communities focused on export agriculture (see Table 4).

Continue to develop mechanisms to ensure that DDT use is restricted to disease vector control (in this case malaria control).

Recommendations

Form a multi-stakeholder IRS Steering Committee. This Steering Committee should include relevant government representatives, as well as representatives from the Food and Agriculture Organization (FAO), Livaningo, and any other interested international or civil society groups. The precise terms of reference should be developed by the committee itself, but can include planning and resolving issues surrounding logistics, environmental monitoring, IEC mobilization, training, and IRS operations. **Annex 1** of this EA contains a sample Terms of Reference from the Technical Committee on IRS in Zanzibar. The Steering Committee should increase accountability for IRS planning and implementation activities.

Do not procure or distribute pesticides and larvicides to provinces/districts that do not request them. Currently, the larvicide Actellic is delivered to Zambezia Province is delivered to the province once a year, not upon provincial request. When the larvicide is used, its use is based on entomological surveillance from several years ago. Ad-hoc larviciding based on old data is likely ineffective in preventing malaria. Until the provincial government is committed to highly-effective larviciding and actively requests larvicide from the MISAU, it should not be ordered for or delivered to Zambezia Province. Moreover, pesticide should always be ordered based on precise planning and strong communication between the central and provincial levels. Proper planning and communication will be part of the interactive training on logistics of IRS procurement and management.

The above requirements and recommendations are also included in **Table 1**, which describes the potential negative activities and/or impacts of the operation, their respective mitigation activities, and the parties responsible for those mitigation activities. Many, but not all, of these mitigation activities are already being conducted in the field. The recommended mitigation actions are also summarized in **Annex 2** of this EA, according to the time that the actions should be taken. Upon signature of this EA, it is understood that the recommended mitigation activities are to be implemented during the planning and implementation of the IRS program. The only exceptions to this are the recommended mitigation activities under the *Future Activities* subheading in **Table 1**. Parties responsible for implementation of mitigation measures will be determined through an agreement between USAID, MISAU, and any additional stakeholders as necessary.

In support of subsequent IRS campaigns supported by USAID, this Environmental Assessment will be reviewed and revised to ensure the USAID support remains consistent with stipulations in Annex B, Part II of the Stockholm Convention (http://www.pops.int), Mozambique's National Implementation Plan (NIP), and Stockholm Convention party reporting requirements for DDT use, which can be found at http://www.pops.int/ddt_info/default.htm.

Table 1. Mitigation Activities for IRS Program

Key	
	Recommended mitigation actions
	Repeat recommended mitigation actions

Potential Negative Activities/Impacts	Mitigation Actions	Responsible Parties[2]
Daily Operations		
Occupational exposure to insecticide from daily IRS operations	Develop IRS Steering Committee, including the MISAU, MICOA, MINAG, and civil society stakeholders (e.g., Livaningo)	MISAU and USAID/Mozambique
	Train spray operators, team leaders, and supervisors according to WHO guidelines	
	Procure and ensure proper use of PPE by spray operators, team leaders, and supervisors (e.g., cotton overalls, face mask, broad-rimmed hat, rubber gloves, gum boots)	
	Develop program-specific guidelines for pesticide poisoning, according to guidance provided in this EA	
	Supervise spray operators	
	Procure and use funnels to prevent spillage of insecticide when filling sprayers	
	Reprimand spray operators that do not follow proper procedure in all aspects of operations (e.g., handling, spraying, hygiene, cleanup)	
	Conduct progressive rinsing of sprayers and PPE	
	Procure and distribute barrels for progressive rinsing and wash-tubs for overall washing and personal hygiene	
Fetal exposure to insecticide from daily IRS operations (pertaining to female spray operators)	Prohibit women spray operators	
	Develop IRS Steering Committee, including the MISAU, MICOA, MINAG, and civil society stakeholders (e.g., Livaningo)	MISAU and USAID/Mozambique
	Prohibit spraying in homes where pregnant women are living and cannot move outside the home and stay outside the home during and 1 hour after spraying	
Community and environmental exposure to insecticide from daily IRS operations	Work with FAO on pesticide management issues, as described in recommendations 5 and 6, above.	
	Procure only as much insecticide as will be used in the province during one year	
	Develop protocol for decision-making when environmental monitoring indicates environmental contamination as a result of IRS (suggested protocol involves the MISAU, MICOA, MINAG, and civil society stakeholder consultation at the district level)	
	Prohibit spraying in flood-prone areas, areas	

[2] USAID contractor will ensure that appropriate training and followup will be provided so that responsible parties have the capacity to conduct or oversee these actions.

Potential Negative Activities/Impacts	Mitigation Actions	Responsible Parties[2]
	important for agricultural production, and protected areas/sensitive ecosystems.	
	Prohibit spraying in homes where sick persons or pregnant women are living and cannot move outside the home *and* stay outside the home during and 1 hour after spraying	
	Prohibit spraying in homes where food and utensils have not been removed from the house, and where furniture has not been removed outside *or* moved to the middle of the room and covered with a cloth by the spray operator	
	Prohibit cleaning/rinsing sprayers after each charge	
	Conduct IEC Campaign, citing importance of removing all food 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	
	Prior to spraying, cover furniture that cannot be moved with cloths provided by the MISAU, District Health Office, or Program	
	Allow spray operators to take home gloves for the purpose of washing overalls	
	Provide instruction to spray operators that tubs used for washing overalls should be thoroughly washed before being used for any other purpose (including washing other clothes), and that rinse-water should be dumped in a latrine or pit especially dug for that purpose, not existing water bodies.	
	Inscribe all program barrels and tubs as District Health Office property and label with poison stickers to deter sale and domestic use in event of pilferage	
	Store all insecticides, empty packaging, barrels and tubs inside storage facilities, reducing use of contaminated goods domestically	
	Use sprayer rinse-water from the previous spray season in the current spray season	
	Export empty DDT sachets to manufacturer or internationally recognized incineration facility at end of spray season	
	Develop IRS Steering Committee, including the MISAU, MICOA, MINAG and civil society stakeholders (e.g. Livaningo)	MISAU and USAID/Mozambique
	Reprimand spray operators that do not follow proper procedure in all aspects of operations (e.g., handling, spraying, hygiene, cleanup)	
	Conduct training for spray operators, team leaders and supervisors according to WHO guidelines.	
	Procure and use funnels to prevent spillage of insecticide when filling sprayers	
	Conduct progressive rinsing of sprayers and PPE	
	Develop and implement environmental reporting system	
Special Circumstances		
Pilferage of insecticide,	Padlock and guard storage facilities	

Potential Negative Activities/Impacts	Mitigation Actions	Responsible Parties[2]
consequential human and environmental exposure	Insecticide sachet accounting, according to LSDI procedures	
	Supervise spray operators	
	Develop IRS Steering Committee, including the MISAU, MICOA, MINAG and civil society stakeholders (e.g. Livaningo)	MISAU and USAID/Mozambique
	Develop and implement environmental monitoring plan	
Storehouse fire, inhalation of toxic fumes from insecticide fire	Procure and distribute emergency equipment to *central* insecticide storage facilities	
	Conduct refresher training for storekeepers	
	Notify fire brigade of storage facility location and contents	
Accidents and spills during insecticide transport	Conduct training of drivers for long-distance transport of insecticide and short-distance transport during the campaign period	
	Follow Guidelines for the Registration and Handling of Pesticides section on Pesticide Transportation	
	Provide emergency equipment in storage facilities	
	Conduct refresher training for storekeepers	
	Develop and implement environmental reporting system	
Insecticide Quality and Resistance		
Decreased effectiveness of insecticide, lessening impact on malaria incidence	Select insecticide to minimize resistance and maximize residuality on surfaces sprayed	
	Conduct interactive training in procurement, logistics and management of public health pesticides to prevent accumulation of unused and obsolete stocks	
	Conduct lab-testing of insecticide to ensure quality control	
	Entomological monitoring of resistance	
	Conduct IEC Campaign, citing importance of not plastering or painting walls after the home has been sprayed	
	Procure and use sprayers manufactured according to WHO specifications	
	Conduct daily sprayer maintenance	
	Ensure proper insecticide storage by renovation of storage facilities	
	Train spray operators in proper application for specific wall types (uniform spray speed, constant and accurate spray distance, etc).	
Future Activities		
Indirect support of malaria vector control operations that have not undergone environmental review through procurement of sprayers and storage facilities	Importance of an EA for any pesticides used in IRS will be discussed with the MISAU and MOE staff--online resource for conducting assessments will be provided (http://www.encapafrica.org/)	
Adaptive Management (potentially reducing pesticide use for malaria vector control)	Develop a strong malaria surveillance system to target IRS interventions, reducing pesticide use	
	Pursue an integrated strategy involving environmental management and larviciding	

Potential Negative Activities/Impacts	Mitigation Actions	Responsible Parties[2]
	Develop of protocol/implementation of measures to mitigate mosquito resistance to insecticides--pesticide rotation or mosaicing.	

Background and Purpose

The planned IRS program in Zambezia Province, Mozambique, is associated with the PMI in Africa, which was announced 30 June, 2005, and seeks to reduce malaria mortality by 50% in up to 15 countries (total population: 175 million) in sub-Saharan Africa by 2010 (see **Annex 3** of this EA). This reduction will be accomplished by rapidly scaling up the following proven malaria prevention and treatment interventions in each country to reach 85% coverage of vulnerable groups (e.g., children under five, pregnant women, and people living with HIV/AIDS):

- Treatment of malarial illnesses with artemisinin-based combination therapies (ACTs)
- Intermittent preventive treatment (IPT) of pregnant women with effective antimalarial drugs, currently sulfadoxine-pyrimethamine
- Distribution of ITNs
- IRS.

In implementing these interventions, the United States will work in partnership with host governments and build on existing national malaria control plans, policies, and resources. The PMI will support and complement efforts of the Global Fund, the World Bank, and other members of the Roll Back Malaria Partnership and will include detailed reporting on inputs, outputs, and results.

Need for Action and the Preferred Alternative

Malaria is endemic throughout Mozambique, varying between mesoendemic and hyperendemic. Transmission is perennial, with peaks during and after the rainy season (December to April); however, the intensities of transmission may vary depending on the amount of rain and air temperatures observed in each year.

The coastal region is mostly hyperendemic, and the principal vectors are members of the complex *Anopheles gambiae* and *Anopheles funestus*. Regions of high altitudes and with mean annual temperatures below 21°C are generally hypoendemic, with the same principal vectors, but in different proportions. Some very dry areas are considered epidemic prone. *Plasmodium falciparum* is the most prevalent parasite, responsible for about 90% of all malaria infections. *P. malariae* and *ovale* account for 9.1% and 0.9 %, respectively, of all infections.

Malaria accounts for a large part of disease burden in Mozambique and is the leading cause of morbidity and mortality. The most vulnerable groups are children under five years of age and pregnant women.

In 2000, 42% of the total patient attendances in rural and general hospitals were due to malaria (e.g., fever cases), and 61% of admissions to the pediatric ward were also due to malaria. In the same period, about 28% of hospital mortality was caused by malaria, and the case fatality rate varied between 0.4% and 7.3%. Malaria accounted for 33% of all reported deaths (verbal autopsy) in 2000. The estimated malaria prevalence for children aged two to nine ranges between 40% and 80%. It is estimated that the risk of malaria is highest between the ages of one and three, when children may experience an average of more than two episodes per year (MISAU, 2002).

Malaria is also a major problem in pregnant women in rural areas. Approximately 20% of women are parasitaemic, and among them, primigravidae (i.e., women pregnant for the first time) show the highest prevalence (31%) of malaria (MISAU, 2002).

An increase in the resistance of *P. falciparum* to anti-malarial drugs, especially to chloroquine (which varies between 15% and 40% in different sites and is the drug of choice for the treatment of non-complicated malaria), presents a big obstacle in case management, particularly at the periphery, where there is also a problem of weak capacity in clinical and laboratory diagnosis.

Mozambique's economic loss due to malaria is not really known. Episodes of illness due to malaria contribute to a loss of industrial labor, school absenteeism, and poor agricultural productivity, which is the source of potential economic gains for the majority of the rural population.

Figure 1. Alternatives Considered and Not Considered

Alternatives Considered	
IRS Program using Bendiocarb, DDT, or Lambda-Cyhalothrin WP formulations	USAID support would include an IRS program for malaria epidemic prevention in district with the following components: • Purchase of insecticide, spraying equipment, and adequate amounts of personal protective clothing and PPE for spray operators as required • Financial support for trainers, spray teams, and transport • Financial support for storage facility renovation (as needed) • Technical advisors to aid program planning, train field staff, and supervise field operations • Analysis to identify risk-prone areas • Health education to raise public awareness and promote cooperation • Additional human health and environmental safety components.
Alternatives Not Considered	
ITN Program	USAID supports ITN and LLIN programs in Mozambique. The IRS program is intended to complement these efforts.
Larviciding	Larviciding using Actellic is conducted in three provinces in Mozambique on an ad hoc basis. Scale-up of this intervention is currently not a priority for the MISAU.
Environmental Management	Environmental Management is not an intervention currently supported by the MISAU.

Human Health and Environmental Effects of Preferred Alternative

As a consequence of implementing the Preferred Alternative, approximately 500,000 people in Nicoadala District, Namacurra District, and Quelimane City in Zambezia Province will be covered by 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

Zambezia Province is divided into districts, as illustrated in **Table 2**. Two districts and one city in Zambezia Province were targeted for an IRS campaign using DDT 75% WP during the 2005–2006 spray season. The Provincial health office wants to scale up its IRS efforts to all 17 districts by 2008. District health offices work with the Provincial health office to plan and implement the MISAU's IRS program.

Table 2. Administrative Divisions

Administrative Level	Number
Province	1
District	2 targeted, 17 total

Approximately 700,000 people will be affected by the IRS Program. **Table 3** breaks down this population by district.

Table 3. Population Affected by IRS Program

Target District	Population
Nicoadala	259,603
Namacurra	202,540
Cidade de Quelimane	271,497
Total	**733,640**

Environmental Consequences

Unavoidable Adverse Effects

Bendiocarb

The risk of vehicle accidents and consequent insecticide spillage is always present. Such spillage could expose humans, birds (e.g. chickens) and aquatic environments to bendiocarb 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). No information is available on the combustion byproducts of bendiocarb in the event of fire.

DDT

It is possible that the impacts of normal residential exposure of pregnant women could include a host of adverse human health impacts, including pre-term abortion, still birth, or shortened lactation (Longnecker, 2005; Damstra et al., 2004). Residential exposure to DDT may also delay neurodevelopment in children prior to the first two years of life (Eskenazi et al.; 2006).

Scientific evidence cited in WHO's *Global Assessment of the State-of-the-Science of Endocrine Disruptors* also supports the hypothesis that *in utero* exposure to DDT can cause "reduced testis and epididymis weight, reduced sperm numbers and motility, increased prostate weight and delayed puberty" in males (Damstra et al., 2004:62). *In utero* exposure may also cause hypospadias (the opening of the meatus at a higher point on the penis) in males (Damstra et al., 2004:65). Fetal mortality or adverse reproductive effects on fetuses as a result of exposure to DDT would be an unavoidable risk of the IRS program.

Recent studies also indicate the possibility of reduced male fertility as a result of occupational and non-occupational exposure to DDT used in IRS (de Jager et al., 2006).

The risk of vehicle accidents and consequent insecticide spillage is always present. Human inhalation of toxic fumes in the event of a storehouse fire is also an unavoidable risk because open-burning of DDT "gives off irritating or toxic fumes… in a fire" (IPCS, 2004).

Lambda-cyhalothrin

The risk of vehicle accidents and consequent insecticide spillage is always present. Such spillage could expose both humans and aquatic environments to lambda-cyhalothrin 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 lambda-cyhalothrin creates nitrogen oxides, hydrogen chloride, and hydrogen fluoride (WHO 1997).

Irreversible or Irretrievable Commitments of Resources

All financial costs of the IRS program are irretrievable. It is important to note that, after implementation of this proposal, the Mozambique MISAU would acquire new insecticide storage facilities and sprayers that could be used in future IRS interventions with chemicals that have not undergone environmental review. The storage facilities will also contain barrels and tubs used for rinsing sprayers and cleaning protective wear. If not secured, these barrels and tubs may be pilfered and used for drinking water or food

storage. According to the IVM PEA, these risks are high for all insecticides, and will be discussed during training of the MISAU staff.

Environmental Impacts of the Proposed Action

The primary environmental risks of the IRS program include mortality of freshwater fish and invertebrates from improper disposal of insecticide-contaminated rinse-water, damage to apiaries due to use of bendiocarb or lambda-cyhalothrin, mortality of birds (particularly chickens) due to use of bendiocarb, as well as environmental contamination from leakage of insecticide into the agricultural sector; this latter concern is particularly relevant to DDT, which is banned in Mozambique's agricultural sector through the Stockholm Convention. Training and improved supervision of spray personnel should help address this risk, and environmental monitoring should be carried out to ensure that the insecticides (particularly DDT) used in IRS does not deleteriously impact the environment.

Potential environmental impacts of the proposed action are discussed further in this EA under the *Compatibility of the Proposed Pesticide with Target and Nontarget Ecosystems* subheading in the *Pesticide Procedures* section.

Direct and Indirect Effects and Their Significance

Direct Effects

USAID will directly support the use of bendiocarb, DDT or lambda-cyhalothrin for malaria vector control in Zambezia Province, Mozambique. This support will provide protection against epidemic malaria to approximately 700,000 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

Through this action, USAID will be providing the Mozambique MISAU with spray equipment. Upon completion of the IRS program, USAID will no longer supervise the use of this capital. As a result, USAID may be indirectly supporting the activities (e.g., use of insecticides) that have not undergone environmental review.

Conflicts with Other Policies, Plans, or Controls for the Areas Under Consideration

Mozambican Environmental Requirements

The following italicized information on Mozambique's environmental laws, regulations and procedures are excerpted from Hatton et al.'s *Mozambique: Country Report on*

Environmental Impact Assessment published by the Southern African Institute for Environmental Assessment (2003).

In an effort to ensure sustainable development in its drive for economic growth, the Government created the Ministério para a Coordenação da Acção Ambiental (MICOA) from the National Environmental Commission shortly after the holding of the first election in 1994.

Since 1994, MICOA has developed a legal framework for environmental management, with the following essential elements:

- *National Environmental Management Programme (MICOA 1996)*
- *Framework Environmental Act (No. 20 of 1997)*
- *EIA Regulations (Decree No. 76 of 1998), and*
- *EIA guidelines (in preparation)*

MICOA has two broad domains of responsibility:

1. *Implementing the National Environmental Management Programme and associated environmental policy and legislation, and*
2. *Coordinating with other ministries on environmental matters to integrate environmental aspects in their projects, programmes and policies.*

MICOA is in charge of regulating EIAs, which involves approving the terms of reference for EIAs, reviewing completed EIAs and implementing an audit process.

National Environmental Management Programme (MICOA 1996)

One of MICOA's first tasks was to formulate the NEMP to promote and implement sound environmental policy. The NEMP (MICOA 1996) was approved by the Council of Ministers in 1996 and contains an 'Environmental Policy', a proposal for the 'Framework Environmental Act' (subsequently passed in 1997) and an 'Environmental Strategy."

EIA is progressively becoming a key factor for approving development initiatives in the country.

Framework Environmental Act (No. 20 of 1997)

The Framework Environmental act aims to provide a legal framework for the use and correct management of the environment and its components and to assure the sustainable development of Mozambique.

Chapter 4 of the Act refers to the 'Prevention of Environmental Damage'. Under this clause, licensing of activities that are liable to cause significant environmental impacts is required. The issuance of an environmental license is dependent on an appropriate level of EIA being completed and accepted by MICOA.

A National Commission for Sustainable Development, linked to the Council of Ministers, was created in October 2000 by a provision in the Act. This Commission seeks to ensure the effective coordination and integration of sectoral policies and plans related to environmental management at the highest level.

EIA Regulations (Decree No. 76 of 1998)

The National Environmental Management Programme is the guiding policy for environmental protection and EIA is mandatory to all activities that may cause significant impacts. The Framework Environmental Act establishes the regime of the environmental licensing based on an EIA. Decree No. 76/98 of 29 December 1998 defines the EIA Regulations (comprising 19 Articles).

Article 2 specifies the range of development projects requiring some form of EIA, and is applicable to all public or private activities that may have a direct or indirect impact on the environment.

Article 3 defines MICOA's responsibilities to issue and publicise general directives on EIA procedures, approve the terms of reference, review EIAs and issue environmental licenses.

Article 4 specifies document requirements. To begin an EIA the proponent must present to MICOA a description of the activity, an executive summary of the project and the salient environmental and socio-economic features of the project location.

Article 5 defines pre-assessment procedures. All activities not covered in the Appendix of the EIA regulations but capable of causing significant environmental impact are subject to a pre-assessment by MICOA to determine the level of EIA required.

Article 6 defines the content of an EIA, which must contain at least the following

- *Geographical location of the area of influence of the activity, as well as a description of the baseline environmental situation*
- *A description of the activity and its alternatives in the planning, construction, operation and, in the case of a temporary activity, decommissioning phases*
- *A comparison of the alternatives and a prediction of the environmental impacts of each alternative*
- *Identification and assessment of mitigation measures*
- *An environmental management programme which includes the monitoring of impacts, and accident prevention and contingency plans*
- *A non-technical summary covering the main issues and conclusions for purposes of public consultation, and*
- *Identification of the team that carried out the study.*

Article 7 defines the public consultation process.

Article 8 establishes the criteria for assessing a proposed activity. These are--

- *The number of persons and communities affected*
- *The ecosystems, plants and animals affected*
- *The location and size of the area affected*
- *The duration and intensity of the impact*
- *The direct, indirect, potential, overall and cumulative effects of the impact, and*
- *The reversibility or otherwise of the impact.*

Article 9 describes the review process.

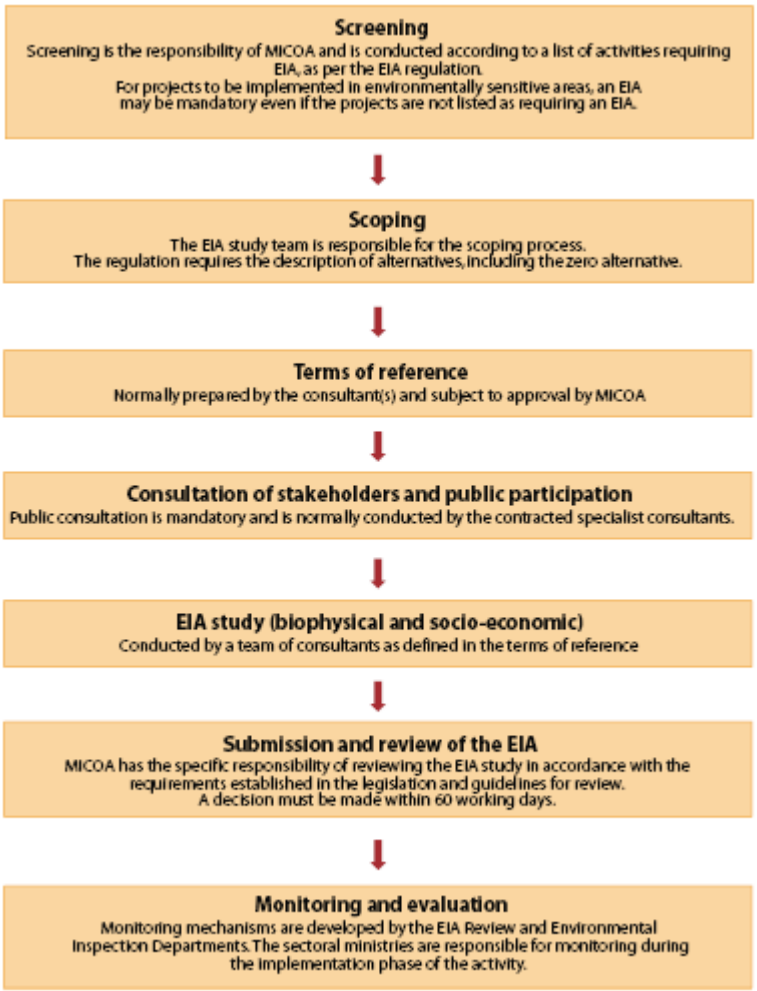
The EIA Regulations explicitly exempt listed activities that are required in order to address emergency situations arising from natural or other disasters. In these instances, MICOA is tasked with issuing instructions to direct the exempted activities (Article 2(4) of Decree 76/98). The regulations require in Article 6(2)(e) that emergency and accident identification, response and impact mitigation plans be included in the impact mitigation strategy.

An important feature of Mozambique's EIA Regulations is that the Annexure containing the list of identified activities includes both programmes and projects. While EIA is often limited to the project level in practice, more attention should be given to applying environmental assessment tools to more strategic activities like programmes and even policies, master plans and legislation.

Steps of the EIA process are described in Figure 2.

According to the Regulations, Only registered consultants, people working for a registered consulting company, or a registered consortium of companies may conduct EIA studies in Mozambique (Article 13(2)-(3)).

Figure 2. EIA Process in Mozambique



Source: Hatton et al. 2003

To-date, an EIA has not been carried out in Mozambique despite the reintroduction of DDT use in IRS in the past year. It is proposed that this document be submitted to MICOA for its approval as a country EIA; issues surrounding the need for host-country EIA consultant registration will be discussed with MICOA.

Stockholm Convention Requirements

As a signatory to the Stockholm Convention, the US Government is committed to ensuring that its support of DDT in developing countries is consistent with Stockholm Convention requirements and recommendations, as well as National Implementation Plans prepared by the host countries. Thus, USAID will support the following planning, program and environmental compliance activities where it supports DDT use in disease vector control:

1. *USAID will base its support of insecticides used in disease vector control on a rational selection process* considering the insecticide's effectiveness in reducing or repelling the vector, risk to human health, the environment and the agricultural and trade sectors, acceptability in the host country, cost, the need for resistance management, and other considerations.
   - Based on insecticide resistance and disease transmission data, DDT is appropriate for use in Zambezia Province. See *Pesticide Procedures B* for more details.
2. *USAID will only provide support of DDT to Parties that have notified the Stockholm Secretariat and the World Health Organization* of its production and/or use of DDT and that restrict DDT use to disease vector control.
   - As a party to the Stockholm Convention, Mozambique is obligated to notify the Stockholm Secretariat in the event that it chooses to use DDT for disease vector control. On July 8, 2005, the Minister of Health signed a letter to the Stockholm Secretariat explaining the MISAU's intention to use DDT for malaria vector control.
3. *All USAID support of DDT use will follow World Health Organization recommendations and guidelines.*
   - DDT will be used in accordance with WHO recommendations from the Manual for Indoor Residual Spraying: Application of Residual Sprays for Vector Control.
4. *USAID will assist the Mozambican government in re-examining the need for DDT* based upon the best available information and to identify the best choice for IRS chemicals, considering safety, effectiveness and affordability in accordance with Annex B, Part II of the Stockholm Convention. The selection of alternatives or combination of alternatives for malaria control will take into consideration human health risks and environmental implications; viable alternatives to DDT should pose less risk to human health and the environment, be suitable for disease control based on Stockholm Convention Party-specific conditions, and be supported with monitoring data.
5. *USAID will regularly review and revise SEAs pertaining to DDT every one to three thears as appropriate* to ensure that USAID support remains consistent with stipulations in Annex B, Part II of the Stockholm Convention, the Mozambican National Implementation Plan (NIP), and Stockholm Convention Party reporting requirements for DDT use.
6. *When local capacity is insufficient, USAID will assist host country governments in conducting activities to fulfill Stockholm Convention reporting requirements.* To receive USAID support for use of DDT in IRS, the host country must demonstrate concerted effort in developing and following a National Implementation Plan (NIP) as well as reporting to the Stockholm Secretariat.

- Mozambique has developed a draft NIP that has not yet been finalized and is not yet operational.

7. *USAID will support the monitoring of DDT in the environments where it is sprayed.* 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."
8. *When local capacity is insufficient, USAID will facilitate appropriate disposal of DDT-contaminated waste* resulting from IRS operations in accordance with the Basel Convention and other relevant regional and international treaties.

Basel and Rotterdam Conventions

The Basel Convention addresses the transboundary movement, management and disposal of hazardous wastes, including waste pesticides. Transboundary movements of hazardous waste between Parties can take place only on prior written notification by the exporting state to importing (or transit) states, and the inclusion of movement documents with each shipment. In addition, Parties may not permit hazardous wastes to be exported to or imported from a non-Party except pursuant to an agreement or arrangement that stipulates provisions no less environmentally sound than those provided for by the Basel Convention. Finally, trade in hazardous waste cannot take place under conditions in which such wastes cannot be handled in an environmentally sound manner. Parties are obligated to consider illegal traffic in hazardous wastes as criminal and to notify other Party states upon prohibition of import of hazardous wastes for disposal. Export of waste pesticides may require specific compliance activities by the host-country government (USAID 2006).

The Rotterdam Convention addresses the transboundary movement of 22 chemicals, including only one chemical used for malaria vector control, DDT. Parties to the Convention must make decisions on each chemical regarding its import, abide by export limitations delineated in the treaty, and notify parties receiving exported waste according to treaty conditions. Host-country governments are responsible for complying with any import or export treaty conditions applicable to their status as a Party or non-Party. Import or export of DDT waste products, may require specific compliance activities by the host-country government (USAID 2006).

The Government of Zambia "accessioned" the Basel Convention on 15 November 1994, and is signatory to the Rotterdam Convention. Since trans-boundary movement of the waste must occur for disposal of DDT sachets by Avima in South Africa, the Basel and Rotterdam Conventions shall be applied, taking into consideration the laws prevailing in transit countries and the recipient country (note that South Africa is party to both the Basel and Rotterdam Conventions).

European Union (EU) Import Restrictions

Nations, trading groups of countries, and international institutions often define thresholds for pesticide residues present on agricultural commodities beyond which those commodities cannot be sold on the market. These thresholds are called Maximum Residue Limits (MRLs). Use of public health pesticides in the agricultural sector may increase the risk that agricultural exports exceed importing-country MRLs, reducing economic gains from agricultural exports in the host country. This is of particular concern for DDT, which persists in the environment and accumulates in animal fat. European Union MRLs are listed in **Annex 8**. The U.S. Department of Agriculture Foreign Agricultural Service (USDA/FAS) hosts an online database containing MRLs for additional countries at http://www.mrldatabase.com/. Agricultural commodities of concern for Mozambique may include those in Table 4, based on EU MRLs for DDT:

Table 4. FAO Export Profile for Mozambique. Accessed 2006.

	Commodity	Quantity			Value (000 US$)		Unit value (US$)
1	Tobacco Leaves	Mt	11637	P	32022	P	2752
2	Cashew Nuts	Mt	39731	P	28473	P	717
3	Cotton Lint	Mt	19577	P	22753	P	1162
4	Sugar (Centrifugal, Raw)	Mt	43402	P	18152	P	418
5	Sesame Seed	Mt	12582	P	9005	P	716
6	Maize	Mt	11965	P	2113	P	177
7	Cáshew Nuts Shelled	Mt	500	P	1974	P	3948
8	Sugar Refined	Mt	3655	P	1300	P	356
9	Cottonseed	Mt	8390	P	937	P	112
10	Oil of Coconuts	Mt	1193	P	753	P	631
11	Pulses nes	Mt	2093	P	752	P	359
12	Molasses	Mt	10370	P	640	P	62
13	Tea	Mt	586	P	630	P	1075
14	Cake of Cotton Seed	Mt	3736	P	561	P	150
15	Grapefruit and Pomelos	Mt	757	P	521	P	688
16	Flour of Wheat	Mt	1398	P	462	P	330
17	Cake of Coconuts	Mt	7210	P	364	P	50
18	Bananas	Mt	1776	P	338	P	190
19	Hides Wet-Salted Cattle	Mt	277	P	210	P	758
20	Oil of Veget Origin nes	Mt	291	F	157	F	540

FAO Africa Stockpiles Program, MINAG, and MICOA

The FAO Africa Stockpiles Program is working with the MINAG to reduce the expired pesticide stockpiles in the country, as well as to build capacity in Mozambique to prevent further accumulation of obsolete pesticides. As the Stockpiles Program's recent Phase II Report states, "The overall objective of the mission was to carry out a review of pesticide distribution and management in Mozambique, with particular focus on the risk for future accumulation of obsolete pesticides" (van der Valk, 2005:13). The use of insecticides for malaria control poses some risk for the further accumulation of obsolete pesticides; as a

result, this EA, which is designed to counteract those risks as much as possible, will be reviewed by the Stockpiles Program and will be subsequently revised to take into account concerns of those participating in the Stockpiles Program.

Pesticide Procedures

A. The USEPA Registration Status of the Requested Pesticide

Table 5 describes the registration status of Bendiocarb, DDT and Lambda-cyhalothrin. Table 6 describes the EPA and WHO toxicity classes for each of the chemicals.

Table 5. Pesticide Registration

Is the pesticide…	Bendiocarb	DDT	Lambda-cyhalothrin
Registered by the host country (for public health use)?	YES	YES[3]	YES
Registered by EPA?	NO	NO	YES
WHO-recommended?	YES	YES	YES

Table 6. Toxicity Classes

	Bendiocarb	DDT	Lambda-cyhalothrin
EPA Toxicity Class	II: Warning	II: Warning	II: Warning
WHO Toxicity Class	II: Moderately Hazardous	II: Moderately Hazardous	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

[3] According to the FAO Africa Stockpiles Program Mission Report for Mozambique, "all pesticides that are used in Mozambique have to be registered before their first importation and distribution, as stipulated in the Pesticide Regulation No. 153/2002. All pesticides, both of chemical and biological origin, and intended for agricultural, veterinary, public health and domestic uses are covered by this regulation" (van der Valk 2006; 27).

As indicated in Pesticide Procedures A., bendiocarb, DDT and lambda-cyhalothrin are registered for use in public health in Mozambique.

- Acceptability of the pesticide to the National Malaria Control Program

The chosen chemicals are acceptable for use by MISAU. Bendiocarb, DDT and lambda-cyhalothrin have all been used in previous IRS campaigns by LSDI, and both DDT and lambda-cyhalothrin have been used in previous IRS campaigns in Zambezia Province.

- 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. With particular regard to DDT, "viable alternatives to DDT should pose less risk to human health and the environment, be suitable for disease control based on [country]-specific conditions, and be supported with monitoring data" (UNEP 2001).

The safety of the different WHO-recommended insecticides is indicated in Table 7, and is based on a risk assessment of IRS chemicals completed for USAID's PEA for IVM.

Table 7. Non-Cancer Risk Results for IRS Exposures[4]

Occupational Exposure				Residential Exposure			
Risk Below Levels of Concern	**Low Risk**	**Moderate Risk**	**High Risk**	**Risk Below Levels of Concern**	**Low Risk**	**Moderate Risk**	**High Risk**
Alpha-cypermethrin	Bendiocarb	Propoxur	DDT	Alpha-cypermethrin		Malathion	DDT
Bifenthrin	Cyfluthrin		Fenitrothion	Bifenthrin			Fenitrothion
Etofenprox	Lambda-cyhalothrin		Pirimiphos-methyl	Bendiocarb			Pirimiphos-methyl
Deltamethrin	Malathion			Cyfluthrin			
				Deltamethrin			
				Etofenprox			
				Lambda-cyhalothrin			

[4] It should also be noted that the health benchmarks for DDT used in the PEA are based on toxicological data that may not be consistent with more recent studies and the current state of knowledge.

	Propoxur

While DDT should generally not be preferred based on the human health risk presented in Table 7, the other chemicals recommended by WHO do not last as long as DDT on mud-walled homes. In this case, the malaria transmission season spans over ten months, necessitating a long-lasting insecticide.

- Risk to environment, livestock and/or agricultural trade

See Pesticide Procedures G, as well as the European Union (EU) Import Restrictions.

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

Testing from 2000-2002 indicates that vectors are fully susceptible to all proposed insecticides. See Pesticide Procedures F for more information on vector resistance.

Secondary factors include:

- Appropriateness of surface for spraying

DDT and bendiocarb should be appropriate for use on mud walls; lambda-cyhalothrin will be appropriate for western-style walls. See Pesticide Procedures F for more information on the appropriateness of household surfaces for spraying with the different insecticides.

- Duration of effectiveness (and implications for cost)

See Pesticide Procedures F. DDT should provide the maximum duration of effectiveness on mud walls; bendiocarb should be effective on mud walls for at least six months. Lambda-cyhalothrin should be effective on plaster or western-style walls for a duration of at least six months.

- Cost of insecticide

The costs of the insecticides range from approximately 4-6 US Dollars per sachet of insecticide, which is acceptable to all parties involved in the program.

Tertiary factors include:

- The need for an insecticide of a different class to prevent resistance

The use of these three insecticides in rotation and mosaic should provide some safeguard against insecticide resistance. This strategy has been used by LSDI in southern Mozambique.

- Major classes of insecticides used in other vector control interventions that could promote resistance

Currently, USAID is supporting scale-up of ITN use in Zambezia Province. This scale-up could promote pyrethroid and, potentially, DDT resistance in the Province. According to

Casimiro et al. 2006, cross-resistance between pyrethroids and DDT through the kdr resistance mechanism has not appeared.

- Major classes of insecticides used in the agricultural sector that could promote resistance

The insecticides typically used in agriculture include pyrethroids and organophosphates, but not carbamates. Thus it is expected that use of pyrethroids in agriculture could contribute to malaria vector resistance.

- Host-country capacity to prevent pilferage

Mozambique does not have the capacity essential to prevention of pilferage of insecticide. As a consequence, measures will be taken to reduce pilferage such as insecticide stock management and sachet accounting according to LSDI procedures, supervision of spray operators, use of secure storage facilities with enough space to accommodate the quantities of insecticide needed, monitoring of the insecticide supply chain and accounting for transported stocks, driver training, and storekeeper training.

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

The proposed pesticide use is part of a vector management strategy that includes IRS, ITNs/LLINs, and larviciding, with the major focus on IRS and ITNs. **Annex 4** of this EA geographically depicts the areas where ITNs are being distributed and IRS is being conducted. As of 2001, 1% to 5% of households "in selected districts" owned at least one treated mosquito net. IRS is focused on as a priority, and is implemented in 46 population centers (e.g., cities, towns, or villages). LSDI covers the urban and rural areas of six districts. As of 2001, IRS coverage by the MISAU was limited to 60% to 70% of targeted areas. Larviciding using Actellic (active ingredient: pirimiphos-methyl) is being conducted in three provinces, but is not well-organized. In its overall malaria control strategy, the MISAU promotes IEC and advocacy, IPT, and case management, as well as vector control.

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 program 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.

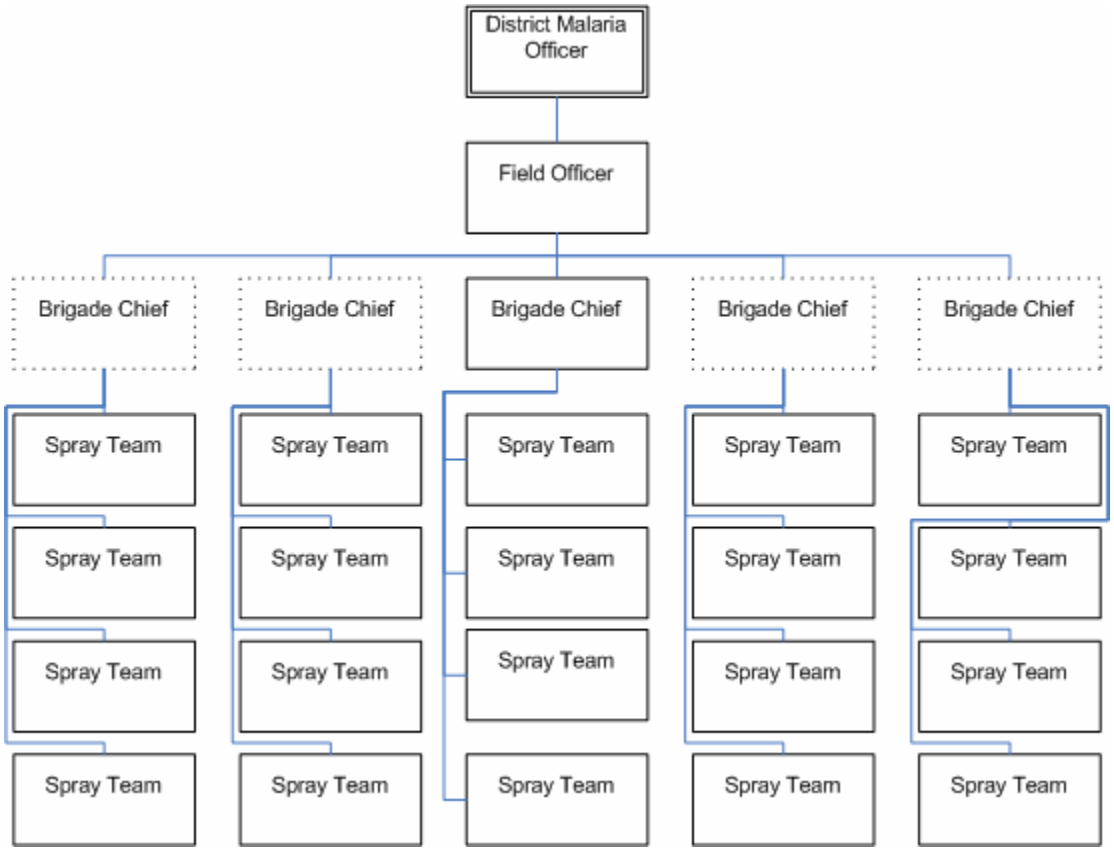
The spray operators who implement IRS use compression sprayers to apply a measured amount of insecticide on the interior walls of houses and structures. Insecticide is emptied from its sachet into a bucket, mixed with water, and poured into the sprayer.[5] The sprayer is pressurized, and the material is then carefully 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.

Mozambique has been using ICON in its IRS operations for several years. In 2005, the MISAU started a DDT pilot program, spraying DDT in two districts in Zambezia Province. ICON is also being sprayed in two other districts in Zambezia, Murumbala, and Makuba (see **Annex 4**).

For program start-up, three provincial and district officers were trained by LSDI in a "Training of Trainers" session. These three officers then shared the information they learned with three other officers, and all six worked as trainers for the spray operation. The current IRS program in Zambezia is structured in the following way:

[5] Currently, water-soluble sachets for DDT are not available on the market. This is due to the greater quantity of water-soluble material that is needed to package one charge of DDT, which, when dissolved, clumps and clogs spray-pump filters. Because of the volume of DDT required per charge and DDT's low water solubility, DDT is thoroughly mixed in a bucket before being poured into the spray pump to avoid clogging of spray filters with non-dissolved DDT. Until spray pump manufacturers produce spray pumps in which DDT can be mixed, this practice will be continued.

Figure 3. Current IRS Program Structure in Zambezia



The Field Officer ensures that the district has an adequate amount of insecticide for the campaign, that the PPE is in order, and that the sprayers are maintained. The Field Officer also collects data and deals with any problems that arise (e.g., refusals).

The Brigade Chiefs supervise the spray teams. It is thought that, ideally, one Brigade Chief should supervise four spray teams; however, in Nicoadala, there is only one Brigade Chief for the 20 spray teams in the district.

Each spray team is comprised of four spray operators and one team leader, who does not conduct spraying. The team leader coordinates with local leaders and communities, supervises spray operators, works with reporting in the field, and is responsible for giving out insecticide sachets with the storekeeper. Ten sachets are given out to each spray operator per day.

Spray operators and team leaders are initially selected by community leaders, using certain criteria (e.g., behavior, seriousness, physical strength, literacy). In Nicoadala District, 700 people were initially chosen in this process, interviewed, and reduced down to 300. Those 300 people were then trained during a 10-day period in December. The training consisted of three days of practical training on spray equipment, followed by seven days of morning spray-practice and afternoon lecture (i.e., how to care for

equipment, importance of their work, and messages about malaria). Of the 300 people trained, 257 passed the training and went on to work in the spray campaign. The IRS program recruits new spray operators each year, although some spray operators have worked in previous campaigns.

The spray equipment used for the IRS program is Hudson X-Pert® sprayers, which are manufactured following WHO specifications for compression sprayers for IRS operations. Each spray operator is provided with the following safety equipment, in accordance with WHO specifications:

- Long-sleeved shirt
- Pants
- Hat that covers ears and neck
- Face shield
- Rubber gloves
- Work boots
- Dust masks.

Spray operators fill out spray cards each day of the operation, documenting the location, number of rooms and households sprayed, and number of charges (amount of insecticide) used during the day. After spraying, the spray operator leaves a spray receipt with the head of household and asks them to put it in a visible place. The receipt serves as a means of cross-checking spray cards. The household is supposed to keep this receipt for the next few years so that the program can know whether the household was sprayed the previous year. Some residents do keep these receipts, but some do not.

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 EA under *Unavoidable Adverse Effects*. For acute and long-term toxicological hazards, see RTI International's (RTI's) *Toxicological Profiles* for Bendiocarb, DDT and Lambda-cyhalothrin in **Annex 5** of this EA.

Residential Exposure. The proposed pesticide use, the measures currently used to mitigate occupational hazards associated with insecticide use in IRS, and the recommendations for further mitigation of occupational risk are primarily 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.

Currently, the MISAU orchestrates a community education campaign two weeks prior to spraying, working with local leaders in targeted communities. Prior to November 2005,

the MISAU did not have a central-level official dedicated to IEC activities. The current IEC official has been tasked with developing a health IEC strategy for the country. Currently, there are no provincial or district health personnel dedicated to IEC activities; thus, when an IEC activity is being implemented, a small task force is created that dedicates its time to the campaign. District health officers were specifically tasked with explaining to community leaders the messages to give to the community, including reasons why IRS is important, and what is expected from community households. For the 2006 spray campaign, the IEC campaign was conducted from the middle to the end of January. In addition to community meetings, radio messages were also played in IRS target areas.

Municipal governments, district administrators, non-governmental organizations (NGOs), and the Anglican Church have all been active in relaying general malaria messages to communities.

If they do not do so already, the MISAU's IEC messages should also instruct IRS target community residents to do the following:

- Clear homes of furniture, cooking implements, and foodstuffs prior to spraying
- 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
- 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
- Do not replaster or paint over the sprayed walls after spraying
- Keep using bednets for protection against malaria.

Pesticide Poisoning. The IRS program 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 program country-level technical manager 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. The institution implementing the program should assure that appropriate short-term technical assistance is provided by the program to provide necessary training of local medical staff.

Guidelines for treatment of poisoning from bendiocarb, DDT and lambda-cyhalothrin exposure are located in **Annex 6** of this EA. 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. 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 will 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 FAO standards)
- Combustibility and combustion byproducts of insecticide.

Drivers hired specifically for the two-month spray campaign period will 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 FAO standards)
- Training on handling vehicle contamination (see 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 should be provided with gloves to wear for cleaning the vehicle. Additional requirements for pesticide transport found in MADER/DINA/DSV Guidelines for the Registration and Handling of Pesticides should be followed.

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

Vector Resistance. Susceptibility tests for lambda-cyhalothrin, deltamethrin, bendiocarb, propoxur, malathion and DDT were conducted in Quelimane and 16 other sites in Mozambique from March 2000 to July 2002. These tests revealed that, in Quelimane specifically, An. arabiensis, and An. gambiae are 100% susceptible to deltamethrin and permethrin, and that An. funestus is 100% susceptible to lambda-cyhalothin, deltamethrin, bendiocarb, and DDT. Other tests in the central and northern parts of Mozambique revealed that An. funestus, An. arabiensis, and An. gambiae should be 100% susceptible to lambda-cyhalothrin, deltamethrin, bendiocarb, propoxur, malathion and DDT (Casimiro et al. 2006).

Residual Persistence. The housing types found in Quelimane proper are generally classified as 'formal houses' with painted or plastered surfaces. On these wall types, lambda-cyhalothrin will be used and will likely be effective for at least six months (Najera and Zaim, 2002). In the surrounding districts, mud or unfinished block walls are more prevalent. DDT would most likely be 100% effective on mud walls throughout the spray season and subsequent malaria transmission season (Sharp, email communication during PEA process). Bendiocarb would likely be effective on mud walls for at least six months of the transmission season (Maharaj et al. 2004).

Insecticide Quality. The insecticides bought for the IRS program are procured through well-known manufacturers with a history of compliance with WHO specifications for malaria control insecticides.

Demonstrations of Effectiveness. The effectiveness of bendiocarb, lambda-cyhalothrin and DDT has been well-demonstrated in the LSDI program, which has substantially reduced malaria incidence in districts surrounding Maputo. LSDI divides its program into different administrative zones, which have each benefited substantially from IRS interventions:

> *In Zone 1, the average infection rate from all sites was 62 % in 2000, which reduced to 7.2% in June 2004. In Zone 1A overall prevalence of infection in June 2000 was 86%. This reduced to 20.8 % in June 2004. In Zone 2 overall prevalence of infection at baseline was 70% in June 2002, dropping to 29.8% in June 2004 after spraying. In Zone 3 the prevalence was 69.6% pre spraying and dropped to 58.4% after the first spray round* (LSDI Website, Update 2005)

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

Bendiocarb and DDT should be compatible with their intended use in peri-urban and rural households, and lambda-cyhalothrin with its intended use in urban households (or peri-urban/rural households, provided an increased dose is sprayed), with the exceptions noted in *Environmental Consequences—Unavoidable Adverse Effects*. The following paragraphs indicate the compatibility of the proposed pesticides with nontarget ecosystems.

Bendiocarb**.** Bendiocarb is toxic to birds, bees, and fish and other aquatic organisms. Thus the primary concern in bendiocarb use for IRS would be the following scenarios:

1. ***Release of sprayer rinse-water into water bodies.*** Currently, sprayer rinse-water is re-used for the next day's operations, so the issue of release of sprayer rinse-water should not be a concern.
2. ***Release of overall/PPE wash-water into water bodies.*** Spray operators wash their overalls at their residences. Spray operators are told to wash their overalls in a tub, and are provided soap to do this. They are told specifically to dig a hole, dump the wash water in the hole, and cover it up. Although this training is appropriate, there are no assurances that this is done consistently.
3. ***Spray operators washing themselves in water bodies.*** Spray operators wash themselves at their residences; thus, there are no assurances that spray operators do not wash themselves in water bodies.
4. ***Accidental spraying of apiaries (beehives).*** Accidental spraying of apiaries would kill bees residing therein.
5. ***Impacts on domestic poultry.*** There is anecdotal evidence of bendiocarb use resulting in the death of domestic poultry that eat insects killed by the insecticide. It is important to inform communities of this risk so they can take precautions as they see fit. When using bendiocarb, it is also important to educate the community about the importance of preventing children and domestic livestock from entering the household until insecticide residue from the flooring is swept out of the home/collected and disposed.

DDT. The potential impact of bioaccumulation in the environment as a result of DDT use in IRS has been studied; thus, it is unknown whether the proposed pesticide use is compatible with nontarget ecosystems from the perspective of impacts resulting from bioaccumulation (e.g., eggshell thinning or other reproductive system impacts on mammals, birds, and reptiles).

In terms of toxicity, DDT is toxic to fish and other aquatic organisms. Unlike bendiocarb or lambda-cyhalothrin, DDT is not toxic to bees. Additionally, DDT is only slightly toxic to birds (although chronic exposure may lead to adverse reproductive impacts). Thus the primary concern in DDT use for IRS would be the following scenarios:

6. ***Release of sprayer rinse-water into water bodies.*** Currently, sprayer rinse-water is re-used for the next day's operations, so the issue of release of sprayer rinse-water should not be a concern.

7. ***Release of overall/PPE wash-water into water bodies*** Spray operators wash their overalls at their residences. Spray operators are told to wash their overalls in a tub, and are provided soap to do this. They are told specifically to dig a hole, dump the wash water in the hole, and cover it up. Although this training is appropriate, there are no assurances that this is done consistently.

8. ***Spray operators washing themselves in water bodies.*** Spray operators wash themselves at their residences; thus, there are no assurances that spray operators do not wash themselves in water bodies.

9. ***Runoff or flooding transporting DDT-contaminated soil to water bodies***. As spraying is currently conducted, runoff or flooding is a concern because DDT solution is deposited at each household when spray tanks are recharged. Spray operators dig a hole in which to dump excess DDT solution (from the previous charge) and rinse off the sprayers. Once the sprayer has been recharged, the hole containing the excess DDT solution is covered up with soil. Erosion of DDT-contaminated soil could cause contamination in water bodies. Additionally, if household residents dig up DDT-contaminated soil for their personal use (e.g., on crops), the disturbance could increase the mobility of the contaminated soil during rain events. Sprayers only need cleaning once at the end each spray day, and do not need to be dumped out or cleaned when one charge is finished. The practice of rinsing out the sprayer after each charge should be prohibited.

10. ***Intentional use of DDT-contaminated soil for fishing***. In Musivi, Mozambique, soils contaminated with pesticides were used to poison fish in water bodies for human consumption. If the current practice of burying DDT solution after each charge is continued, it is possible that households would use DDT-contaminated soil left during the course of IRS operations in such fishing practices.

11. ***Use of DDT for Agricultural Purposes.*** Use of DDT for agricultural purposes must be a primary concern for the IRS program. Rigid sachet accounting procedures must be in place to detect potential pilferage from spray operators. Storage facilities must be secure at all times. A guard should be posted outside each storage facility, and all facilities should be locked—preferably double-padlocked.

<u>Lambda-cyhalothrin</u>**.** Lambda-cyhalothrin is toxic to bees, and fish and other aquatic organisms. Thus the primary concern in lambda-cyhalothrin use for IRS would be the following scenarios:

12. ***Release of sprayer rinse-water into water bodies.*** Currently, sprayer rinse-water is re-used for the next day's operations, so the issue of release of sprayer rinse-water should not be a concern.

13. ***Release of overall/PPE wash-water into water bodies*** Spray operators wash their overalls at their residences. Spray operators are told to wash their overalls

in a tub, and are provided soap to do this. They are told specifically to dig a hole, dump the wash water in the hole, and cover it up. Although this training is appropriate, there are no assurances that this is done consistently.

14. ***Spray operators washing themselves in water bodies.*** Spray operators wash themselves at their residences; thus, there are no assurances that spray operators do not wash themselves in water bodies.

15. ***Accidental spraying of apiaries (beehives).*** Accidental spraying of apiaries would kill bees residing therein.

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

Zambezia Province lies in the central region of Mozambique, stretching from the Indian Ocean to the Malawi border. Zambezia Province has a tropical climate, with one rainy and one dry season. The Zambezia Province capital, Quelimane, experiences peak rainfall from December through April, and temperatures in the Province range from 21 to 28 degrees Celsius (**Table 8**). Cyclones frequent the Mozambique coast during the rainy season, and the coast of Zambezia Province has experience massive flooding in recent years. In 2001, thousands of residents in Zambezia Province were displaced by flooding.

Table 8. Average Monthly Temperature and Precipitation in Quelimane, Mozambique

	Years on Record	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Temperature °C	16	26 (avg)	28	28	28	26	24	22	21	22	24	26	28	28
Average Precipitation mm	83	1400 (total)	229	249	239	117	79	61	58	28	18	23	79	196

Source: www.qwikcast.com. Accessed June 19, 2006.

A list of the endangered species present in Mozambique can be found in **Annex 7** of this EA.

No spraying will be conducted inside the boundaries of protected areas, sensitive ecosystems, or apiaries, and no outdoor spraying will be conducted. Additionally, every effort will be 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
- Re-use of sprayer rinse-water throughout the IRS program

- Supervision of persons hired to wash protective outerwear
- Environmental Compliance monitoring, and
- Environmental monitoring.

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

Other Pesticides. The WHO-recommended chemicals registered in Mozambique include the following:

- Alpha-cypermethrin
- Bendiocarb
- DDT
- Deltamethrin
- Malathion
- Pirimiphos-methyl
- Propoxur.

The effectiveness of alternative IRS pesticides depends highly on vector resistance, house construction materials, and residual life of the pesticide on those construction materials. In Zambezia Province, resistance to no alternative insecticides has been detected. Pyrethroid resistance has been detected in Southern Mozambique.

Actellic is used in three provinces in an ad-hoc manner. The effectiveness of larviciding activities in Mozambique is not known.

Non-Chemical Control Methods. Environmental management activities have not been conducted in Mozambique in any organized manner; therefore, the potential effectiveness of environmental management activities in Mozambique is not known.

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

Distribution. Insecticide is imported at Beira and driven to the Quelimane central store by truck. Every two weeks, the Quelimane central store distributes insecticide to the districts on an as-needed basis to avoid excess stocks at the district level. Personnel, as well as insecticide and PPE, are transported from district insecticide storage sites to target villages either by truck, or by bicycle because trucks are in short supply and spray operators often ride their bicycles into the field.

This most recent spray season, the insecticide was delivered late due to delays in procurement. As a result, the spray campaign started on the day it was supposed to have ended (January 31) and did not achieve as much coverage in target areas as originally intended. The logistics of IRS procurement and management is an area that requires substantial improvement in the MISAU.

Storage. Thus far, Zambezia Province has not had a problem of excess stocks for IRS. The Zambezia Province keeps small amounts of stocks in the event that spraying must be conducted due to public complaints. The central MISAU offices send Actellic, which is used on an ad-hoc basis. The provincial staff do not request the larvicide from the MISAU, but it is sent regardless. Pesticides and larvicides should not be distributed to provinces or districts that do not request them. (The use of Actellic is based on entomological surveillance from several years ago, and it is not applied to drinking water sources.)

Storekeepers were chosen based on their prior experience with storehouse work and are trained locally and on-the-job based on a manual, which could not be produced upon request, but is most likely based on Avima guidelines in accordance with conversations with central MISAU offices. The Minister of Health requested that only women be hired as storekeepers. To avoid excess stocks at the district level, the Quelimane central store distributes insecticide to the districts on an as-needed basis every two weeks. Every district where IRS is conducted has a storehouse, which is guarded 24 hours a day, 7 days per week. The storehouse manager is the only person with the key to the storehouse, and storekeepers are only employed during the spray season. It is recommended that the storekeepers receive up-to-date training on storehouse management, based on the FAO Pesticide Storage and Stock Control Manual (FAO, 1999) and/or storehouse management guidelines developed in Ethiopia under the FAO African Stockpiles Program until Mozambican national guidelines can be updated.

Central storehouses (including the MISAU store in Maputo and the Quelimane store in Zambezia Province) do not have proper equipment for handling spillages or emergencies. Fire safety/emergency equipment should be in major insecticide stores and should include the following:

- Fire extinguisher
- Protective clothing (e.g., overalls, goggles, dust mask, boots)
- Eye wash set
- A few bags of sawdust and/or sand to absorb leaked or spilled pesticides
- Water supply from a tap, or a container of water
- An empty container to contain any spillage
- Spade and brush
- Soap or detergent.

In the event of a leak or spill of wettable powder, absorbent sawdust, sand, or 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 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 (Ethiopia Ministry of Agriculture, 2005).

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.

Pilferage is not seen as a major problem at the district level, although the Minister of Health recently indicated that about 20% of pyrethroids used for vector control are pilfered. IRS program staff indicated that they try to involve the administration and police for these situations. During the campaign, communities are told to notify the IRS program if someone tries to sell them pesticides from the public health sector. During the 2006 spray campaign, one sachet of DDT (670 g) was found on the market. If DDT is found outside the public health sector, the person possessing the DDT is supposed to be arrested immediately; however, current laws do not criminalize illegal pesticide trafficking, repackaging, dumping, or disposal. Such criminalization should take place to provide a basis for preventing and punishing pilferage of public health pesticides (Vera 2006).

Disposal. Because bendiocarb and lambda-cyhalothrin are contained in water-soluble sachets that are placed directly into the spray pump, little to no contaminated packaging should result from the use of these chemicals; however, DDT is not contained in water-soluble sachets due to the large quantity required per charge. Empty DDT sachets should be returned to the manufacturer or to an internationally accredited incineration facility.

Non-contaminated insecticide packaging (e.g., boxes, paper) can be open-burned. Any packaging that has been heavily contaminated should be triple-rinsed, shredded or punctured, and taken to a hazardous waste facility.

Sprayer rinse-water is to be re-used for the next day's operations (this is one of the major points in the operators' training). At each storehouse, there is at least one big water barrel that is used for rinsing the sprayers. These rinse-water barrels are stored just outside the actual storehouses. At the end of the program, all the rinse-water goes back to the Quelimane storehouse. Although the Province is waiting for instructions from the central MISAU office on what to do with this excess rinse-water, this rinse-water should be kept and used in the next spray season during the first day of spraying. Empty DDT sachets (also used to track insecticide) are collected from the spray operators and put in empty barrels. The Province is also waiting for direction from the central level on what to do with the empty sachets.

Spray operators take their overalls and other PPE home and are instructed to wash their overalls in a tub using the soap provided with their PPE. The operators are also 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.

K. The Provisions Made for Training of Users and Applicators

Training for brigade chiefs, team leaders, and spray operators is currently conducted over a 10-day period, based on the "Training of Trainers" sessions provided by LSDI. Seasonal training should be observed to ensure that it is conducted according to LSDI guidelines and the WHO's *Manual for Indoor Residual Spraying: Application of Residual Sprays for Vector Control* (WHO, 2002). Additionally, training of spray operators in recognition of poisoning symptoms and first aid should be integrated into the 10-day training (see *Any Acute and Long-Term Toxicological Hazards…* section).

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

Environmental Compliance Monitoring. According to Hatton et al.:

> *The EIA Regulations (Decree 76 of 1998) make explicit provision for pose-decision follow-up by means of inspection or auditing. Article 15(1) states that –*
>
> … the Ministry for the Co-ordination of Environmental Affairs should regularly inspect and control the monitorisation [sic] and environmental management of the activity undertaken by the proponent.
>
> *MICOA can inspect and control the post-decision activities of the proponent by requesting environmental impact audits to be conducted or by undertaking inspections. The EIA review process should also consider minimum criteria for post-decision performance tracking.*
>
> Hatton et al. 2003

In addition to or in lieu of MICOA inspections, Environmental compliance monitoring will also be provided by the USAID IRS Program contractor, which will conduct a site visit during IRS operations and report to USAID on the implementation of compliance activities. This activity serves to address weaknesses in program implementation and avoid human health and environmental hazards. Throughout the duration of the program, the contractor will inspect operations and track improvement in compliance activities. The contractor will also work with MICOA as appropriate to build capacity for monitoring IRS activities in Mozambique.

Finally, 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.

Entomological Monitoring. The primary function of entomological monitoring associated with vector management is to assure that interventions are effective. Such monitoring is essential for IRS. The monitoring program must include at least the first three types of tests described below; the fourth category should also be included when possible.

Determine vector susceptibility to available insecticides. Susceptibility studies detect the presence of individuals in the vector population that are physiologically resistant to the insecticide being tested. For IRS, susceptibility studies can be conducted by using WHO test strips or CDC bottle assays on adults caught in the wild or adults reared from immature larvae. Although the CDC bottle assays have the advantage of testing a sample of the same chemical batch being applied, the WHO test strips enable more comparability across countries and time. Where possible, both should be done. Larvicides are generally tested for efficacy in small-scale field trials. In addition to the above "in vivo" resistance information, it is also possible to collect large numbers of the vector species for analysis by polymerase chain reaction (PCR) to determine the frequency of genetic markers that code for pesticide resistance in the local vector population. Nevertheless, PCR analysis should not be used as a substitute for "in vivo" resistance analysis.

Verify that the insecticide was applied properly and had an immediate effect. This involves routine follow-up observations. For IRS, wall bioassays are used to verify there is sufficient residual pesticide on the walls of sampled structures to kill vector mosquitoes, and to monitor the loss of residual efficacy over time.

Determine the geographic and temporal distribution of vector populations. To target areas where vector control for malaria is needed, it is necessary to determine where malaria transmission occurs and the length of the transmission season by establishing when populations of adult vectors are present. This can be done by using a variety of collection techniques, including human landing catches, CDC light traps, cattle-baited hut or net collections, nonbaited hut or net collections, pyrethrum spray catches (PSCs), and window exit traps.

Measure the impact of the intervention on the vector population and/or malaria transmission intensity. Several different techniques are used to monitor the vector population and/or the frequency and infectivity of vector biting. In general, the intention is to determine whether the vector management program has substantially reduced the vector population or survivorship, as indicated either by a reduction in the number of mosquitoes that can be collected, a reduction in mosquito biting, or, as detected through mosquito dissections, the proportion parous (the proportion that have laid at least one batch of eggs). Methods are available for human landing catches, CDC light traps, cattlebaited hut or net collections, nonbaited hut or net collections, PSCs, and window exit traps.

Monitoring Environment. 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." Technical assistance will be provided to assess the impact of IRS activities on the environment to the extent "feasible" and "relevant."

Preparation Methodology

The contents of this EA are based on direct communication with MISAU, WHO, Agrifocus Limitada, FAO, PAN UK, Livaningo, Neoquimica, Bayer Environmental Science, the National Institutes of Health Mozambique, UNICEF, the Zambezia Provincial Health Office, the Nicoadala District Health Office, and the Lubombo Spatial Development Initiative. Individuals from these organizations and institutions graciously provided information on pesticide and vector control practices currently being conducted in Mozambique to a team consisting of:

Ms. Melanie Biscoe	Environmental Scientist, RTI International
Ms. Elizabeth Streat	Medical Research Council (MRC) South Africa
Dr. Abuchahama Saifodine	Health Team Leader, USAID/Mozambique
Mr. Camilien Saint-Cyr	Regional Environmental Officer, USAID
Dr. Walter Knausenberger	Regional Environmental Officer, USAID
Dr. Titus Angi	Health, Population and Nutrition Specialist, USAID/Mozambique
José Martins	Mission Environmental Officer, USAID/Mozambique

Research for this EA was conducted over a 10-day period from April 2 to April 13, 2006. Additionally, government documents concerning pesticide use, the environment, and malaria control were reviewed and incorporated into this EA.

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Annex 1: Terms of Reference for Technical Committee on the Indoor Residual Spraying (IRS) Zanzibar

The committee is required to perform the following tasks:

1. Advise and report to the Minister of Health and Social Welfare and also to the Executive committee of the Ministry of health in all issues concerning IRS
2. The Technical committee will work together with the Ministry of Health and Social Welfare particularly with staff from the Zanzibar Malaria Control Programme.
3. Budgeting the IRS activities based to the PMI approval budget
4. Develop and translate the IRS protocol to the District supervisors and spraying team, which will guide IRS implementation in Unguja and Pemba. The protocol to be jointly discussed and agreed upon between the IRS consultant and Malaria Control Program and Technical committee.
5. Identify and approve training need of spraying man.
6. Selecting and leading the sprayer man in conducting the IRS exercises and provide technical guidance required
7. Prepared periodically progress report of the IRS activities
8. Mobilize resources required for IRS operation from deferent Government and Non Government sectors

Proposed Working Groups

Some changes were made to the proposed working groups based on the practical experiences and gaps observed during the discussion.

1. Executive Committee will be presented by the following members

Members:

- Principal Secretary(MoHSW)
- P/S –Agriculture
- Director Environment
- P/S – Regional Adminstration
- Director Chief Minister's Office
- Chairperson of IRS Technical Committee(Directors)
- Secretary of IRS Technical Committee (Programme Manager ZMCP)
- RTI Advisor ZMCP
- Vector Control Focal Person ZMCP

Task:

- Oversee activities of other committees
- Ensure timely availability of financial and other operational resources for IRS timely
- Decide on matters of urgency pending a meeting of Technical Committee.
- Collaborate with consultants, international and local organizations pertaining to IRS issues.

2. IEC/Community Mobilization Committee

Members:

- Health Education Unit MoHSW
- IEC focal Person ZMCP
- Ministry of Information
- NGO Representative
- T- MARK
- Vector Control Officer MoHSW
- Region Administration Representative
- Sociologist
- RTI Advisor

Task:

- Development of IEC material/messages
- Pre-testing IEC materials/messages
- Production of IEC materials
- Dissemination of IEC material
- Conduct Health education campaigns on IRS

3. Logistic and Supply Committee

Members:

- M/Communication and Transport
- Ministry of Finance Representative
- Medical store Department MoHSW
- Transport Officer MoHSW
- IRS Advisor ZMCP

Task:

- Facilitate tax exemption of goods for IRS
- Procurement of IRS equipment

- Storage and distribution of all supplies to respective areas of operation
- Allocate transport and other supplies according to IRS plan

4. Environmental Monitoring Committee

Members:

- Environmental Department
- Environmental Health Unit MoHSW
- Water Department
- Marine Science Institution
- Ministry of Agriculture
- Vector Control Officer MoHSW
- Medical Doctors MoHSW

Task:

- Manage safety disposal of used pesticide sachets
- Monitoring blood picture changes, congenital malformation, incidence of cancers etc.
- Monitoring of Environmental pollution
- Regular follow-up of warehouses

5. Training and IRS Operation Committee

Members:

- Vector Control/ Entomologist - MoHSW
- Regional Gov. Administration
- Local Sprayer maintenance
- RTI Advisor

Task:

- Selection of supervisors and Operators
- TOT for supervisors
- Spray operators training
- Geographical reconnaissance
- District level micro planning
- Oversee entomological monitoring
- Medical Doctors
- Nurses
- Pharmacist
- Ensure timely availability of financial and other operational resources for IRS

6. First Aid Committee

Training to local peripheral staff to be conducted by Medical Practitioners to equip them on pesticide reactions, toxicity and its overall management. First aid kits to be made available

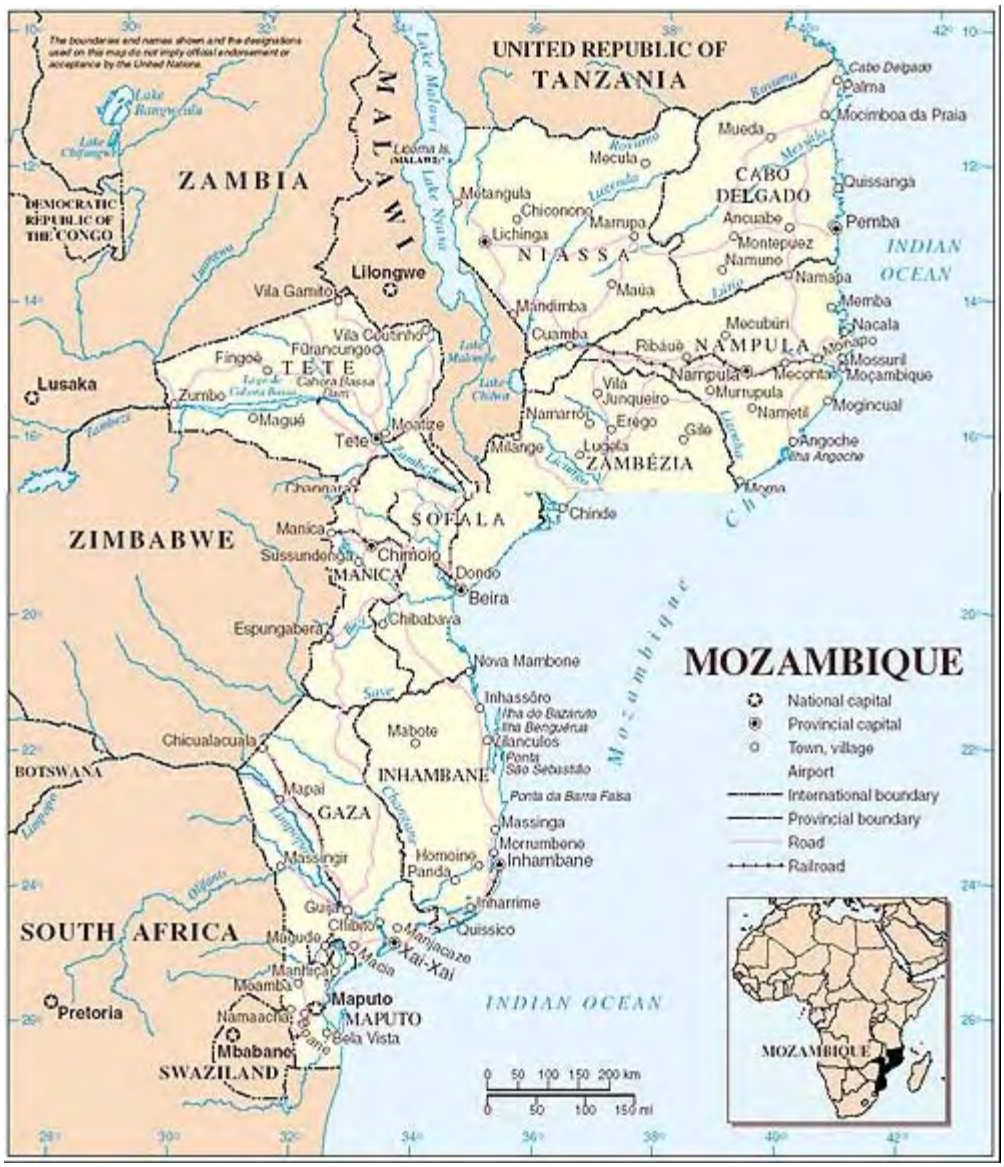
Annex 2: Recommended Mitigation Activities for IRS Program

Pre-Campaign	During Campaign	Post-Campaign
Develop IRS Steering Committee, including MISAU, MICOA, MINAG, and civil society stakeholders (e.g. Livaningo)	Reprimand spray operators that do not follow proper procedure in all aspects of operations (e.g., handling, spraying, hygiene, cleanup)	Conduct end-of-program cleaning/decontamination of interior and exterior of vehicle
Conduct training of spray operators, team leaders, and supervisors according to WHO guidelines	Conduct progressive rinsing of sprayers and PPE	Conduct end-of-campaign washing of seat covers and damp cloths used to wipe seats/bed of program vehicle
Procure PPE for spray operators, team leaders, and supervisors, including cotton overalls, face mask, broad-rimmed hat, rubber gloves, and gum boots	Prohibit spraying in homes where sick persons or pregnant women are living and cannot move outside the home *and* stay outside the home during and 1 hour after spraying	Return empty DDT sachets to manufacturer at end of spray season
Develop program-specific guidelines for pesticide poisoning, according to guidance provided in this EA	Prohibit spraying in homes where food and utensils have not been removed from the house and where furniture has not been removed outside *or* moved to the middle of the room and covered with a cloth by the spray operator	Entomological monitoring of resistance
Procure funnels to prevent spillage of insecticide when filling sprayers	Prohibit cleaning/rinsing sprayers after each charge	Submit environmental reporting to IRS Steering Committee and USAID Mission Environmental Officer
Develop environmental reporting system	Cover cloth interior seats of program vehicles with seat cover or cloth to prevent seat contamination	
Prohibition of women spray operators	Use gloves for washing interior and exterior of program vehicle	
Work with FAO on pesticide management issues, as described in recommendations 5 and 6 in the SUAP	Prior to exterior washing of program vehicles, wipe contaminated bed of truck with damp cloth	
Procure only as much insecticide as will be used in the province during one year	Prior to spraying, cover furniture that cannot be moved with cloths provided by the MISAU, District Health Office, or IRA program	
Develop protocol for decision-making when environmental monitoring indicates environmental contamination as a result of IRS (suggested protocol involves MISAU, MICOA, MINAG, and civil society stakeholder consultation at	Allow spray operators to take home gloves for the purpose of washing overalls	

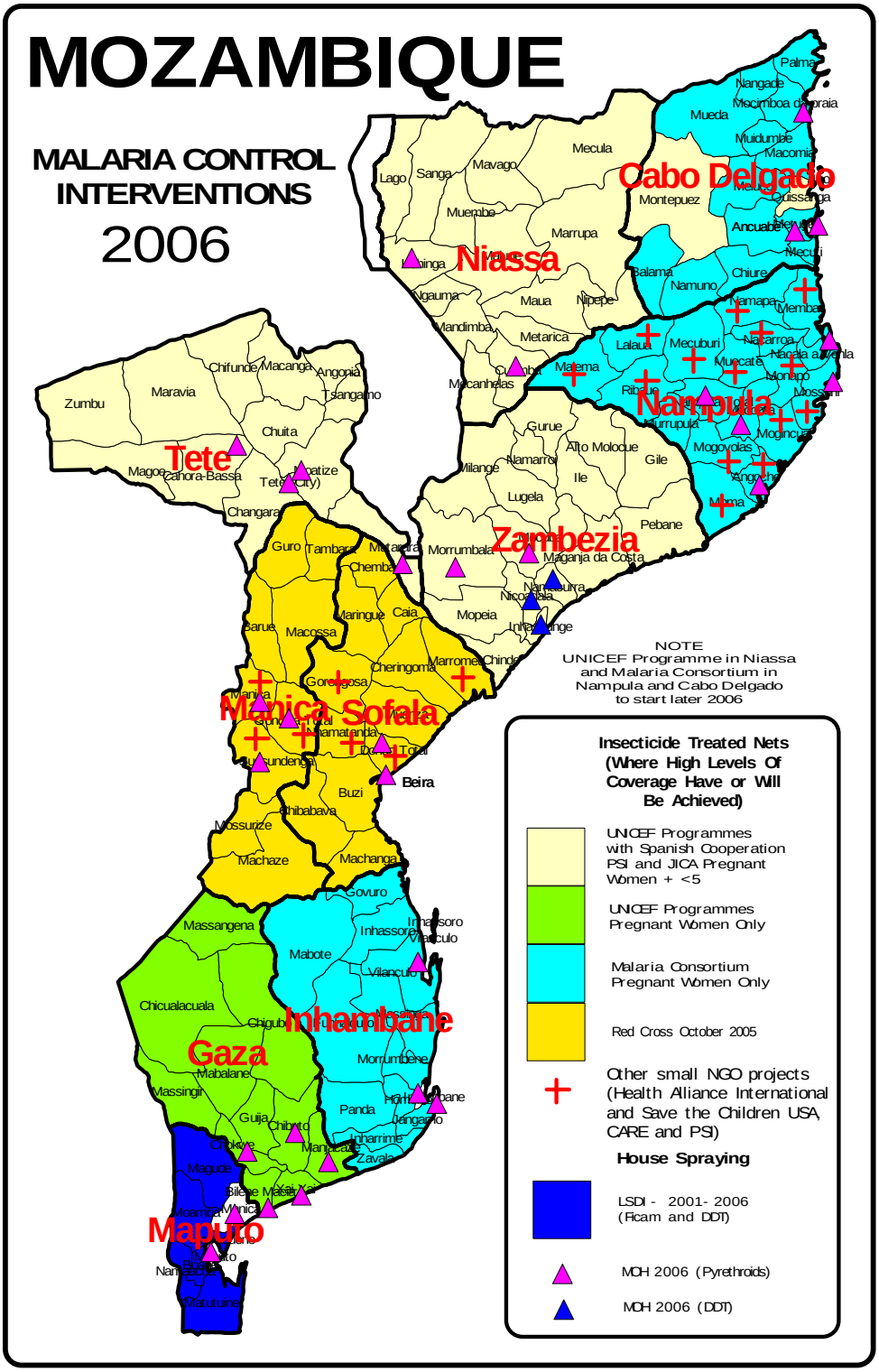
Pre-Campaign	During Campaign	Post-Campaign
the district level)		
Prohibit spraying in flood-prone areas, areas important for agricultural production, and protected areas/sensitive ecosystems.	Store all insecticides, empty packaging, barrels, and tubs inside storage facilities, reducing use of contaminated goods domestically	
Conduct IEC Campaign, citing importance of removing all food, 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	Use sprayer rinse-water from the previous spray season in the current spray season	
Procure seat covers or sheets for covering cloth vehicle seats	Padlock and guard storage facilities	
Provide instruction to spray operators that tubs used for washing overalls should be thoroughly washed before being used for any other purpose (including washing other clothes) and that rinse-water should be dumped in a latrine or pit especially dug for that purpose, not existing water bodies.	Supervise spray operators	
Inscribe all program barrels and tubs as District Health Office property and label with poison stickers to deter sale and domestic use in event of pilferage	Conduct daily sprayer maintenance	
Develop and implement environmental monitoring plan	Implement environmental reporting system	
Procure and distribute emergency equipment to *central* insecticide storage facilities	Ensure proper use of PPE by spray operators, team leaders and supervisors (e.g., cotton overalls, face mask, broad-rimmed hat, rubber gloves, gum boots)	
Conduct refresher training for storekeepers	Implement environmental monitoring plan	
Conduct training of drivers for long-distance transport of insecticide and short-distance transport during the campaign period	Use funnels to prevent spillage of insecticide when filling sprayers	

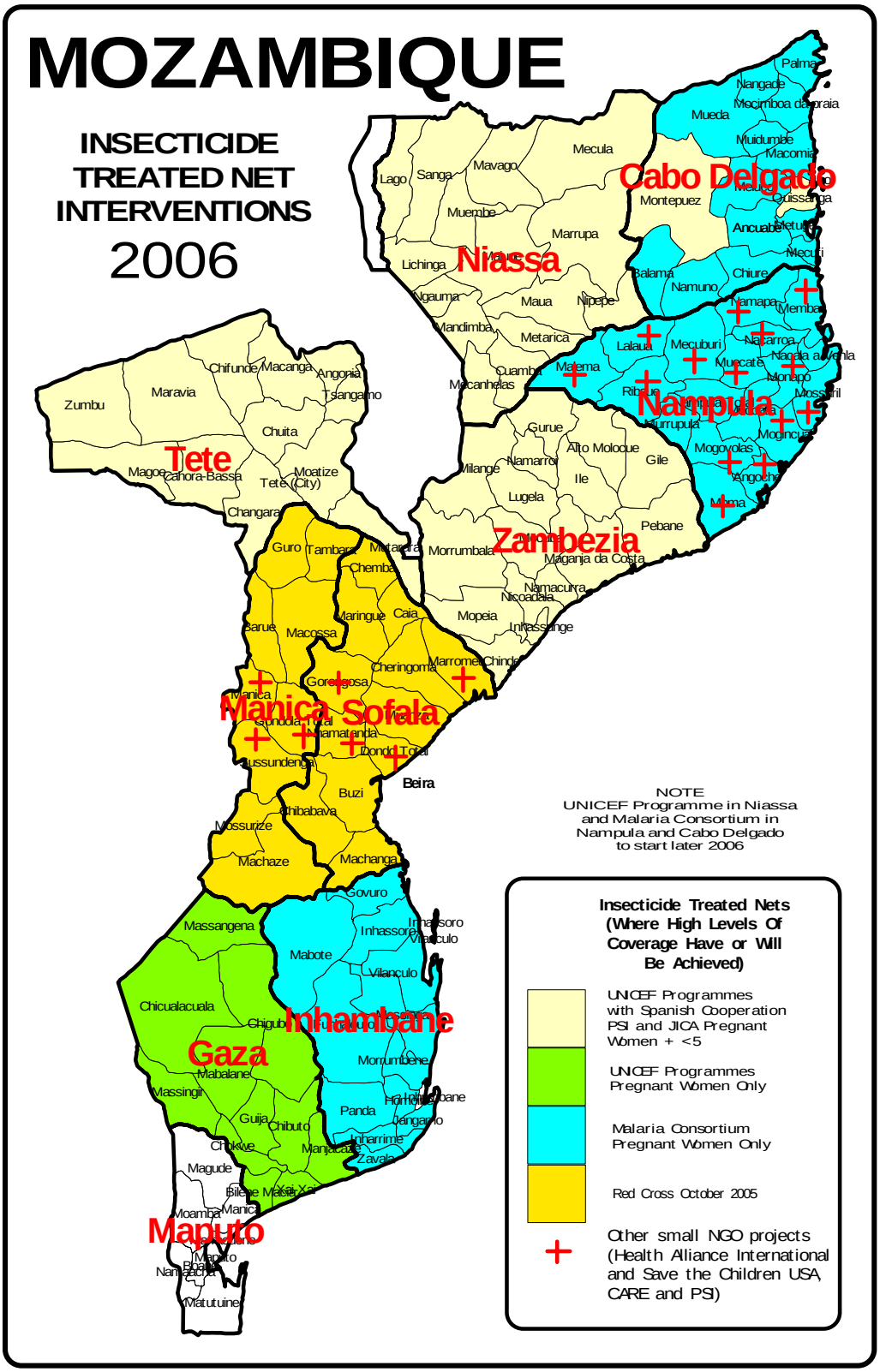
Pre-Campaign	During Campaign	Post-Campaign
Select insecticide to minimize resistance and maximize residuality on surfaces sprayed	Use spot-check card for quality assurance	
Conduct interactive training in procurement, logistics, and management of public health pesticides to prevent accumulation of unused and obsolete stocks		
Conduct lab-testing of insecticide to ensure quality control		
Conduct IEC Campaign, citing importance of not plastering or painting walls after the home has been sprayed		
Procure and use sprayers manufactured according to WHO specifications		
Inform fire brigade of location and contents of pesticide storage facilities		
Importance of an environmental assessment for any pesticides used in IRS will be discussed with MOH and MOE staff-- online resource for conducting assessments will be provided (http://www.encapafrica.org/)		

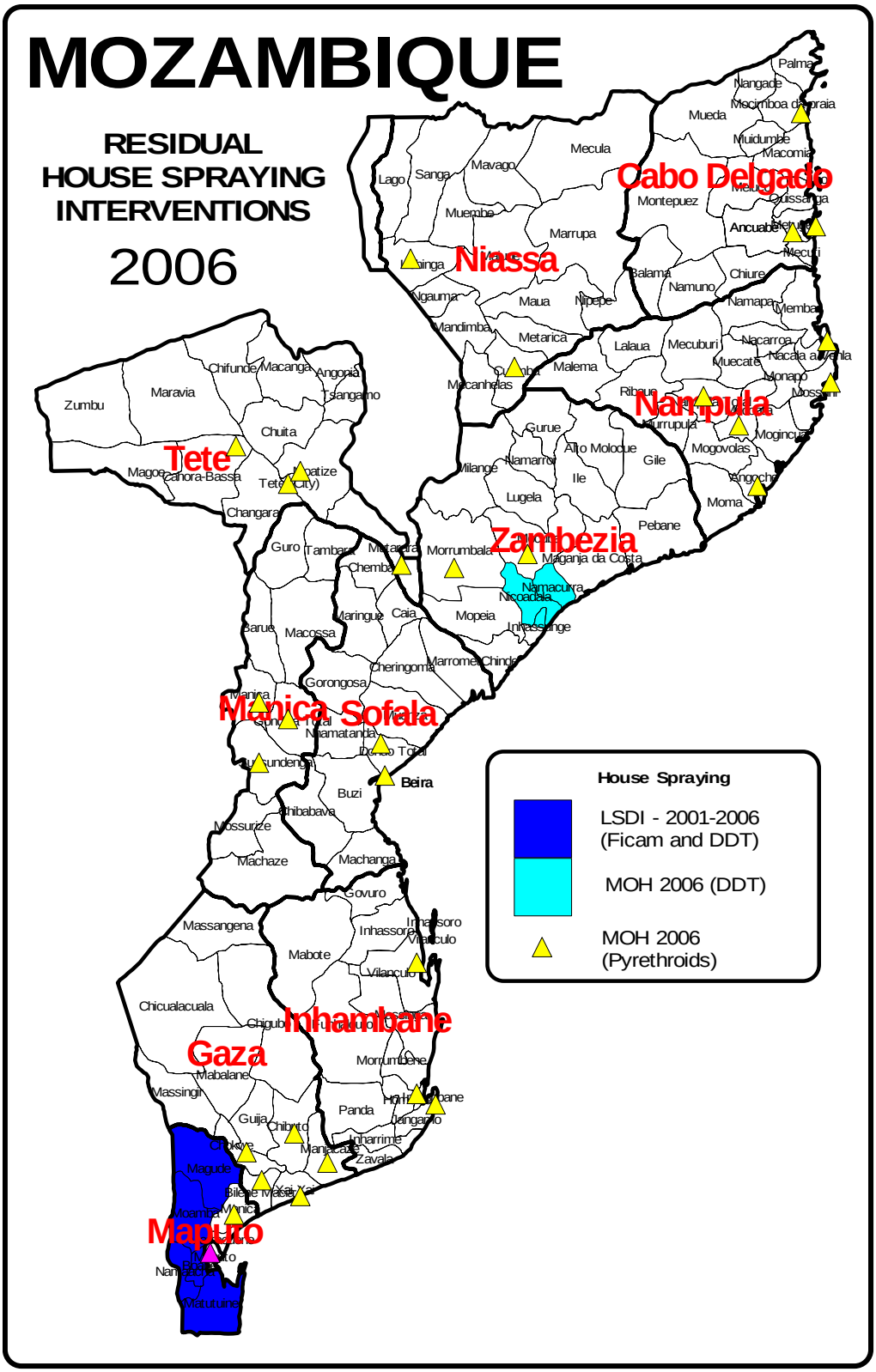
Annex 3: Map of Mozambique, UN


The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.
UNITED REPUBLIC OF TANZANIA
ZAMBIA
MALAWI
DEMOCRATIC REPUBLIC OF THE CONGO
Lilongwe
Lusaka
TETE
NIASSA
CABO DELGADO
NAMPULA
ZAMBÉZIA
SOFALA
MANICA
INHAMBANE
GAZA
ZIMBABWE
BOTSWANA
SOUTH AFRICA
SWAZILAND
Pretoria
Maputo
MAPUTO
Mbabane
Beira
Tete
Chimoio
Nampula
Pemba
Quelimane
Inhambane
Xai-Xai
Chibabava
Nova Mambone
Massinga
Quissico
Cabo Delgado
Palma
Mocimboa da Praia
Mueda
Quissanga
Ancuabe
Montepuez
Namuno
Namapa
Memba
Nacala
Monapo
Mossuril
Moçambique
Mecubúri
Ribáuè
Mecontá
Murrupula
Nametil
Mogincual
Angoche
Ilha Angoche
Mogovolas
Mecula
Metangula
Chiconono
Lichinga
Marrupa
Maúa
Mandimba
Cuamba
Vila Gamito
Vila Coutinho
Fúrancungo
Fingoé
Zumbo
Magué
Moatize
Milange
Lugela
Namarroi
Erego
Gilé
Vila Junqueiro
Chinde
Manica
Sussundenga
Dondo
Espungabera
Mabote
Chicualacuala
Mapai
Massingir
Homoine
Panda
Inhassoro
Ilha do Bazaruto
Ilha Bengueriua
Inhamitanga
Ponta São Sebastião
Ponta da Barra Falsa
Morrumbene
Inhambane
Inharrime
Guijá
Chibuto
Magude
Manhiça
Moamba
Namaacha
Bela Vista
Lake Rukwa
Lake Chilwa
Lake Malawi
Lake Nyasa
Lake Chiuta
Lake Cahora Bassa Dam
Lake Malombe
Lake Chiphwa
Lake Chifunga
Lake Bangweulu
Lake Mweru
Lake Mweru Wa Ntipa
Lake Tanganyika
Lake Rukwa
Lake Chilwa
Lake Malawi
Lake Nyasa
Lake Chiuta
Lake Cahora Bassa Dam
Lake Malombe
Lake Chiphwa
Lake Chifunga
Lake Bangweulu
Lake Mweru
Lake Mweru Wa Ntipa
Lake Tanganyika
Rovuma
Lúrio
Ligonha
Mecubúri
Ligonha
Zambeze
Luenha
Luenha
Luenha

Annex 4: Malaria Control Intervention Maps, UNICEF




MOZAMBIQUE
INSECTICIDE TREATED NET INTERVENTIONS
2006
Cabo Delgado
Niassa
Nampula
Tete
Zambezia
Manica
Sofala
Inhambane
Gaza
Maputo
Palma
Nangade
Mueda
Montepuez
Ancuabe
Balama
Chiure
Namuno
Mecula
Lago
Sanga
Mavago
Muembe
Marrupa
Lichinga
Ngauma
Maua
Nipepe
Mandimba
Metarica
Cuamba
Mecanhelas
Lalaua
Mecuburi
Malema
Ribaue
Murrupula
Gurue
Alto Molocue
Gile
Milange
Namarroi
Ile
Lugela
Pebane
Morrumbala
Maganja da Costa
Namacurra
Nicoadala
Mopeia
Inhassunge
Zumbu
Maravia
Chifunde
Macanga
Angonia
Tsangamo
Chuita
Magoe
Cahora-Bassa
Tete (City)
Moatize
Changara
Guro
Tambara
Chemba
Caia
Marromeu
Chinde
Gorongosa
Manica
Sofala
Beira
Buzi
Dondo
Tossundengue
Mossurize
Machaze
Machanga
Govuro
Massangena
Inhassoro
Vilanculo
Mabote
Chicualacuala
Chigubo
Mabalane
Massingir
Morrumbene
Panda
Jangamo
Guija
Chibuto
Chokwe
Manjacaze
Zavala
Magude
Moamba
Manica
Matutuine
NOTE
UNICEF Programme in Niassa and Malaria Consortium in Nampula and Cabo Delgado to start later 2006
Insecticide Treated Nets (Where High Levels Of Coverage Have or Will Be Achieved)
UNICEF Programmes with Spanish Cooperation PSI and JICA Pregnant Women + <5
UNICEF Programmes Pregnant Women Only
Malaria Consortium Pregnant Women Only
Red Cross October 2005
Other small NGO projects (Health Alliance International and Save the Children USA, CARE and PSI)

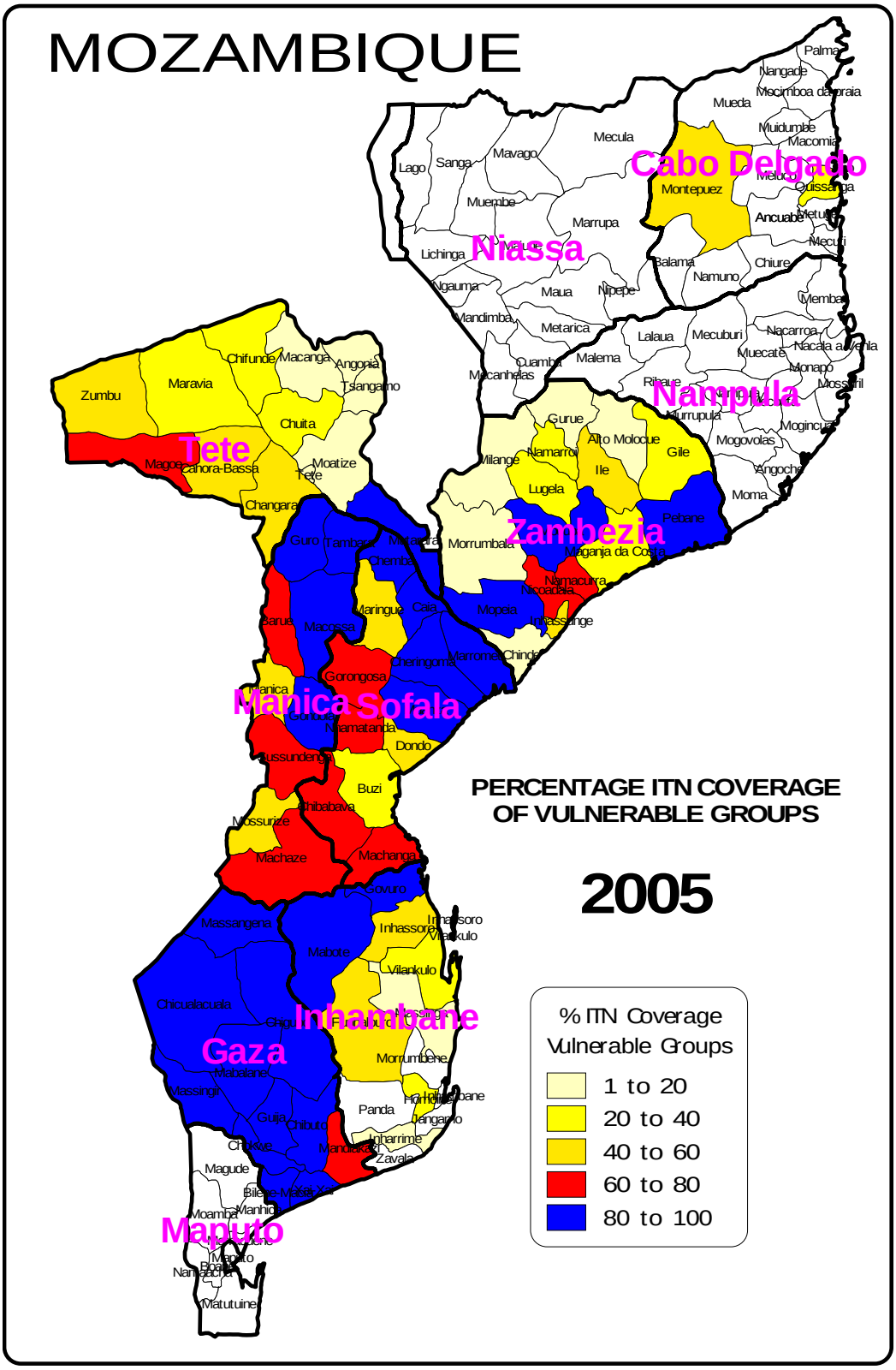


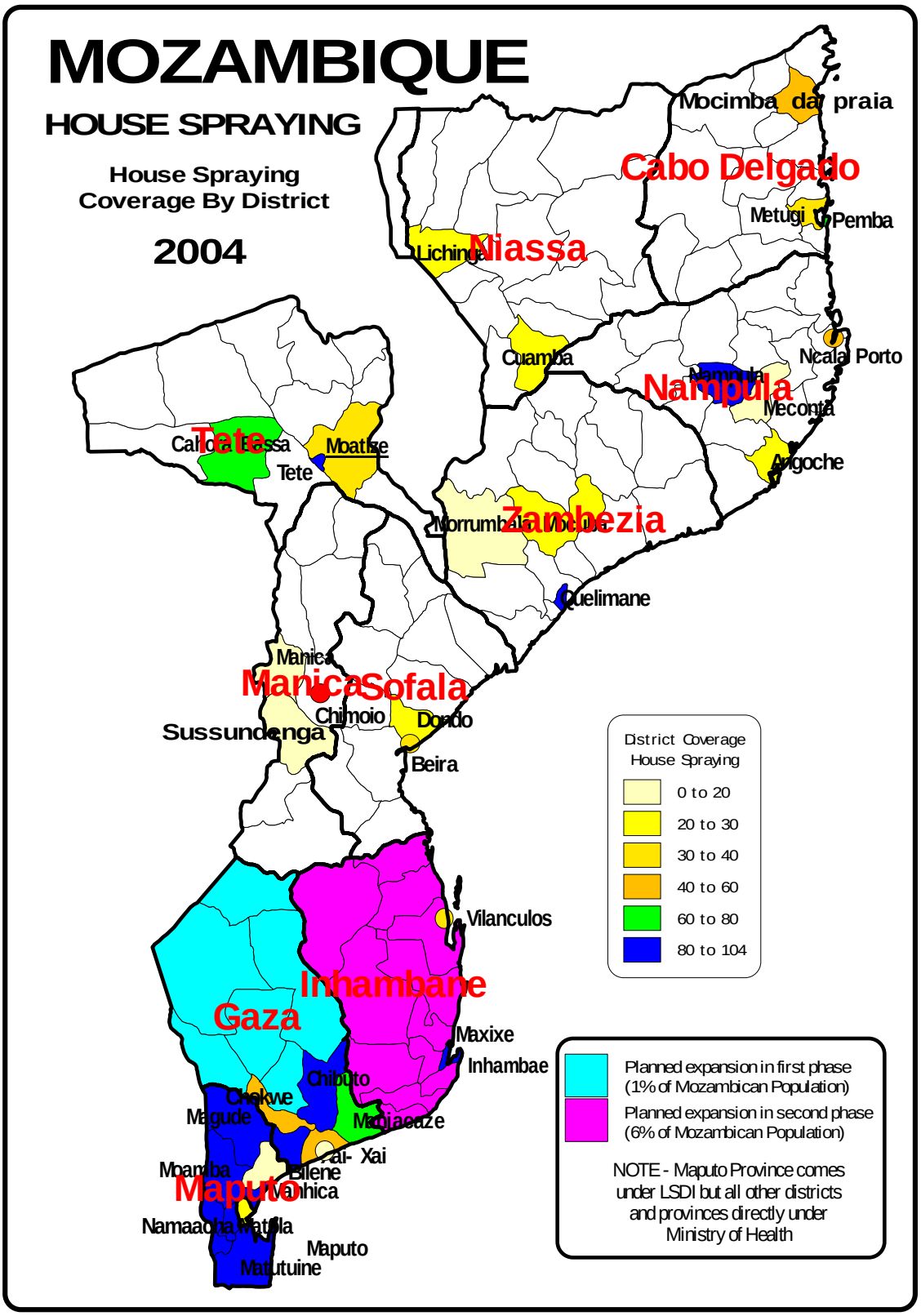
House Spraying

LSDI - 2001-2006 (Ficam and DDT)

MOH 2006 (DDT)

MOH 2006 (Pyrethroids)


MOZAMBIQUE
Cabo Delgado
Niassa
Nampula
Tete
Zambezia
Manica
Sofala
Inhambane
Gaza
Maputo
PERCENTAGE ITN COVERAGE
OF VULNERABLE GROUPS
2005
% ITN Coverage
Vulnerable Groups
1 to 20
20 to 40
40 to 60
60 to 80
80 to 100


MOZAMBIQUE
HOUSE SPRAYING
House Spraying
Coverage By District
2004
Mocimba da praia
Cabo Delgado
Metugi
Pemba
Lichinga
Niassa
Cuamba
Nacala Porto
Nampula
Nampula
Meconta
Angoche
Tete
Calomue
Tessa
Moatize
Tete
Zambezia
Morrumbala
Mocuba
Quelimane
Manica
Manica
Sofala
Chimoio
Dondo
Sussundenga
Beira
District Coverage
House Spraying
0 to 20
20 to 30
30 to 40
40 to 60
60 to 80
80 to 104
Vilanculos
Inhambane
Gaza
Maxixe
Inhambane
Chibuto
Chokwe
Magude
Mandlakazi
Xai- Xai
Moamba
Bilene
Maputo
Manhica
Namaacha
Matola
Maputo
Matutuine
Planned expansion in first phase
(1% of Mozambican Population)
Planned expansion in second phase
(6% of Mozambican Population)
NOTE - Maputo Province comes
under LSDI but all other districts
and provinces directly under
Ministry of Health

Annex 5: RTI Toxicological Profiles

Profile for Bendiocarb:

CAS Registry Number 22781-23-3

Summary of Insecticide

Chemical History

Bendiocarb is a broad spectrum carbamate insecticide first registered in the United States in 1980 for use to control a wide variety of nuisance and disease vector insects, such as mosquitoes, flies, wasps, ants, fleas, cockroaches, silverfish, and ticks. It is also effective against a variety of agricultural insects and to treat seeds against pests (U.S. EPA, 1999a, 1999b; EXTOXNET, 1996). The registration for bendiocarb was voluntarily canceled in 1999 (U.S. EPA, 1999a).

Bendiocarb exhibits its toxic effects through fast-acting, but reversible, cholinesterase inhibition. It has moderate toxicity in mammals (WHO/FAO, 1982), moderate toxicity in birds, and moderate to high toxicity in fish (EXTOXNET, 1996). In humans, symptoms of poisoning are neurological and include headache, blurred vision, nausea, vomiting, giddiness, slurred speech, excessive sweating and salivation, chest tightness, and twitching muscles (WHO/FAO, 1982). Bendiocarb pesticides were formulated as dusts, granules, wettable powders, pellets, and ultra low volume (ULV) sprays (U.S. EPA, 1999a; EXTOXNET, 1996).

Description of Data Quality and Quantity

Review data for bendiocarb are limited. Relevant resources include

- Bendiocarb: Revised HED Chapter for the Reregistration Eligibility Decision (RED) Document (U.S. EPA, 1999b)
- Data Sheet on Pesticides No. 52: Bendiocarb (WHO/FAO, 1982)
- Pesticide Information Profile for Bendiocarb (EXTOXNET, 1996).

EPA has developed quantitative human health benchmarks (acute and chronic oral RfDs and short-, intermediate-, and long-term dermal and inhalation benchmarks) for bendiocarb.

Summary Table

Duration	Route	Benchmark Value	Units	Endpoint	Reference
Acute, Intermediate, Chronic	Inhalation	0.002	mg/kg/day	Inhalation NOAEL (0.00018 mg/L) for neurological effects with UF of 100 applied	U.S. EPA (1999b)

Duration	Route	Benchmark Value	Units	Endpoint	Reference
Acute, Intermediate, Chronic	Oral	0.00125	mg/kg/day	Acute and chronic oral RfDs based on neurological effects; adopt chronic for intermediate duration	U.S. EPA (1999b)
Acute	Dermal	0.5	mg/kg/day	Dermal NOAEL for neurological effects of 50 mg/kg/day with UF of 100 applied	U.S. EPA (1999b)
Intermediate	Dermal	0.2	mg/kg/day	Dermal LOAEL for neurological effects of 50 mg/kg/day with UF of 300 applied	U.S. EPA (1999b)
Chronic	Dermal	0.00125	mg/kg/day	Oral NOAEL for neurological effects of 0.125 mg/kg/day with UF of 100 applied	U.S. EPA (1999b)

For inhalation exposure, a NOAEL of 0.00018 mg/L (0.2 mg/kg/day)[6] was identified for whole blood cholinesterase inhibition in rats exposed to bendiocarb via inhalation for 6 hours per day, 5 days per week, for 90 days (Coombs et al., 1995). An uncertainty factor of 100 to account for interspecies and intrahuman variation was applied, for an inhalation benchmark of 0.002 mg/kg/day. This value is appropriate for all exposure durations (U.S. EPA, 1999b).

The acute and chronic oral RfDs of 0.00125 mg/kg/day were based on a NOAEL of 0.125 mg/kg for whole blood cholinesterase inhibition (about 25 percent) in rats exposed via gavage five days per week for two weeks (EPA MRID No. 00059269, no additional citation provided), with an uncertainty factor of 100 applied (10 each for interspecies and intrahuman variability). This value was also adopted for intermediate exposure (U.S. EPA, 1999b).

For acute dermal exposures, a NOAEL of 50 mg/kg/day in rats for whole blood cholinesterase inhibition from a single exposure was identified (EPA MRID No. 00122308, no additional citation provided) and an uncertainty factor of 100 was applied (10 each for interspecies and intrahuman variability). For intermediate dermal exposures, a LOAEL of 50 mg/kg/day for whole blood cholinesterase inhibition from repeated dermal exposures was identified (EPA MRID No. 00122308, no additional citation provided) and an uncertainty factor of 300 was applied (10 each for interspecies and intrahuman variability and 3 for the use of a LOAEL). For chronic dermal exposures, the NOAEL that was used to develop the oral RfDs was used with an uncertainty factor of 100 applied (10 each for interspecies and intrahuman variability) (U.S. EPA, 1999b).

Insecticide Background

CAS #: 22781-23-3

[6] Conversion between mg/m^3 and mg/kg/day assumes, for Wistar rats, an average body weight of 0.187 kg and inhalation rate of 0.2 m^3/day (U.S. EPA, 1988).

Synonyms:	2,3-isopropylidenedioxyphenyl methylcarbamate (EXTOXNET, 1996), Ent-27695; OMS 1394; (WHO/FAO, 1982), 1,3-Benzodioxol-4-ol, 2,2-dimethyl-, methylcarbamate , 1,3-Benzodioxole, 2,2-dimethyl-4-(N-methylamino-carboxylato)- , 105201 (U.S. EPA PC Code) , 1924 (CA DPR Chem Code) , 2,2-Dimethyl-1,3-benzodioxol-4-yl methylcarbamate, Carbamic acid, methyl-, 2,3-(dimethylmethylenedioxy)-phenyl ester, Carbamic acid, methyl-, 2,3-(isopropylidenedioxy)phenyl ester (PAN, 2005), bencarbate, 1,3-benzodioxole,2,2,-dimethyl-4(n-methylcarbamato), 2,2-dimethyl-1,3-benzodioxol-4-ol methcarbamate, 2,3-isopropylidenedioxyphenyl methylcarbamate, methylcarbamic acid 2,3,-(isopropylidenedioxy)phenyl ester (HSDB, 2005)
Chemical Group:	n-methyl carbamate (PAN, 2005)
Registered Trade Names:	Compounds containing bendiocarb: Ficam, Dycarb, Garvox, Multamat, Multimet, Niomil, Rotate, Seedox, Tattoo, Turcam (EXTOXNET, 1996), NC-6897, Ficam D, Ficam plus, Ficam W, Ficam ULV (HSDB, 2005).

Usage

Bendiocarb is a residual carbamate insecticide that has a variety of indoor and outdoor uses, including the control of mosquitoes, household and ornamental plant pests, and fire ants. It has no registered uses on either food of feed crops (U.S. EPA, 1999b). Most products containing bendiocarb are General Use Pesticides (EXTOXNET, 1996) and are meant for homeowner/residential use. However, some formulations (e.g., wettable powders) are recommended to be used only by pest control operators. Bendiocarb is not a Restricted Use Pesticide (U.S. EPA, 1999b); however, the formulations Turcam and Turcam 2.5 G are classified as *restricted* and may only be used by certified applicators (EXTOXNET, 1996).

Common bendiocarb formulations for both agricultural and public health program uses include wettable powders (800, 500 and 200 g active ingredient/kg [g a.i./kg]), granules for soil and turf treatment (30, 50, and 100 g a.i./kg), dust (10 g a.i./kg), suspension concentrate (500 g a.i./1) for spray or seed treatments, suspension in oil for ULV application (250 g a.i./1), residual sprays, and paint on and granular preparations with bait. The use patterns for bendiocarb in agricultural, horticultural, or forestry applications are reported as follows: soil treatment (300–2,000 g a.i./ha), seed treatment (1–10 g a.i./kg), residual spray (100–1,000 g a.i./ha), and ULV spray (50–500 g a.i./ha). In public health programs, it is reported that the 80 percent wettable powder should be applied only by a professional applicator (WHO/FAO, 1982).

Formulations and Concentrations

- Common formulations of pesticides containing bendiocarb include technical grade, dusts, granules (for soil and turf treatment: 30, 50, and 100 g a.i./kg), wettable powders (800, 500, and 200 g a.i./kg), dust (10 g a.i./kg), suspension concentrate (for spray or seed treatment: 500 g a.i./L) and ULV sprays (in oil: 250 g, a.i./L) (WHO/FAO, 1982; EXTOXNET, 1996). WHO (1999) indicated that the bendiocarb content in various preparations should be declared and contain the following:
- Technical grade bendiocarb: not less than 940 g/kg
- Wettable Powder: above 250 up to 500 g/kg $\pm$ 5% of the declared content or above 500 g/kg $\pm$ 25 g/kg
- Dustable Powder: shall not differ from the declared content by more than -10% to + 35%.
- ULV Liquid: Above 100 up to 200 g/kg $\pm$ 6% of the declared content (WHO, 1999)

Shelf Life

Bendiocarb is reported to be stable below 40°C. Its half-life in aqueous solutions at 25°C is reported as 48 days at pH 5, 81 hours at pH 7, and 45 minutes at pH 9. Bendiocarb degrades slowly at pH 5. Bendiocarb is resistant to oxidation on nonabsorbant surfaces and at low humidity. In sunlight, bendiocarb photo-oxidizes (WHO/FAO, 1982).

Degradation Products

In moist soils and water, a major fate process for bendiocarb is hydrolsis. This is particularly true in neutral and alkaline environments. In neutral hydrolysis, the products are 2,3-isopropylidenedioxyphenol, methylamine, and carbon dioxide (HSDB, 2005). At pHs less than 5, bendiocarb slowly degrades into pyrogallol and acetone (WHO/FAO, 1982). The major degradation product of terrestrial field dissipation on turf is NC-7312 (U.S. EPA, 1999b).

Environmental Behavior

Fate and Transport in Terrestrial Systems

Insecticidal carbamates that are applied to plants reach the soil both directly and indirectly. Degradation of carbamates in soil depends on volatility, leaching, soil moisture, absorption, pH, temperature, photodecomposition, microbial degradation, and soil type (IPCS, 1986). With a Koc range of 28 to 200, moderately to very high mobility is expected if bendiocarb is released in soil (HSDB, 2005). The major fate processes are hydrolysis in moist soils and biodegradation, with volatilization being an unimportant fate process for both dry and moist soils due to the low vapor pressure of bendiocarb. In moist soils, bendiocarb may undergo hydrolysis, and hydrolytic degradation depends on pH (HSDB, 2005; U.S. EPA, 1999b). Biodegradation of bendiocarb is expected to be

rapid (HSDB, 2005). The half-life of bendiocarb in soil varies from less than 1 week up to 4 weeks, depending on the type of soil and the pH (EXTOXNET, 1996). The estimated hydrolysis half-life of bendiocarb is 46.5 days at pH 5, 2 days at pH 7, and 0.33 days at pH 9 (U.S. EPA, 1999b). Soil photolysis is important in the photodegradation of bendiocarb in soil. In field dissipation studies on turf, bendiocarb and its degradate NC-7312 are not highly mobile, with intermediate half-lives of 20 days (bendiocarb) and 21 days (NC-7312) (U.S. EPA, 1999b). Bendiocarb degrades before leaching through soil, and degradates remain in the upper layers of soil in low concentrations (U.S. EPA, 1999a, 1999b). It is unlikely that bendiocarb will move through soil to groundwater or to surface water through runoff (U.S. EPA, 1999a). Bendiocarb is of low persistence in soil (EXTOXNET, 1996).

Fate and Transport in Aquatic Systems

Water is an important factor in the transport of carbamates; however, the hazard posed by carbamates under these conditions is limited due to their rapid decomposition under aqueous conditions (IPCS, 1986). In water, bendiocarb is not expected to adsorb to suspended soils and sediments based on its Koc range (28 to 200). The major fate processes in water are hydrolysis and biodegradation; volatilization is an unimportant fate process due to the low vapor pressure of bendiocarb. Additionally, direct photolysis is not a major degradation pathway in water (U.S. EPA, 1999b) and depends on the turbidity of the water (IPCS, 1986). In alkaline and neutral environments, hydrolysis is expected to be a major fate process. Half-lives have been reported of 48 days at pH 5, 4 days at pH 7, and 45 minutes at pH 9 (HSDB, 2005). Bendiocarb does not accumulate in water (EXTOXNET, 1996), and based on soil studies, biodegradation in water is expected to be rapid (HSDB, 2005). Because bendiocarb degrades rapidly in water, bioconcentration in fish is unlikely (U.S. EPA, 1999a). The estimated bioconcentration factor is 12 (HSDB, 2005).

Human Health Effects

Acute Exposure

Effects/Symptoms

Bendiocarb causes toxic effects by the rapid, but reversible, inhibition of cholinesterase in the blood. It is moderately toxic if absorbed through the skin or ingested (EXTOXNET, 1996). Typical signs of acute poisoning are neurological, and include weakness, excessive sweating and salivation, headache, blurred vision, nausea, vomiting, stomach pain, tightness in the chest, muscular twitching, giddiness, slurred speech, confusion, and muscular incoordination (WHO/FAO, 1982; EXTOXNET, 1996). Death from bendiocarb poisoning can result from paralysis of the respiratory system, severe constriction of the lung openings, or stopped breathing (EXTOXNET, 1996). Little data exist on the human health effects of acute exposure to bendiocarb. In humans, the threshold for mild symptoms and blood cholinesterase inhibition is 0.15–0.20 mg a.i./kg for ingestion. No symptoms were reported following repeated hourly doses of 0.1 mg

a.i./kg. Studies in human volunteers have shown that both the onset and recovery from cholinesterase inhibition are very rapid (WHO/FAO, 1982). Case reports of accidental bendiocarb exposures report typical symptoms with reversible cholinesterase inhibition. In one case, cholinesterase was inhibited by 63 percent, and the exposed person recovered in less than 3 hours without any medical treatment. Cholinesterase levels returned to normal within 24 hours. In another case, recovery from symptoms occurred within 2 hours after being decontaminated and treated with atropine, with complete recovery by the next day. Bendiocarb is also a mild irritant to the skin and eyes (EXTOXNET, 1996).

In animals, bendiocarb is acutely toxic via the oral, inhalation, and dermal routes (U.S. EPA, 1999b). The oral LD_{50} values of unformulated bendiocarb in various animal species include 34–156 mg/kg in rats, 35–40 mg/kg in rabbits, and 35 mg/kg in guinea pigs. The reported dermal LD_{50} value in rats is greater than 566 mg/kg (EXTOXNET, 1996; IPCS, 1986; WHO/FAO, 1982) and the reported 4-hour LC_{50} in rats is 0.55 mg/L (EXTOXNET, 1996). For formulated bendiocarb compounds, an LD_{50} of 143–179 mg/kg was reported in rats for an 80 percent a.i. water dispersible powder. A dermal LD_{50} of greater than 1,000 mg/kg was reported for an 80 percent a.i. liquid formulation (WHO/FAO, 1982).

As in humans, acute exposure to bendiocarb in animals causes symptoms typical of cholinesterase inhibition (U.S. EPA, 1999a, 1999b). No acute delayed neurotoxicity was observed in hens. Although bendiocarb causes slight eye irritation in animals, it is not considered a skin or eye irritant or a dermal sensitizer (U.S. EPA, 1999b).

Treatment

Exposure to bendiocarb may be determined through laboratory tests that determine cholinesterase levels in blood; however, the enzyme will only be inhibited for a few hours following exposure. Additionally, bendiocarb metabolites may be identified in urine (WHO/FAO, 1982). Bendiocarb poisoning should be treated in the same way as high-toxicity carbamate poisoning (PAN, 2005). First removing any contaminated clothing and wash affected areas with soap and water. If bendiocarb gets in the eyes, they should be rinsed immediately with isotonic saline or water. Oral exposure to bendiocarb should be treated by rapid gastric lavage with 5 percent sodium bicarbonate if the patient is not already vomiting. Medical attention should be sought. Adults showing signs of bendiocarb toxicity should be treated with 1–2 mg atropine sulfate given intramuscularly or intravenously as needed. Oxygen may be necessary for unconscious patients or those in respiratory distress. Pralidoxime is not effective in treating bendiocarb poisoning (WHO/FAO, 1982).

Chronic Exposure

Noncancer Endpoints

The effects of chronic exposure to bendiocarb in humans have not been well described in the literature, although it is not expected to be toxic at the levels applied to control mosquitoes. When used as a residual mosquito insecticide, few adverse effects were reported by occupationally exposed workers. Those effects that were reported were transient and mild. Additionally, no effects were reported by residents of villages where it was applied (WHO/FAO, 1982).

Subchronic and chronic exposure studies in rats, mice, and dogs have shown that bendiocarb inhibits cholinesterase activity in whole blood, plasma, red blood cells, and the brain (U.S. EPA, 1999a, 1999b; WHO/FAO, 1982). No macroscopic pathology or histological evidence of dermal irritation or treatment-related mortality was observed in a 21-day dermal study in rats. Rats exposed to bendiocarb for 90 days via inhalation showed whole-blood cholinesterase inhibition (U.S. EPA, 1999b). Additionally, bendiocarb does not accumulate in mammalian tissue. There was no evidence of cumulative toxicity in rats or dogs fed bendiocarb for 90 days (WHO/FAO, 1982).

Bendiocarb is not expected to cause reproductive effects in humans. In rats, no effect on fertility and reproduction was seen in rats fed diets containing bendiocarb for three generations. However, very high doses were toxic to dams and pups, as indicated by decreased survival rate and decreased pup weight (EXTOXNET, 1996). No teratogenicity was seen in rats or rabbit fetuses or offspring following pre- and/or postnatal exposures to bendiocarb (U.S. EPA 1999a, 1999b; WHO/FAO, 1982). No evidence of mutagenicity was observed following *in vivo* or *in vitro* exposures to bendiocarb (U.S. EPA, 1999a, 1999b; EXTOXNET, 1996; WHO/FAO, 1982). No irreversible or delayed neurotoxicity has been reported in animals following long-term bendiocarb exposure (WHO/FAO, 1982).

Cancer Endpoints

EPA has classified bendiocarb as a Group E chemical, noncarcingenic to humans (U.S. EPA, 1999b). The classification is based on the lack of increase in tumors in rat and mouse studies and is supported by the lack of mutagenicity in somatic cells (U.S. EPA, 1999b). No human data are available.

Toxicokinetics

Bendiocarb can be absorbed through oral, dermal, and inhalation pathways; dermal absorption is especially rapid and is the main route of absorption. Absorption from inhalation, except inhalation of airborne dusts or fine spray mists, is unlikely due to bendiocarb's low vapor pressure (EXTOXNET, 1996; WHO/FAO, 1982). Animal metabolism studies indicate that bendiocarb is rapidly absorbed following oral exposure (U.S. EPA, 1999b). Liver microsome enzymes readily conjugate and metabolize bendiocarb, and it is rapidly excreted. Because of its rapid metabolism and excretion, bendiocarb does not accumulate in mammalian tissues (WHO/FAO, 1982). The majority of an orally administered dose is eliminated in the urine (U.S. EPA, 1999b). In rats fed diets containing up to 10 mg/kg bendiocarb, 89 to 90 percent of the dose was excreted in

the urine, 2 to 6 percent was excreted in the feces, and 2 to 6 percent was exhaled. A human subject orally exposed to bendiocarb exhibited a similar excretion pattern (EXTOXNET, 1996). Bendiocarb is excreted mainly as sulfate and beta-glucuronide conjugates of the phenol derivative (WHO/FAO, 1982).

Ecological Effects

Acute Exposure

When applied at the maximum registered application rate, bendiocarb poses acute risk to nontarget terrestrial organisms, such as mammals and birds (WHO/FAO, 1982; U.S. EPA, 1999a). Single broadcast applications on turf may result in high risk to birds, and multiple applications may result in repeated acute effects (U.S. EPA, 1999a). Oral LD_{50} values range from 3.1 mg a.i./kg body weight in mallard ducks to 137 mg a.i./ kg body weight in domestic hens (WHO/FAO, 1982; U.S. EPA, 1999a). However, bendiocarb does not affect avian reproductive parameters (WHO/FAO, 1982). Additionally, bendiocarb has been found to be highly toxic to bees (WHO/FAO, 1982; EXTOXNET, 1996; U.S. EPA, 1999a), with an oral LD_{50} of 0.0001 mg/bee (EXTOXNET, 1996). Additionally, bendiocarb severely affects earthworms under treated turf (EXTOXNET, 1996).

Bendiocarb poses acute risks to freshwater fish, and estuarine and marine animals (U.S. EPA, 1999a). It is moderately to highly toxic to fish, with LC_{50} values ranging from 0.7 to 1.76 mg a.i./L in various species (U.S. EPA, 1999a; WHO/FAO, 1982). The 96-hour LC_{50} for rainbow trout is 1.55 mg/L (EXTOXNET, 1996). When applied at the maximum registered rate, bendiocarb also poses acute risks to freshwater invertebrates (U.S. EPA, 1999a).

Chronic Exposure

Very little data exist for chronic exposure to bendiocarb in nonterrestrial target organisms. In birds, multiple applications of the maximum registered application rate to turf are expected to result in repeated acute effects. The reproductive effects of chronic exposures cannot be assessed due to limited data (U.S. EPA, 1999a).

Little data exist for chronic exposure to bendiocarb in marine or estuarine organisms. When applied at the maximum registered rate, bendiocarb poses chronic risks to freshwater invertebrates. However, it poses no chronic risk to freshwater fish (U.S. EPA, 1999a).

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Profile for DDT:

CAS Registry Number 50-29-3

Summary

Chemical History

Dichloro-diphenyl-trichloroethane (DDT) is a broad-range pesticide used since the late 1930s on agricultural crops to control disease-carrying insects, such as those that spread malaria and typhus. In 1955, a global campaign to eradicate malaria was adopted based on the use of DDT, and endemic malaria in developed countries, subtropical Asia, and Latin America was eradiated by 1967. However, few African countries participated in this campaign, which ended in 1969 due to lack of support and developing mosquito resistance to DDT (Rogan and Chen, 2005). DDT was banned in the United States and other industrialized countries in the early 1970s, largely due to its persistence in the environment; however, DDT is still in use today in sub-Saharan African countries to control malaria (ATSDR, 2002). DDT is not generally thought to be toxic to humans; however, recent data have indicated that exposure to DDT in amounts necessary for malaria control may cause pre-term birth and early weaning (Rogan and Chen, 2005). Acute exposure to high levels of DDT by any route causes neurological effects, including excitability, headache, nausea, vomiting, and dizziness (ATSDR, 2002).

Data on Mexican workers who use DDT show very high levels of DDT in adipose (fat) tissues and serum (Rogan and Chen, 2005). Children are also at risk for increased exposure to DDT and its metabolites via consumption of breast milk and cow's milk. DDT exhibits its toxic effects in humans on the nervous system and liver (ATSDR, 2002).

Description of Data Quality and Quantity

EPA and the Agency for Toxic Substances and Disease Registry (ATSDR) have developed quantitative human heath benchmarks (EPA's chronic RfD and oral and inhalation cancer slope factors [CSFs] and ATSDR's acute and intermediate oral minimal risk levels [MRLs]). Several comprehensive reviews on the toxicity of DDT are available and recommended:

- *Toxicological Profile for DDT, DDE, and DDD* (ATSDR, 2002)
- IRIS summary review (U.S. EPA, 2005a)
- A recent review article by Rogan and Chen (2005).

Other relevant resources include the following:

- *Specifications for Pesticides Used in Public Health* (WHO, 1999)
- *Environmental Health Criteria 9: DDT and its Derivatives* (IPCS,1979)
- *Pesticide Information Profile for DDT* (EXTOXNET, 2003)
- The Pesticide Action Network (PAN) Pesticide Database (PAN, 2005).

Summary Table

Duration	Route	Benchmark Value	Units	Endpoint	Reference
Acute	Inhalation	0.0005	mg/kg/day	Adopt acute oral MRL as acute inhalation; assume no portal of entry effects	
Intermediate	Inhalation	0.0005	mg/kg/day	Adopt intermediate oral MRL as intermediate inhalation; assume no portal of entry effects	
Chronic	Inhalation	0.0005	mg/kg/day	Adopt chronic RfD as chronic inhalation; assume no portal of entry effects	
Cancer	Inhalation	0.034	per mg/kg/day	Inhalation CSF (calculated from oral data) for benign and malignant liver tumors in rats and mice	U.S. EPA (1997)
Acute	Oral	0.0005	mg/kg/day	Acute oral MRL based on neurodevelopmental effects in mice	ATSDR (2002)
Intermediate	Oral	0.0005	mg/kg/day	Intermediate oral MRL based on liver effects in rats	ATSDR (2002)
Chronic	Oral	0.0005	mg/kg/day	Chronic oral RfD based on liver effects in rats	U.S. EPA (2005a)
Cancer	Oral	0.034	per mg/kg/day	Oral CSF for benign and malignant liver tumors in rats and mice	U.S. EPA (2005a)
Acute	Dermal	0.0005	mg/kg/day	Adopt acute oral MRL as acute dermal; assume no first pass effects and 100% oral absorption	
Intermediate	Dermal	0.0005	mg/kg/day	Adopt intermediate oral MRL as intermediate dermal; assume no first pass effects and 100% oral absorption	
Chronic	Dermal	0.0005	mg/kg/day	Adopt chronic RfD as chronic dermal; assume no first pass effects and 100% oral absorption	
Cancer	Dermal	0.034	per mg/kg/day	Adopt oral CSF as chronic dermal; assume no first pass effects and 100% oral absorption	

For oral exposure, the acute oral MRL of 0.0005 mg/kg/day was derived for DDT based on the lowest observed adverse effect level (LOAEL) for neurodevelopmental effects in mice perinatally exposed to DDT (ATSDR, 2002). The intermediate oral MRL of 0.0005 mg/kg/day was derived for DDT based on the no observed adverse effect level (NOAEL) for liver effects in rats exposed to DDT in the diet (ATSDR, 2002). A chronic RfD of 0.0005 mg/kg/day was derived for DDT based on liver lesions in male and female rats exposed to DDT in the diet for 27 weeks. An oral CSF of 3.4E-1 per mg/kg/day was also derived based on benign and malignant liver tumors in male and female rats and mice chronically exposed to DDT in the diet (U.S. EPA, 2005a).

For inhalation exposure, no noncancer toxicity factors were derived for DDT because adequate experimental data do not exist for this route (ATSDR, 2002; U.S. EPA, 2005a). An inhalation unit risk of 9.75E-5 per $\mu g/m^3$ and an inhalation cancer slope factor of 3.4E-1 per mg/kg/day were calculated from oral data for benign and malignant liver tumors in male and female rats and mice chronically exposed to DDT in the diet (U.S. EPA, 2005a).

For dermal exposure, no dermal toxicity factors have been derived because EPA and ATSDR have not yet identified a method suitable for this route of exposure; however, EPA has developed a simplified paradigm for making route-to-route extrapolations for systemic effects via percutaneous absorption in which complete oral absorption is assumed, thereby eliminating the need to adjust the oral toxicity value (U.S. EPA, 2004). This approach may result in underestimating risk. No adjustment was made, and oral toxicity values were used for the dermal assessment.

Background

CASRN:	50-29-3
Synonyms:	(p-chlorophenyl)ethane; dichlorodiphenyl trichloroethane; DDT; 1,1'-(2,2,2-trichloroethylidene)bis(4-chlorobenzene); α-α-bis(p-chlorophenyl)-β, β, β –trichloroethane (ATSDR, 2002)
Chemical Group:	organochlorine (ATSDR, 2002)
Registered Trade Names:	Genitox, Anofex, Detoxan, Neocid, Gesarol, Pentachlorin, Dicophane, Chlorophenothane (ATSDR, 2002) Cesarex, p,p'-DDT, Dichlorodiphenyltrichloroethane, Dinocide, Didimac, Digmar, ENT 1506, Guesapon, Guesarol, Gexarex, Gyron, Hildit, Ixodex, Kopsol, Neocid, OMS 16, Micro DDT 75, Rukseam, R50 and Zerdane (EXTOXNET, 2003).

Usage

DDT is a broad-spectrum insecticide that was once widely used. In World War II, it was used extensively to control insect-borne diseases, such as malaria and typhus. In the early 1970s, it was banned in the United States and most industrial countries due to its persistence in the environment. Currently, it is used only in sub-Saharan Africa and in emergency cases to control malaria (ATSDR, 2002).

Formulations and Concentrations

Technical-grade DDT is generally used as an insecticide and is made up of three isomers of DDT, including p,p'-DDT (up to 85%), o,p'-DDT (15%), and o,o-DDT (trace amounts) (ATSDR, 2002). DDT is available as an aerosol, a dustable powder, an emulsifiable concentrate, in granules, or as wettable powders (EXTOXNET, 2003). DDT that is used for indoor residual spraying is usually a wettable powder that has 75% active ingredient. The WHO (1999) indicated that the content of p,p'-DDT in the DDT formulation should be declared and contain the following:

- Technical grade DDT: no less than 700 g/kg p,p'-DDT
- Dustable powder: over 25–100 g/kg p,p'-DDT with a permitted tolerance of +/- 10% of the declared content
- Wettable powder: 100–250 g/kg p,p'-DDT with a permitted tolerance of +/- 6% of the declared content, or 250–500 g/kg p,p'-DDT with a permitted tolerance of +/- 5% of the declared content, or greater than 500 g/kg with a permitted tolerance of +/- 25 g/kg.

Shelf Life

DDT has a long shelf life and is resistant to destruction by light or oxidation (HSDB, 2005).

Degradation Products

DDT breaks down very slowly by dehydrohalogenation into DDE [1,1-dichloro-2,2-bis(p-dichlorodiphenyl)ethylene] and DDE [1,1-dichloro-2,2-bis(p-chlorophenyl)ethane]. In animal systems, these metabolites are stored in body fat and either leave the body slowly if exposure decreases, remain constant in the tissues, or increase with continued exposures (ATSDR, 2002). Stored DDE and DDD are slowly transformed to DDA [bis(dichlorodiphenyl) acetic acid] by other metabolites. DDA and its metabolites are then excreted in the urine (EXTOXNET, 2003).

Environmental Behavior

Fate and Transport in Terrestrial Systems

DDT and its metabolites are highly persistent and bioaccumulate in the environment (ATSDR, 2002). The persistence of DDT in the environment is mainly due to its being soluble in fat and virtually insoluble in water (IPCS, 1979). In countries where it is still being used, DDT is released into the air as a result of spraying operation. DDT and its metabolites may also enter the air when they evaporate from contaminated soil and water and may then be deposited back onto land and surface waters. This cycle of volatilization and deposition may be repeated numerous times, resulting in the movement of DDT in the atmosphere. DDT and its metabolites have been found in air, sediment, and snow, and accumulated in biota in the Arctic and Antarctic regions. As a result of this ability to undergo long-range global transport, the actual lifetime of DDT and its metabolites is substantially longer than indicated by their estimated half-lives. In the atmosphere, DDT and its metabolites occur as a vapor or are attached to particulates in the air. As a vapor,

DDT and its metabolites are broken down by sunlight. DDT is also broken down slowly by microorganisms (ATSDR, 2002).

In most soils, DDT is practically immobile due to its strong affinity to soil, especially organic soil matter (EXTOXNET, 2003). Because DDT and its metabolites (DDD and DDE) stick strongly to the soil, they remain mostly in the surface layers of soil. Soil with DDT bound to it may enter waterways via runoff (ATSDR, 2002). Other routes of loss and breakdown of DDT in soil include volatilization, photolysis, and aerobic and anaerobic biodegradation. Loss from volatilization depends on how much DDT was applied, the amount of organic material in the soil, the proximity to the soil-air interface, and the amount of sunlight (EXTOXNET, 2003). Very little DDT will seep into groundwater, and the persistence of DDT is soil varies with the type of soil, temperature, and soil moisture (ATSDR, 2002). The typical half-life of DDT in soil ranges from 2 years to 15 years (EXTOXNET, 2003). DDT and its metabolites last for a shorter time in soils that contain more microorganisms, wet soils, and warmer soils (ATSDR, 2002). Because DDT persists in the soil, bioaccumulation in plants has been observed, especially in the root.

Fate and Transport in Aquatic Systems

The two main ways that DDT may be released into surface waters are by direct application for the control of mosquito-borne malaria and by runoff from sprayed areas; atmospheric transport and drift represent lesser scenarios (EXTOXNET, 2003). DDT is a highly persistent compound with low volatility and low solubility in water, leading to great potential to bioaccumulate in the environment. DDT binds to particles in surface water, settles, and then deposits in the sediment (ATSDR, 2002). Studies have shown that DDT does not readily break down in estuary sediments. Additionally, DDT has been widely detected in ambient surface water samples in the United States. The reported half-life of DDT in lake and river water is 56 and 28 days, respectively; the half-life in river water is shorter because river water usually has more organic soil matter (EXTOXNET, 2003). The main fate processes in the aquatic environment are volatilization, photodegradation, absorption to water-borne particles, and sedimentation, with the dominant fate process being volatilization. In surface waters, DDT is transformed via biotransformation and photolysis (ATSDR, 2002). DDT is also readily taken up by and accumulates in aquatic organisms (EXTOXNET, 2003).

Human Health Effects

Acute Exposure

Effects/Symptoms

DDT has been used in large populations for more than 60 years with little acute toxicity except from accidental exposures (Rogan and Chen, 2005). DDT impairs the conduction of nerve impulses. In humans, this can cause effects ranging from mild altered sensations to tremors, convulsions, and respiratory depression (ATSDR, 2002). Additional effects observed in humans following acute DDT exposure include headaches; nausea; vomiting; diarrhea; numbness; paresthesia; increased liver enzyme activity; irritation of the eyes, nose, or throat; altered gait; and malaise or excitability (EXTOXNET, 2003; PAN, 2005).

The toxicity of DDT varies with formulation and the exposure pathway. In humans, the oral route is thought to be the most significant. Fatalities have been documented following ingestion of commercial preparations that also contain substances other than DDT (ATSDR, 2002). Children appear to be more susceptible to the fatal effects of DDT than adults (EXTOXNET, 2003). Dermal and inhalation exposures to DDT are more likely in humans if the compound is in solution form (dermal) or aerosol form (inhalation). Exposure through dermal contact is more likely when DDT is in an oily solution than when it is in a wettable powder form, which is the formulation used most often in indoor residual spraying (ATSDR, 2002).

In animals, the toxicity DDT and its analogues have been studied extensively. Acute exposure to high doses of DDT can cause death, with the toxicity dependent upon the formulation. Acute oral LD_{50} values range from 150 to 200 mg/kg in mice, 113 to 800 mg/kg in rats, and 500 to 750 mg/kg in dogs (EXTOXNET, 2003). Deaths were usually a result of respiratory arrest (ATSDR, 2002). DDT is most known for its neurotoxic effects in animals. Similar to its effects in humans, DDT causes hyperactivity, tremor, and seizures in animals. Acute exposure to low doses of DDT can cause subtle neurodevelopmental effects in neonatal mice (EXTOXNET, 2003). Liver effects such as increased liver weights, induction of liver enzymes, and hepatic-cell hypertrophy and necrosis have also been observed (Rogan and Chen, 2005). Because of the hormone altering action of DDT isomers, reproductive and developmental effects have also been seen in laboratory animals. Acute exposure to DDT and its metabolites in food may have negative effects on reproduction (ATSDR, 2002). DDT is very slightly toxic to laboratory animals via acute dermal exposure; LD_{50} values range from 2,500 to 3,000 mg/kg in rats, 1,000 mg/kg in guinea pigs, and 300 mg/kg in rabbits. Acute inhalation exposure of animals to DDT does not result in significant absorption in the lungs (EXTOXNET, 2003).

Treatment

Exposure to DDT may be measured through laboratory tests. DDT and its metabolites (DDE and DDD) may be detected in the blood/plasma, semen, urine, liver, kidney, fatty tissue, skin lipids, breastmilk, and lymphatic tissues (ATSDR, 2002). DDT exposure should be treated with anticonvulsants (benzodiazepines), oxygen, and cardiopulmonary monitoring. Epinephrine, other adrenergic amines, atropine, and orally administered fats are all contraindicated (PAN, 2005; Reigart and Roberts, 1999).

Chronic Exposure

Noncancer Endpoints

Most chronic exposure human data come from studies of workers who are exposed to DDT while working in manufacturing facilities or as spray applicators, and from epidemiological studies. These studies indicate that chronic oral exposure to small amounts of DDT does not produce toxic effects in humans. However, DDT and its metabolite DDE may alter hormonally mediated endpoints, such as lactation duration, maintenance of pregnancy, and fertility. Increased chances of premature birth, infants that are small for their gestational age, and height abnormalities in children have also been associated with high DDE levels in the blood (ATSDR, 2002). DDT and its metabolites

also affect male reproductive parameters, such as semen volume, sperm count, testosterone ratios, and sperm DNA damage (Rogan and Chen, 2005).

In animals, liver effects have been seen following chronic exposure to moderate levels of DDT (ATSDR, 2002). The main effect was localized liver damage. Additional chronic effects in animals include nervous system (e.g., tremors, central nervous system cellular chemistry changes, loss of equilibrium), kidneys (e.g., adrenal gland and kidney damage), and immune system (e.g., reduced antibody formation, reduced immune cells) effects. Those effects were seen at levels much higher than expected human exposure levels (EXTOXNET, 2003).

Cancer Endpoints

IARC has classified DDT in group 2B; a probable human carcinogen (IARC, 1991). EPA has also determined that DDT is a probable human carcinogen (U.S. EPA, 2005a). The available epidemiological evidence regarding carcinogenicity in humans is inconclusive. A slight increase in risk from lung cancer was observed in workers at two DDT production facilities. No other cancer incidences were found in sufficient numbers for analysis. Inconsistent results have been found when comparing serum DDT/DDE levels in people with and without cancer (IARC, 1991). One study indicated a potential link between chronic, high-dose DDT exposure and pancreatic cancer in chemical workers, but the reliability of the study is questionable. The association between p,p'-DDE and breast cancer has been studied extensively, but studies have failed to show an association (Rogan and Chen, 2005). Studies have indicated that DDT and its metabolites are not mutagenic (ATSDR, 2002). In animals, DDT has been shown to cause liver and lung cancers (ATSDR, 2002).

Toxicokinetics

DDT is absorbed via inhalation, the gastrointestinal tract, and dermally. In humans, oral exposure to DDT is considered the most significant. Orally, DDT is absorbed from the gastrointestinal tract into the lymphatic system. There is also some absorption into the portal blood. Distribution of DDT to all body tissues then occurs from the lymphatic system and blood. In the tissues, DDT is stored in proportion to the lipid (fat) content of the tissue (ATSDR, 2002). DDT is initially metabolized into DDE and DDD; however, these are ultimately transformed into DDA (EXTOXNET, 2003). DDA and its metabolites are eventually excreted in the urine. DDT may also be excreted via feces, semen, and breastmilk (ATSDR, 2002).

Ecological Effects

Acute Exposure

DDT is only slightly toxic to birds. Acute oral LD_{50} values in various bird species include the following: Japanese quail (841 mg/kg), pheasant (1,334 mg/kg), and mallard (2,240 mg/kg). Most avian exposures are a result of the food chain and consumption of aquatic (e.g., fish) or terrestrial (e.g., earthworms or other birds) species that have an accumulated body burden of DDT. However, earthworms are not susceptible to the acute toxic effects of DDT. Additionally, DDT is not toxic to bees (EXTOXNET, 2003).

DDT is highly toxic to many aquatic species. On average, acute exposure to DDT is only slightly toxic to amphibians and phytoplankton; moderately toxic to annelida, mollusks, and zooplankton; highly to very highly toxic to fish; and very highly toxic to crustaceans (PAN, 2005). In fish, the 96-hour LC_{50} values range from 1.5 µg/L in northern pike to 21.5 µg/L in fathead minnows. DDT is very highly toxic to stoneflies, midges, crayfish, sow bugs, and other aquatic invertebrate, with 96-hour LC_{50} values ranging from 0.18 to 7.0 µg/L. In aquatic invertebrates, DDT adult stages are less susceptible than developmental stages (EXTOXNET, 2003).

Chronic Toxicity

Chronic exposure to DDT has been linked to reproductive effects in birds, with eggshell thinning and embryo death two of the main concerns of exposure, especially in birds of prey. The mechanism of eggshell thinning is thought to be from the major metabolite DDE. Additionally, the reproductive behavior of birds may also be subtlety altered by DDT and DDE exposure. In laboratory studies, changes in courtship behavior, delays in pairing and egg laying, and decreases in egg weight have been observed in some bird species, though it is not clear what these effects mean for the survival of wild bird species. A synergism may exist between DDT metabolites and organophosphate pesticides to produce greater neurotoxicity and increased deaths (EXTOXNET, 2003).

Chronic exposure to DDT may occur in fish and aquatic species through bioaccumulation. This occurs from the uptake of DDT in sediments and water, with smaller fish taking up higher amounts of DDT. It has been estimated that the half-time elimination of DDT for rainbow trout is 160 days. Bioaccumulation can occur at very low environmental concentrations, and the bioconcentration factor for DDT is 1,000 to 1,000,000, depending on the aquatic species (EXTOXNET, 2003).

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Profile for Lambda-Cyhalothrin:

CAS Registry Number 91465-08-6

Summary

Chemical History

The synthetic pyrethroid lambda-cyhalothrin is a relatively new addition to this insecticide group. It was developed in 1977 and consists of one enantiomeric (i.e., nonsuperimposable, mirror image) pair of isomers and is a more biologically active form than cyhalothrin (IPCS, 1990a). It is used in the control of pests, including mosquitoes, in agricultural and public and animal health settings (EXTOXNET, 1996). The risks of occupational exposures and exposures to the general public are expected to be very low if proper precautions are followed. At the recommended application rates, lambda-

cyhalothrin is not expected to cause adverse environmental effects. As is typical of synthetic pyrethroids, the typical symptoms for acute exposure are neurological and include tingling, burning, or numbness sensations (particularly at the point of skin contact), tremors, incoordination of movements, paralysis or other disrupted motor functions. These effects are generally reversible because lambda-cyhalothrin beaks down rapidly in the body (IPCS, 1990a; EXTOXNET, 1996).

Description of Data Quality and Quantity

Lambda-cyhalothrin and cyhalothrin are basically the same chemical and differ only in their stereo chemistry and the number of isomers in each mixture (U.S. EPA, 2002a). Cyhalothrin consists of four stereo isomers while lambda-cyhalothrin is a mixture of only two isomers. The two lambda-cyhalothrin isomers are contained in cyhalothrin and they represent 40 percent of the cyhalothrin mixture. The majority of toxicity studies available were conducted using cyhalothrin as the test chemical. Evidence based on subchronic studies in rats suggests that the two mixtures are not biologically different with respect to their mammalian toxicity (U.S. EPA, 2002a).

EPA and ATSDR have developed quantitative human health benchmarks for cyhalothrin (EPA's acute and chronic oral RfDs and short-, intermediate-, and long-term dermal and inhalation benchmarks, and ATSDR's acute and intermediate oral MRLs).

Recommended resources include:

- Environmental Health Criteria 99: Cyhalothrin (IPCS, 1990a)
- Toxicological Profile for Pyrethrin and Pyrethroids (ATSDR, 2003a)
- Pesticide Information Profiles (PIP) for Lambda-cyhalothrin (EXTOXNET, 1996)
- Specifications and Evaluations for Public Health Pesticides for Lambda-cyhalothrin (WHO, 2003)
- Integrated Risk Information System (IRIS) summary review for cyhalothrin (U.S. EPA, 2005b).

Summary Table

Duration	Route	Benchmark Value	Units	Endpoint	Reference
Acute, Intermediate, Chronic	Inhalation	0.0008	mg/kg/day	Inhalation NOAEL for neurotoxicity in rats at 0.08 mg/kg/day (0.3 µg/L) with uncertainty factor (UF) of 100 applied	U.S. EPA (2002b)
Acute	Oral	0.005	mg/kg/day	Acute RfD based on neurotoxicity in dogs	U.S. EPA (2002b)
Intermediate	Oral	0.001	mg/kg/day	Adopt chronic RfD for intermediate duration	

Chronic	Oral	0.001	mg/kg/day	Chronic RfD based on neurological effects in dogs	U.S. EPA (2002b)
Acute, Intermediate, Chronic	Dermal	0.1	mg/kg/day	Dermal NOAEL in rats with UF of 100 applied	U.S. EPA (2002b)

For inhalation exposure, a NOAEL of 0.3 µg/L (0.08 mg/kg/day) was identified for neurotoxicity, decreased body weight, and slight changes in urinalysis parameters in rats exposed to lambda-cyhalothrin via inhalation for 21 days. An uncertainty factor of 100 was applied, for an inhalation benchmark value of 0.0008 mg/kg/day. This value is appropriate for all exposure durations (U.S. EPA, 2002a).

For oral exposure, an acute RfD of 0.005 mg/kg/day was derived based on a NOAEL of 0.5 mg/kg/day for neurotoxicity (ataxia) observed in dogs exposed to lambda-cyhalothrin, with an uncertainty factor of 100 applied (U.S. EPA, 2002a). A chronic oral RfD of 0.001 mg/kg/day was derived based on a NOAEL of 0.1 mg/kg/day for gait abnormalities in dogs exposed to lambda-cyhalothrin, with an uncertainty factor of 100 applied (U.S. EPA, 2002a). The chronic RfD was adopted to represent intermediate exposures.

For dermal exposure, a NOAEL of 10 mg/kg/day was identified in rats dermally exposed to lambda-cyhalothrin for 21 days. An uncertainty factor of 100 was applied, for a dermal benchmark value of 0.1 mg/kg/day. This value is appropriate for all exposure durations (U.S. EPA, 2002a).

Background

CAS #:	91465-08-6
Synonyms:	none (WHO, 2003)
Chemical Group:	synthetic pyrethroid
Registered Trade Names:	Charge, Excaliber, Grenade, Karate, Hallmark, Icon, OMS 0321, PP321, Saber, Samurai, Sentinel, and Matador (EXTOXNET, 1996)

Usage

Lambda-cyhalothrin is a synthetic pyrethroid (IPCS, 1990a) most commonly used for pest control, especially mosquitoes; the insecticide is usually sprayed on interior walls or used to impregnate bed nets (EXTOXNET, 1996). This insecticide is a restricted use pesticide, so it can be purchased and used only by certified applicators (EXTOXNET, 1996). Lambda-cyhalothrin has adulticidal, ovicidal, and larvicidal activity (IPCS, 1990a). In addition to mosquitoes, it is effectively used to control: cockroaches, ticks, fleas, aphids, Colorado beetles, cutworms and butterfly larvae (EXTOXNET, 1996; IPCS, 1990a).

Formulations and Concentrations

There are several formulations for lambda-cyhalothrin, each containing varying amounts of the active ingredient. The typical formulations for lambda-cyhalothrin are

- Technical grade (not less than 810 g/kg lambda-cyhalothrin)
- Emulsifiable concentrate (at 20 +/- 2°C: up to 25 g/l +/- 15% declared content; > 25 g/l to 100 g/l +/- 10% of declared content)
- Wettable powder (up to 25 +/- 15% of declared content: > 25-100 +/- 10 % of declared content)
- Slow release capsule suspension (at 20 +/- 2°C: up to 25 g/l +/- 15% declared content).

The main formulation used for agricultural purposes is the emulsifiable concentrate. The wettable powder formulation is mainly used for public health reasons (WHO, 2003). Lambda-cyhalothrin is commonly mixed with buprofezin, pirimicarb, dimethoate, or tetramethrin, resulting in the usual product (WHO, 2003; EXTOXNET, 1996).

Shelf-Life

This insecticide, like many others, needs to be stored in a cool, dry, and well-ventilated facility (IPCS, 1990a). Lambda-cyhalothrin should not be stored or transported with foodstuffs and household supplies to the limit the potential for cross contamination and human exposure (IPCS, 1990a).

Degradation Products

In the environment, lambda-cyhalothrin degrades through biological and photochemical reactions (IPCS, 1990a). Biological reactions are thought to be more important. Lambda-cyhalothrin will degrade rapidly in soils, remain relatively stable in water, and is usually not found in air due to its low vapor pressure. The main degradation products are 3-(2-chloro-3,3,3-trifluoroprop-1-enyl)-2, 2-dimenthyl-cyclopropanecorboxylic acid, the amide derivative of cyhalothrin, and 3-phenoxybenzoic acid. The degradation is a result of the cleavage of the ester linkage to give two main degradation products, which are further degraded to carbon dioxide. Lambda-cyhalothrin degrades fairly quickly in alkaline conditions, in comparison to neutral or acidic media. It is strongly absorbed in soils and sediments with little tendency for bioaccumulation (IPCS, 1990a).

In water, lambda-cyhalothrin is stable at pH 5. Racemization at the alpha-cyano carbon occurs at pH 7 to pH 9, creating a one to one mixture of enantiomer pairs A and B. The ester bond is hydrolysed at pH 9. Additionally, a moderately high rate of photolysis is seen in dilute aqueous solutions (IPCS, 1990a).

Environmental Behavior

Fate and Transport in Terrestrial Systems

In most soil types, lambda-cyhalothrin is not very mobile. Its high reported organic carbon partitioning coefficient (Koc) value reflects its strong affinity for soil. It is retained more in soil with low sand content or high organic matter content (EXTOXNET, 1996). Studies have shown that lambda-cyhalothrin and its degradation products do not leach through soils into groundwater nor are they transported to other compartments of the environment following agricultural uses (IPCS, 1990a).

Lambda-cyhalothrin is moderately persistent in soil with a soil half-life ranging from 4 to 12 weeks. A longer in-field half-life of approximately 30 days is reported for most soils (EXTOXNET, 1996). The half-life is variable because it is dependent on the availability of sunlight, which speeds degradation (IPCS, 1990a).

Fate and Transport in Aquatic Systems

Lambda-cyhalothrin is not expected to be prevalent in surface or groundwater because it has extremely low water solubility and binds tightly to soil. Lambda-cyhalothrin enters surface water largely through surface runoff. Even so, lambda-cyhalothrin is most likely to stay bound to sediment and settle to the bottom. Studies have shown that hydrolysis of lambda-cyhalothrin occurs rapidly at a pH of 9 but not at a pH of 7, though isomerization was observed at a pH of 7. No hydrolysis or isomerization was seen at a pH of 5.

Human Health Effects

Acute Exposure

Effects/Symptoms

No data on accidental human poisonings have been reported. Additionally, no quantitative epidemiological studies are available (IPCS, 1990a). However, under normal use conditions, acute exposure to lambda-cyhalothrin is not expected to represent a hazard in humans. Transient skin sensations such as periorbital facial tingling and burning have been reported following direct skin exposure in laboratory workers and manufacturing workers handling synthetic pyrethroids. This sensation is possibly due to repetitive firing of sensory nerve terminals and usually lasts for a few hours up to 72 hours post-exposure. No neurological abnormalities have been observed upon medical examination (IPCS, 1990a). Lambda-cyhalothrin can irritate the eyes, skin, and upper respiratory tract. Additionally, oral exposure can cause neurological effects, including tremors and convulsions. Ingestion of liquid formulations may result in aspiration of the solvent into the lungs, resulting in chemical pneumonitis. Based on the acute oral toxicity data, lambda-cyhalothrin has been classified as “Moderately Hazardous” (Class II) (WHO, 2003).

In animals, the technical form of lambda-cyhalothrin is moderately toxic; however, toxicity depends on both the formulation (concentration of active ingredient and solvent vehicle) and the route of exposure (EXTOXNET, 1996). Laboratory data indicate that acute oral exposure to lambda-cyhalothrin is moderately to highly toxic in rats and mice and that mice are more susceptible to the toxic effects than rats (WHO, 2003). The oral

LD_{50} for lambda-cyhalothrin in corn oil has been reported to range from 56 mg/kg in female rats up to 79 mg/kg in males. A similar LD_{50} is reported for technical grade lambda-cyhalothrin in rats at 64 mg/kg (EXTOXNET, 1996). The oral LD_{50} in mice is reported as 20 mg/kg (IPCS, 1990a). The effects of acute oral exposure are typical of pyrethroid toxicity, including abnormal motor function (WHO, 2003).

Acute inhalation exposures are also highly toxic to animals (WHO, 2003). In the formulated product Karate, the 4-hour LC_{50} in rats is reported as 0.175 mg/L in females and 0.315 mg/L in males (EXTOXNET, 1996).

Lambda-cyhalothrin is less toxic in animals via acute dermal exposure (WHO, 2003). In rats, dermal LD_{50}s of 632 mg/kg for males and 696 mg/kg for females have been reported for the technical product. Studies have also shown the technical product produced no skin irritation to rabbits and is nonsensitizing in guinea pigs. Mild eye irritation was observed in rabbits. However, dermal exposure to the formulated product Karate causes severe primary skin irritation in rabbits and mild skin sensitization in guinea pigs. Other acute dermal effects are related to the nervous system and include tingling, burning sensations, or numbness (EXTOXNET, 1996).

Treatment

Lambda-cyhalothrin and its breakdown products can be detected in blood and urine, but only within a few days of the last exposure (ATSDR, 2003a). Dermal exposure to lambda-cyhalothrin exposure should be treated by removing contaminated clothing and washing the exposed areas with soap and water. If lambda-cyhalothrin gets into the eyes, they should be rinsed with water for several minutes. Contact lenses should be removed if possible and medical attention should be sought. Vomiting should not be induced following ingestion of lambda-cyhalothrin, and medical attention sought. Inhalation exposures require removal to fresh air and rest (IPCS, 1990b)

Chronic Exposure

Noncancer Endpoints

Based on the available data, it is unlikely that lambda-cyhalothrin would cause chronic effects in humans under normal conditions. No specific target organs have been identified in the available chronic studies (EXTOXNET, 1996). Decreased body weight gain and mild neurological effects have been observed in some animal studies (EXTOXNET, 1996; IPCS, 1990a).

Lambda-cyhalothrin is not expected to be teratogenic, mutagenic, or genotoxic in humans. Studies in animals have found no teratogenic or fetotoxic effects in rats or rabbits. Additionally, it was negative in five test strains in the Ames mutagenicity assay (IPCS, 1990a). No mutagenic or genotoxic effects were seen in other in vitro cytogenic assays or chromosomal aberration tests (EXTOXNET, 1996).

Cancer Endpoints

Data on the carcinogenic potential suggest that lambda-cyhalothrin is not carcinogenic in humans. In rats and mice exposed to cyhalothrin, no carcinogenic effects were observed. EPA has classified lambda-cyhalothrin as a Group D chemical, "not classifiable as to human carcinogenicity" (U.S. EPA, 2002a).

Toxicokinetics

Animal studies have been have been conducted in various species to investigate the toxicokinetics of cyhalothrin and lambda-cyhalothrin. Oral cyhalothrin is readily absorbed, metabolized thoroughly, and eliminated as polar conjugates in the urine (IPCS, 1990a). Studies with lambda-cyhalothrin have shown that it also is rapidly metabolized into less toxic water-soluble compounds and excreted in the urine and feces (EXTOXNET, 1996). In mammals, cyhalothrin is metabolized as a result of ester cleavage to cyclopropanecarboxylic acid and 3-phenoxybenzoic acid, and eliminated as conjugates. Tissue levels decline after exposure stops and residues in the body are low (IPCS, 1990a).

Ecological Effects

Acute Exposure

Toxicity to Non-Target Terrestrial Organisms

Like other synthetic pyrethroids, lambda-cyhalothrin has been shown to be toxic to honey bees but has little effect on birds and domestic animals (EXTOXNET, 1996). In birds, the toxicity of lambda-cyhalothrin ranges from nontoxic to slightly toxic. Oral LD_{50} values in mallard duck are reported as greater than 3,950 mg/kg. Dietary LC_{50} values of 5,300 ppm are reported in bobwhite quail. Additionally, there is no evidence of lambda-cyhalothrin accumulation in bird tissues or in eggs (EXTOXNET, 1996). Lambda-cyhalothrin has shown mixed toxicity to other non-target terrestrial organisms. It is extremely toxic to honey bees, with a contact LD_{50} of 0.9 µg/bee and an oral LD_{50} of 38 ng/bee (EXTOXNET, 1996), but has no adverse effect on earthworms (IPCS, 1990a).

Toxicity to Aquatic Organisms

Like other synthetic pyrethroids, lambda-cyhalothrin has been shown to be quite toxic under laboratory conditions to both cold and warm water fish. Acute 96-hr LC_{50} values range from 0.2 to 1.3 µg/L. It is also highly toxic to aquatic arthropods with 48-hr LC_{50} ranging from 0.008 to 0.4 µg/L (IPCS, 1990a; WHO, 2003). In the field, however, these effects are not likely to occur under the recommended use scenarios (WHO, 2003). No serious adverse effects have been observed due to the low rates of application and the lack of persistence in the environments (IPCS, 1990a). Accumulation studies have shown that although bioaccumulation is possible in fish, it is unlikely due to the rapid metabolism of lambda-cyhalothrin (EXTOXNET, 1996).

Chronic Exposure

Toxicity to Non-Target Terrestrial Organisms

No data were located on the chronic toxicity to non-target terrestrial organisms.

Toxicity to Aquatic Organisms

No data for chronic duration exposures of aquatic organisms were located; however, a subchronic study in Sheepshead minnow embryos and larvae showed no effect on hatchability or larval survival when exposed to up to 0.25 µg/L through 28 days post hatching. A significant effect on larval weight was observed at 0.38 µg/L. In an additional subchronic exposure study, survival, growth, and reproduction of *Daphnia magna* were seen at 40 ng/L but not at 2.5 ng/L (IPCS, 1990a).

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Annex 6: Exposure Treatment Guidelines*

Organochlorines

DDT is the only insecticide of the organochlorine chemical group that is still recommended for indoor residual spraying (IRS). Previously used organochlorines belonged to the cyclodiene sub-class, which included dieldrin and HCH. Dieldrin was abandoned because of its high acute toxicity to humans. Eventually, the whole subgroup became unusable because a mechanism common to all cyclodienes caused the rapid development of resistance.

DDT

DDT is an organochlorine insecticide with low volatility and very low solubility in water, but which is soluble in fats and organic solvents. DDT is highly persistent and has a long residual effect on most sprayed surfaces. The long persistence in the environment and its high bioaccumulation in fatty tissues have contributed to the dispersal of DDT residues everywhere (including arctic ice) from the agricultural use of DDT in the 1950s and 1960s. This bioaccumulation has resulted in highly toxic effects at the top of food chains, particularly in sharks, eagles, and falcons.

The main danger of environmental contamination from using DDT as an indoor residual spray comes from diverting the insecticide from malaria control to agricultural use. A similar danger would occur if containers were inadequately disposed of or pumps indiscriminately washed in surface waters. These risks could be prevented by proper education and strict supervision.

Toxicology

Absorption route: Absorbed from the gastrointestinal tract and by inhalation. DDT in oily solution may also be absorbed through intact skin. This is not applicable to the WP formulations used for malaria control.

Mode of action: DDT is a central nervous system stimulant that produces hyperactivity and tremor; convulsions may occur but are less common than with other organochlorine insecticides.

Symptoms of poisoning

Acute poisoning by DDT is very rare, particularly when used for indoor residual spraying. Nevertheless, it could potentially occur if there is gross mishandling. Early symptoms may include paresthesia (tingling) of the tongue, lips, and parts of the face, which in severe cases extends to the extremities. The patient may have a sense of

* 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.

apprehension and disturbance of equilibrium, dizziness, confusion, and a characteristic tremor.

Emergency Treatment

Emergency treatment for organochlorine pesticide exposure includes removing the contaminated clothing, washing the affected skin with clean water and soap, and flushing the affected area with large quantities of clean water. Keep the patient calm and in quiet, shaded conditions and seek medical assistance. Do not give the patient oils and fats.

Treatment by Medical Professional

1. **Observation**. Persons exposed to high levels of organochlorine pesticides by any route should be observed for sensory disturbances, incoordination, speech slurring, mental aberrations, and involuntary motor activity that would warn of imminent convulsions.
2. **Convulsions**. If convulsions occur, place the victim in the left lateral decubitus position with the head down. Move away furniture or other solid objects that could be a source of injury. If jaw movements are violent, place padded tongue blades between the teeth to protect the tongue. Whenever possible, remove dentures and other removable dental work. Aspirate oral and pharyngeal secretion, and when possible, insert an oropharyngeal airway to maintain an open passage unobstructed by the tongue. Minimize noise and any manipulation of the patient that may trigger seizure activity.

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.**

Although lorazepam is widely accepted as a treatment of choice for status epilepticus, there are no reports of its use for organochlorine intoxication. Some cases have required aggressive management that included the addition of phenobarbital and induction of entobarbital coma.

Seizures in patients caused by organochlorine toxicity are likely to be prolonged and difficult to control. Status epilepticus is common. For this reason, patients with seizures that do not respond immediately to anticonvulsants should be transferred as soon as possible to a trauma center and will generally require intensive care admission until seizures are controlled and neurologic status is improved. Initial therapy with benzodiazepines should be instituted.

3. **Oxygen.** Administer oxygen by mask. Maintain pulmonary gas exchange by mechanically assisted ventilation whenever respiration is depressed.
4. **Skin decontamination.** Thoroughly decontaminate the skin.
5. **Gastrointestinal decontamination.** If organochlorine has been ingested in a quantity sufficient to cause poisoning and the patient presents symptoms within an hour, consider gastric decontamination procedures. If the patient presents more than an hour after ingestion, activated charcoal may still be beneficial. If

the victim is convulsing, it is almost always necessary first to control the seizures before attempting gastric decontamination. Activated charcoal administration has been advocated in such poisonings, but there is little human or experimental evidence to support it.

6. **Respiratory failure.** Particularly in poisonings by large doses of organochlorine, monitor pulmonary ventilation carefully to forestall respiratory failure. Assist pulmonary ventilation mechanically with oxygen whenever respiration is depressed. Because these compounds are often formulated in a hydrocarbon vehicle, hydrocarbon aspiration may occur with ingestion of these agents. The hydrocarbon aspiration should be managed in accordance with accepted medical practice as a case of acute respiratory distress syndrome, which will usually require intensive care management.
7. **Cardiac monitoring.** In severely poisoned patients, monitor cardiac status by continuous ECG recording to detect arrhythmia.
8. **Contraindications.** Do not give epinephrine, other adrenergic amines, or atropine unless absolutely necessary because of the enhanced myocardial irritability induced by chlorinated hydrocarbons, which predisposes to ventricular fibrillation. Do not give animal or vegetable oils or fats by mouth. They enhance gastrointestinal absorption of the lipophilic organochlorines.
9. **Phenobarbital.** To control seizures and myoclonic movements that sometimes persist for several days following acute poisoning by the more slowly excreted organochlorines, phenobarbital given orally is likely to be effective. Dosage should be based on manifestations in the individual case and on information contained in the package insert.
10. **Cholestryamine resin.** Cholestryamine resin accelerates the biliary-fecal excretion of the more slowly eliminated organochlorine compounds. It is usually administered in 4 g doses, 4 times a day, before meals and at bedtime. The usual dose for children is 240 mg/kg/24 hours, divided Q 8 hours. The dose may be mixed with a pulpy fruit or liquid. It should never be given in its dry form and must always be administered with water, other liquids, or a pulpy fruit. Prolonged treatment (several weeks or months) may be necessary.
11. **Convalescence.** During convalescence, enhance carbohydrate, protein, and vitamin intake by diet or parenteral therapy.

Carbamates

Carbamates are fast-acting anticholinesterase (AchE) compounds, with relatively high acute oral toxicity.

Toxicology

The inhibition of AchE induced by carbamates is relatively labile. As a result, although symptoms may occur during operational exposure, the patient recovers normally follows

once exposure stops. Specific toxicology information on the approved carbamates is as follows:

Bendiocarb

Bendiocarb is a carbamate insecticide with low vapor pressure, low odor and no corrosive and staining properties. This makes it acceptable to most householders. It is rapidly hydrolysed in alkaline media (such as whitewash) and rapidly degraded in soil. Like other N-methylcarbamates, bendiocarb is a fast-acting anticholinesterase compound, with high acute oral toxicity.

Toxicology

Bendiocarb may be absorbed from the gastrointestinal tract or, to a limited extent, through intact skin. It is mainly metabolized through hydrolysis and excreted rapidly; there is no accumulation in organs and tissues. Its low vapor pressure makes inhalation unlikely except from airborne spray mist.

Mode of action: Bendiocarb inhibits cholinesterase activity, which is rapidly reversible. The half-life of the inhibited enzyme is approximately 30 minutes.

Symptoms of poisoning

Symptoms of mild carbamate poisoning are similar to those of organophosphate poisoning. They include excessive sweating, headache, nausea, blurred vision, chest pain, vomiting, excessive salivation, and slurred speech. Severe intoxication causes narrowed pupils, muscle twitching, spasms, intestinal convulsions, diarrhea, and labored respiration. These symptoms rapidly subside when spraying is stopped and heavily contaminated clothes are removed, particularly if some atropine is given to the patient.

Emergency Treatment

The affected person should stop work immediately, remove any contaminated clothing and wash the affected skin with soap and clean water. The whole contaminated area (including the eyes, if necessary) should be flushed with large quantities of clean water. The patient should be kept at rest and immediate medical aid obtained (show medical personnel the product label).

The patient can be treated by atropine, but it is often no longer necessary by the time the patient reaches the place where atropine is available. Oximes are contraindicated for the treatment of carbamate poisoning. Morphine should not be used, but diazepam may be useful for convulsions.

Treatment by Medical Professional

Caution: Persons attending the victim should avoid direct contact with heavily contaminated clothing and vomitus. Wear rubber gloves while washing pesticide from skin and hair. Vinyl gloves provide no protection.

1. **Airway protection**. Ensure that a clear airway exists. Intubate the patient and aspirate the secretions with a large-bore suction device if necessary. Administer oxygen by mechanically assisted pulmonary ventilation if respiration is depressed. Improve tissue oxygenation as much as possible before administering atropine to minimize the risk of ventricular fibrillation. In severe poisonings, it may be necessary to support pulmonary ventilation mechanically for several days.

2. **Atropine**. Administer atropine sulfate intravenously or intramuscularly if intravenous injection is not possible. Remember that atropine can be administered through an endotracheal tube if initial IV access is difficult to obtain. Carbamates usually reverse with much smaller dosages of atropine than those required to reverse organophosphates. (See dosage on next page.)

The objective of atropine antidotal therapy is to antagonize the effects of excessive concentrations of acetylcholine at end-organs having muscarinic receptors. Atropine does not reactivate the cholinesterase enzyme or accelerate excretion or breakdown of carbamate. Recrudescence of poisoning may occur if tissue concentrations of toxicant remain high when the effect of atropine wears off. Atropine is effective against muscarinic manifestations, but is ineffective against nicotinic actions, specifically, muscle weakness and twitching, and respiratory depression.

Despite these limitations, atropine is often a life-saving agent in N-methyl carbamate poisonings. Favorable response to a test dose of atropine (1 mg in adults, 0.01 mg/kg in children under 12 years) given intravenously can help differentiate poisoning by anticholinesterase agents from other conditions such as cardiogenic pulmonary edema and hydrocarbon ingestion. However, lack of response to the test dose, indicating no atropinization (atropine refractoriness), is characteristic of moderately severe to severe poisoning and indicates a need for further atropine. If the test dose does not result in mydriasis and drying of secretions, the patient can be considered atropine refractory.

Dosage of Atropine:

In *moderately severe poisoning* **(hypersecretion and other end-organ manifestations without central nervous system depression), the following dosage schedules have proven effective:**

- ***Adults and children over 12 years:*** **2.0-4.0 mg, repeated every 15 minutes until pulmonary secretions are controlled, which may be accompanied by other signs of atropinization, including flushing, dry mouth, dilated pupils, and tachycardia (pulse of 140 per minute).** Warning: **In cases of ingestion of liquid concentrates of carbamate pesticides, hydrocarbon aspiration may complicate these poisonings. Pulmonary edema and poor oxygenation in these cases will not respond to atropine and should be treated as a case of acute respiratory distress syndrome.**
- ***Children under 12 years:*** **0.05-0.1 mg/kg body weight, repeated every 15 minutes until pulmonary secretions are controlled, which may be accompanied by other signs of atropinization as above (heart rates vary depending on age of child with young toddlers having a rate approaching 200). There is a minimum dose of 0.1 mg in children.**

Maintain atropinization by repeated doses based on recurrence of symptoms for 2-12 hours or longer depending on severity of poisoning. Crackles in the lung bases nearly always indicate inadequate atropinization and pulmonary improvement may not parallel other signs. Continuation or return of cholinergic signs indicates the need for more atropine.

Severely poisoned **individuals may exhibit remarkable tolerance to atropine; two or more times the dosages suggested above may be needed. Reversal of muscarinic manifestations, rather than a specific dosage, is the object of atropine therapy. However, prolonged intensive intravenous administration of atropine sometimes required in organophosphate poisonings is rarely needed in treating carbamate poisoning.**

Note: Persons not poisoned or only slightly poisoned by N-methyl carbamates may develop signs of atropine toxicity from such large doses. Fever, muscle fibrillations, and delirium are the main signs of atropine toxicity. If these signs appear while the patient is fully atropinized, atropine administration should be discontinued, at least temporarily, while the severity of poisoning is reevaluated.

3. **Skin decontamination**. In patients with contaminated skin, clothing, hair, and/or eyes, decontamination must proceed concurrently with whatever resuscitative and antidotal measures are needed to preserve life. Flush the chemical from eyes with copious amounts of clean water. For asymptomatic individuals who are alert and physically able, a prompt shower and shampoo may be appropriate for thorough skin decontamination, provided the patient is carefully observed to insure against sudden appearance of poisoning. 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. Wash the chemical from skin folds and from under fingernails. Attendants should wear rubber gloves, as vinyl provides no protection against skin absorption.

Contaminated clothing should be promptly removed, bagged, and laundered before returning. Contaminated leather shoes should be discarded. Note that the pesticide can contaminate the inside surfaces of gloves, boots, and headgear.

4. **Gastrointestinal decontamination**. If N-methyl carbamate has been ingested in a quantity probably sufficient to cause poisoning, consider giving gastrointestinal decontamination as outlined in Chapter 2. If the patient has presented with a recent ingestion and is still asymptomatic, adsorption of poison with activated charcoal may be

beneficial. In significant ingestions, diarrhea and/or vomiting are so constant that charcoal adsorption and catharsis are not indicated. Attention should be given to oxygen, airway management, and atropine.

5. **Urine sample**. Save a urine sample for metabolite analysis if there is need to identify the agent responsible for the poisoning.

6. **Pralidoxime** is probably of little value in N-methyl carbamate poisonings because atropine alone is effective. Although not indicated in isolated carbamate poisoning, pralidoxime appears to be useful in cases of mixed carbamate/organophosphate poisonings and cases of an unknown pesticide that present with muscarinic symptoms.

7. **Observation**. Observe patient closely for at least 24 hours to ensure that symptoms (sweating, visual disturbances, vomiting, diarrhea, chest and abdominal distress, and sometimes pulmonary edema) do not recur as atropinization is withdrawn. The observation period should be longer in the case of mixed pesticide ingestion, because of the prolonged and delayed symptoms associated with organophosphate poisoning. As the dosage of atropine is reduced over time, check the lung bases frequently for crackles. Atropinization must be re-established promptly, if crackles are heard, or if there is a return of miosis, sweating, or other signs of poisoning.

8. **Furosemide** may be considered for relief of pulmonary edema if crackles persist in the lungs even after full atropinization. Furosemide should not be considered until the maximum effect of atropine has been achieved. Consult package insert for dosage and administration.

9. **Pulmonary ventilation**. Particularly in poisonings by large doses of N-methyl carbamates, monitor pulmonary ventilation carefully to forestall respiratory failure, even after the patient recovers from muscarinic symptomatology.

10. **Cardiopulmonary monitoring**. In severely poisoned patients, monitor cardiac status by continuous ECG recording.

11. **Contraindications**. The following drugs are probably contraindicated in nearly all N-methyl carbamate poisoning cases: morphine, succinlycholine, theophylline, phenothiazines, and reserpine. Adrenergic amines should be given only if there is a specific indication, such as marked hypotension.

12. **Hydrocarbon** aspiration may complicate poisonings that involve ingestion of liquid concentrates of some carbamates formulated in a petroleum product base. Pulmonary edema and poor oxygenation in these cases will not respond to atropine and should be treated as cases of acute respiratory distress syndrome.

13. **Prophylaxis**. Do not administer atropine prophylactically to workers exposed to N-methyl carbamate pesticides. Prophylactic dosage may mask early symptoms and signs of carbamate poisoning and thus allow the worker to continue exposure and possibly progress to more severe poisoning. Atropine itself may increase the health hazards of the agricultural work setting, including impaired heat loss due to reduced sweating and impaired ability to operate mechanical equipment due to blurred vision (mydriasis).

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, deltapermethrin, 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 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.

Lambda-cyhalothrin

Lambda-cyhalothrin is a synthetic pyrethroid, of the alpha-cyano group, with a core (-CCOOCHCN-), as in alpha-cypermethrin and deltamethrin. Lambda-cyhalothrin has low vapor pressure, is essentially insoluble in water, and has low volatility. It is available in WP formulation and is used at a dosage of 20-30 mg/m^2 giving a residual effect of 3-6 months.

Toxicology

Absorption route: Lambda-cyhalothrin may be absorbed through the gastrointestinal tract, by inhalation, or through the skin. Skin absorption of lambda-cyhalothrin is very low and no systemic effects from skin absorption have been described. Dermal and inhalational exposures usually have mild or no adverse effects. Following substantial ingestion, patients may develop coma, convulsions, and severe muscle fasciculations, and may take several days and occasionally weeks to recover. No known fatalities have been reported after lambda-cyhalothrin exposure.

Mode of action: Lambda-cyhalothrin's mode of action is the same as that of other alpha-cyano pyrethroids, primarily affecting the sodium channels in the nerve membrane and causing a long-lasting prolongation of the transient increase in sodium permeability of the membrane during excitation.

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 deltamethrin 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.

Section 2: 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. **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 7: Endangered Species of Mozambique

Scientific Name	Common Name	Class	Population Trend
Dermochelys coriacea	LEATHERBACK, LEATHERY TURTLE, LUTH, TRUNKBACK TURTLE	CR	
Diceros bicornis	BLACK RHINOCEROS, HOOK-LIPPED RHINOCEROS	CR	I
Eretmochelys imbricata	HAWKSBILL TURTLE	CR	
Paraxerus vincenti	VINCENT'S BUSH SQUIRREL	CR	D
Pristis microdon	FRESHWATER SAWFISH, LARGETOOTH SAWFISH, LEICHHARDT'S SAWFISH, SMALLTOOTH SAWFISH	CR	D
Pristis zijsron	NARROWSNOUT SAWFISH	CR	D
Encephalartos munchii		CR	D
Encephalartos pterogonus		CR	D
Apalis moreaui	LONG-BILLED TAILORBIRD	CR	D
Arthroleptis troglodytes	CAVE SQUEAKER	CR	D
Acrocephalus griseldis	BASRA REED-WARBLER	EN	D
Alethe choloensis	THYOLO ALETHE	EN	D
Ardeola idae	MADAGASCAR POND-HERON	EN	D
Balaenoptera borealis	COALFISH WHALE, POLLACK WHALE, RUDOPHI'S RORQUAL, SEI WHALE	EN	
Bellamya robertsoni		EN	
Caretta caretta	LOGGERHEAD	EN	
Cheilinus undulatus	GIANT WRASSE, HUMPHEAD WRASSE, HUMPHEAD, MAORI WRASSE, NAPOLEON WRASSE, TRUCK WRASSE, UNDULATE WRASSE	EN	D
Chelonia mydas	GREEN TURTLE	EN	D
Epinephelus marginatus	DUSKY GROUPER	EN	D
Lanistes nasutus		EN	
Lanistes nyssanus		EN	
Lanistes solidus		EN	
Lepidochelys olivacea	OLIVE RIDLEY, PACIFIC RIDLEY	EN	
Lycaon pictus	AFRICAN WILD DOG, CAPE HUNTING DOG, PAINTED HUNTING DOG, WILD DOG	EN	D
Pterodroma baraui	BARAU'S PETREL	EN	D
Zoothera guttata	SPOTTED GROUND-THRUSH	EN	D
Warburgia salutaris	MURANGA, PEPPER BARK TREE	EN	
Lovoa swynnertonii	BROWN MAHOGANY, KILIMANJARO MAHOGANY	EN	
Aloe ballii		EN	
Ficus muelleriana		EN	
Thalassarche chlororhynchos	ATLANTIC YELLOW-NOSED ALBATROSS	EN	D
Thalassarche carteri	INDIAN YELLOW-NOSED ALBATROSS	EN	D
Encephalartos chimanimaniensis	CHIMANIMANI CYCAD	EN	D
Encephalartos lebomboensis	LEBOMBO CYCAD	EN	D
Bufo inyangae	INYANGA TOAD	EN	D

Scientific Name	Common Name	Class	Population Trend
Stephopaedes anotis	CHIRINDA TOAD	EN	D
Probreviceps rhodesianus		EN	D
Nothophryne broadleyi		EN	D
Afrana inyangae	INYANGANI RIVER FROG	EN	D
Aetomylaeus vespertilio	ORNATE EAGLE RAY, RETICULATE EAGLE RAY	EN	D
Oreochromis squamipinnis		EN	D
Opsaridium microlepis	LAKE SALMON	EN	D
Oreochromis lidole		EN	D
Oreochromis karongae		EN	D
Aepyceros melampus	IMPALA	LR/cd	S
Alcelaphus lichtensteinii	LICHTENSTEIN'S HARTEBEEST	LR/cd	S
Cephalophus natalensis	NATAL DUIKER, NATAL RED DUIKER, RED FOREST DUIKER	LR/cd	D
Connochaetes taurinus	BLUE & WHITE-BEARDED WILDEBEEST, BLUE WILDEBEEST	LR/cd	D
Crocuta crocuta	SPOTTED HYAENA	LR/cd	U
Damaliscus lunatus	TSESSEBE	LR/cd	D
Eubalaena australis	SOUTHERN RIGHT WHALE	LR/cd	I
Giraffa camelopardalis	GIRAFFE	LR/cd	S
Hippotragus equinus	ROAN ANTELOPE	LR/cd	D
Hippotragus niger	SABLE ANTELOPE	LR/cd	D
Kobus ellipsiprymnus	WATERBUCK	LR/cd	D
Neotragus moschatus	SUNI	LR/cd	S
Orcinus orca	KILLER WHALE, ORCA	LR/cd	
Oreotragus oreotragus	KLIPSPRINGER	LR/cd	D
Ourebia ourebi	ORIBI	LR/cd	D
Raphicerus sharpei	SHARPE'S GRYSBOK	LR/cd	S
Redunca arundinum	SOUTHERN REEDBUCK	LR/cd	S
Stenella coeruleoalba	EUPHROSYNE DOLPHIN, STRIPED DOLPHIN	LR/cd	
Stenella longirostris	LONG-BEAKED DOLPHIN, LONG-SNOUTED DOLPHIN, SPINNER DOLPHIN	LR/cd	
Syncerus caffer	AFRICAN BUFFALO	LR/cd	D
Tragelaphus angasii	NYALA	LR/cd	S
Tragelaphus strepsiceros	GREATER KUDU	LR/cd	S
Tragelaphus oryx	COMMON ELAND, ELAND	LR/cd	S
Tridacna maxima	SMALL GIANT CLAM	LR/cd	
Tridacna squamosa	FLUTED CLAM, FLUTED GIANT CLAM, SCALY CLAM	LR/cd	
Butis butis	DUCKBILL SLEEPER	LR/nt	
Carcharhinus limbatus	BLACKTIP SHARK	LR/nt	U
Carcharhinus obscurus	DUSKY SHARK	LR/nt	D
Carcharhinus plumbeus	SANDBAR SHARK	LR/nt	U
Croilia mossambica	BURROWING GOBY, NAKED GOBY	LR/nt	
Cycloderma frenatum	ZAMBEZI FLAPSHELL TURTLE	LR/nt	
Eleotris melanosoma	BROADHEAD SLEEPER	LR/nt	

Scientific Name	Common Name	Class	Population Trend
Galago zanzibaricus	MATUNDU DWARF GALAGO, ZANZIBAR BUSHBABY, ZANZIBAR GALAGO	LR/nt	U
Glossogobius biocellatus	SLEEPY GOBY	LR/nt	
Hexanchus griseus	BLUNTNOSE SIXGILL SHARK	LR/nt	U
Hyaena brunnea	BROWN HYAENA	LR/nt	U
Kinixys natalensis	NATAL HINGE-BACK TORTOISE, NATAL HINGE-BACKED TORTOISE, NATAL HINGED TORTOISE	LR/nt	
Lanistes elliptus		LR/nt	
Manis temminckii	CAPE PANGOLIN, GROUND PANGOLIN, SCALY ANTEATER, SOUTH AFRICAN PANGOLIN, TEMMINCK'S GROUND PANGOLIN	LR/nt	
Oligolepis keiensis	KEI GOBY	LR/nt	
Papillogobius melanobranchus	BLACKTHROAT GOBY	LR/nt	
Papillogobius reichei	TROPICAL SAND GOBY	LR/nt	
Redigobius dewaali	CHECKED GOBY	LR/nt	
Silhouettea sibayi	SIBAYI GOBY	LR/nt	
Tragelaphus spekii	MARSHBUCK, SITATUNGA	LR/nt	D
Dalbergia melanoxylon	AFRICAN BLACKWOOD, MOZAMBIQUE EBONY	LR/nt	
Pterocarpus angolensis	BLEEDWOOD TREE, KIAAT, MUKWA	LR/nt	
Brachylaena huillensis		LR/nt	
Milicia excelsa		LR/nt	
Croton megalocarpoides		LR/nt	
Haplocoelum trigonocarpum		LR/nt	
Dalbergia bracteolata		LR/nt	
Combretum mkuzense		LR/nt	
Bivinia jalbertii		LR/nt	
Isurus oxyrinchus	SHORTFIN MAKO	LR/nt	U
Hypogaleus hyugaensis	BLACKTIP TOPESHARK	LR/nt	U
Carcharhinus amblyrhynchos	GRAY REEF SHARK	LR/nt	U
Carcharhinus brevipinna	SPINNER SHARK	LR/nt	U
Carcharhinus leucas	BULL SHARK	LR/nt	U
Carcharhinus melanopterus	BLACKTIP REEF SHARK	LR/nt	U
Galeocerdo cuvier	TIGER SHARK	LR/nt	U
Prionace glauca	BLUE SHARK	LR/nt	U
Scoliodon laticaudus	SPADENOSE SHARK	LR/nt	U
Triaenodon obesus	WHITETIP REEF SHARK	LR/nt	U
Sphyrna lewini	SCALLOPED HAMMERHEAD	LR/nt	U
Sphyrna zygaena	SMOOTH HAMMERHEAD	LR/nt	U
Taeniura lymma	BLUE-SPOTTED STINGRAY, BLUESPOTTED RIBBONTAIL RAY	LR/nt	U
Anthreptes reichenowi	PLAIN-BACKED SUNBIRD	NT	
Apalis lynesi	NAMULI APALIS	NT	U
Ceratotherium simum	SQUARE-LIPPED RHINOCEROS, WHITE RHINOCEROS	NT	I
Circaetus fasciolatus	SOUTHERN BANDED SNAKE-EAGLE	NT	I
Circus macrourus	PALLID HARRIER	NT	D

Scientific Name	Common Name	Class	Population Trend
Crex crex	CORNCRAKE	NT	D
Dendropicos stierlingi	STIERLING'S WOODPECKER	NT	D
Falco fasciinucha	TAITA FALCON	NT	
Gallinago media	GREAT SNIPE	NT	
Haematopus moquini	AFRICAN OYSTERCATCHER	NT	
Nycteris woodi	WOOD'S SLIT-FACED BAT	NT	D
Phoenicopterus minor	LESSER FLAMINGO	NT	
Praomys delectorum	DELECTABLE SOFT-FURRED MOUSE, EAST AFRICAN PRAOMYS	NT	S
Rhinolophus blasii	BLASIUS'S HORSESHOE BAT	NT	D
Rhinolophus swinnyi	SWINNY'S HORSESHOE BAT	NT	U
Rhynchocyon cirnei	CHECKERED ELEPHANT SHREW, CHECKERED SENGI	NT	U
Scotophilus nigrita	SCHREBER'S YELLOW BAT	NT	U
Tadarida ventralis	AFRICAN GIANT FREE-TAILED BAT	NT	U
Aetobatus narinari	BONNETRAY, MAYLAN, SPOTTED EAGLE RAY	NT	D
Manta birostris	DEVIL FISH, DEVIL RAY, GIANT MANTA, MANTA RAY, PRINCE ALFRED'S RAY	NT	U
Neotis denhami	STANLEY'S BUSTARD	NT	
Rynchops flavirostris	AFRICAN SKIMMER	NT	
Phalacrocorax capensis	CAPE CORMORANT	NT	
Bulweria fallax	JOUANIN'S PETREL	NT	U
Procellaria cinerea	GREY PETREL	NT	
Ploceus olivaceiceps	OLIVE-HEADED WEAVER	NT	
Centrophorus niaukang	QUELVACHO CHINO, TAIWAN GULPER SHARK	NT	D
Heptranchias perlo	ONE-FINNED SHARK, PERLON SHARK, SEVENGILL COW SHARK, SHARPNOSE SEVENGILL SHARK, SHARPSNOUTED SEVENGILL, SLENDER SEVENGILL	NT	U
Mobula eregoodootenkee	PYGMY DEVILRAY	NT	U
Stangeria eriopus		NT	D
Pliotrema warreni	SIXGILL SAWSHARK	NT	U
Dipturus campbelli	BLACKSPOT SKATE	NT	U
Epinephelus fuscoguttatus	BROWN-MARBLED GROUPER	NT	U
Epinephelus coioides	ESTUARY COD, ORANGE-SPOTTED GROUPER	NT	D
Epinephelus andersoni	BROWN-SPOTTED ROCKCOD, CATFACE ROCKCOD	NT	U
Hipposideros marungensis		NT	D
Miniopterus natalensis	NATAL LONG-FINGERED BAT	NT	U
Proscymnodon plunketi	PLUNKET'S DOGFISH, PLUNKET'S SHARK, WAITE'S DOGFISH	NT	U
Nectarinia neergardi	NEERGAARD'S SUNBIRD	NT	
Coracias garrulus	EUROPEAN ROLLER	NT	
Agapornis lilianae	LILIAN'S LOVEBIRD	NT	
Chlorolestes elegans	ELEGANT SYLPH	NT	U
Hadrothemis scabrifrons	RED JUNGLE-SKIMMER	NT	U
Epinephelus malabaricus	MALABAR GROUPER	NT	D

Scientific Name	Common Name	Class	Population Trend
Epinephelus polyphekadion	CAMOUFLAGE GROUPER	NT	D
Acinonyx jubatus	CHEETAH, HUNTING LEOPARD	VU	D
Aethomys silindensis	SELINDA VELD RAT, SILINDA ROCK RAT	VU	U
Apalis chariessa	WHITE-WINGED APALIS	VU	D
Barbus brevipinnis	SHORTFIN BARB	VU	
Carcharias taurus	GREY NURSE SHARK, SAND TIGER SHARK, SPOTTED RAGGED-TOOTH SHARK	VU	U
Carcharodon carcharias	GREAT WHITE SHARK	VU	U
Chaetodon marleyi	MARLEY'S BUTTERFLYFISH	VU	
Chetia brevis	ORANGE-FRINGED LARGEMOUTH	VU	
Cloeotis percivali	PERCIVAL'S TRIDENT BAT	VU	U
Diomedea exulans	WANDERING ALBATROSS	VU	D
Dugong dugon	DUGONG, SEA COW	VU	U
Egretta vinaceigula	SLATY EGRET	VU	D
Epinephelus lanceolatus	BRINDLE BASS, BRINDLED GROUPER, GIANT GROUPER, QUEENSLAND GROPER	VU	D
Falco naumanni	LESSER KESTREL	VU	D
Grus carunculatus	WATTLED CRANE	VU	D
Gyps coprotheres	CAPE GRIFFON	VU	D
Hippopotamus amphibius	COMMON HIPPOPOTAMUS, HIPPOPOTAMUS, LARGE HIPPO	VU	D
Hirundo atrocaerulea	BLUE SWALLOW	VU	D
Loxodonta africana	AFRICAN ELEPHANT	VU	U
Megaptera novaeangliae	BUNCH, HUMP WHALE, HUMPBACK WHALE, HUNCHBACKED WHALE	VU	I
Morus capensis	CAPE GANNET	VU	D
Panthera leo	AFRICAN LION, LION	VU	D
Rhincodon typus	WHALE SHARK	VU	D
Sheppardia gunningi	EAST COAST AKALAT	VU	D
Spheniscus demersus	AFRICAN PENGUIN	VU	D
Swynnertonia swynnertoni	SWYNNERTON'S ROBIN	VU	D
Thunnus obesus	BIGEYE TUNA	VU	
Ocotea kenyensis		VU	
Euphorbia lividiflora		VU	
Allophylus chirindensis		VU	
Vitellariopsis ferruginea		VU	
Olea chimanimani		VU	
Pleioceras orientale		VU	
Khaya anthotheca	AFRICAN MAHOGANY, WHITE MAHOGANY	VU	
Nauclea diderrichii		VU	
Prunus africana	RED STINKWOOD	VU	
Garcinia acutifolia		VU	
Tannodia swynnertonii		VU	
Bussea xylocarpa		VU	
Acacia purpurea		VU	
Sterculia schliebenii		VU	

Scientific Name	Common Name	Class	Population Trend
Dialium holtzii		VU	
Strychnos mellodora		VU	
Baphia macrocalyx		VU	
Berlinia orientalis		VU	
Guibourtia schliebenii		VU	
Millettia bussei		VU	
Premna schliebenii		VU	
Cola mossambicensis		VU	
Cordia stuhlmannii		VU	
Cordia mandimbana		VU	
Synsepalum kassneri		VU	
Mildbraedia carpinifolia		VU	
Paranecepsia alchorneifolia		VU	
Coffea zanguebariae		VU	
Cuviera tomentosa		VU	
Psydrax micans		VU	
Baphia kirkii		VU	
Premna tanganyikensis		VU	
Pandanus petersii		VU	
Centrophorus granulosus	GULPER SHARK	VU	D
Galeorhinus galeus	LIVER-OIL SHARK, MILLER'S DOG, OIL SHARK, PENNY DOG, RIG, SCHOOL SHARK, SNAPPER SHARK, SOUPFIN, SOUPIE, SOUTHERN TOPE, SWEET WILLIAM, TIBURON, TOPE SHARK, TOPER, TOPE, VITAMIN SHARK, WHITHOUND	VU	D
Rhynchobatus djiddensis	GIANT GUITARFISH, WHITESPOTTED WEDGEFISH	VU	D
Urogymnus asperrimus	PORCUPINE RAY	VU	U
Torgos tracheliotos	LAPPET-FACED VULTURE	VU	D
Macronectes giganteus	SOUTHERN GIANT-PETREL	VU	D
Procellaria aequinoctialis	WHITE-CHINNED PETREL	VU	D
Modulatrix orostruthus	DAPPLE-THROAT	VU	D
Carpitalpa arendsi	AREND'S GOLDEN MOLE	VU	U
Aetomylaeus nichofii	BANDED EAGLE RAY	VU	D
Physeter macrocephalus	CACHELOT, POT WHALE, SPERM WHALE, SPERMACET WHALE	VU	
Nebrius ferrugineus	TAWNY NURSE SHARK	VU	D
Rhina ancylostoma	BOWMOUTH GUITARFISH, MUD SKATE, SHARK RAY	VU	D
Hemipristis elongatus	FOSSIL SHARK, SNAGGLETOOTH SHARK	VU	D
Stegostoma fasciatum	LEOPARD SHARK, ZEBRA SHARK	VU	D
Encephalartos aplanatus		VU	D
Encephalartos gratus	MULANJE CYCAD	VU	D
Encephalartos manikensis	GORONGOWE CYCAD	VU	D
Encephalartos ngoyanus	NGOYE CYCAD	VU	D
Encephalartos senticosus		VU	D
Encephalartos umbeluziensis	UMBELUZI CYCAD	VU	D

Scientific Name	Common Name	Class	Population Trend
Epinephelus albomarginatus	CAPTAIN FINE, WHITE-EDGED ROCKCOD	VU	D
Lissonycteris goliath	HARRISON'S FRUIT BAT	VU	D
Glareola ocularis	MADAGASCAR PRATINCOLE	VU	D
Strongylopus rhodesianus	CHIMANIMANI STREAM FROG	VU	D
Coryphagrion grandis		VU	U
Nepogomphoides stuhlmanni		VU	U
Rhinoptera javanica	FLAPNOSE RAY, JAVANESE COWNOSE RAY	VU	U
Taeniura meyeni	BLACK-BLOTCHED STINGRAY, BLACK-SPOTTED STINGRAY, BLOTCHED FANTAIL RAY, FANTAIL STINGRAY, GIANT REEF RAY, ROUND RIBBONTAIL RAY, SPECKLED STINGRAY	VU	U
Opsaridium microcephalum		VU	D
Haplochromis tweddlei		VU	U
Copadichromis geertsi		VU	U
Copadichromis trewavasae		VU	U
Copadichromis verduyni		VU	U
Iodotropheus stuartgranti		VU	U
Aulonocara hansbaenschi	AULONOCARA FORT MAGUIRE	VU	U
Maylandia aurora		VU	U
Maylandia phaeos		VU	U
Nothobranchius orthonotus	SPOTTED KILLIFISH	VU	U

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

Annex 8: EU MRLs for DDT

According to the Pesticides Safety Directorate of the United Kingdom, MRLs are defined as "the maximum concentration of pesticide residue (expressed as milligrams of residue per kilogram of commodity) likely to occur in or on food commodities and animal feeds after the use of pesticides according to Good Agricultural Practice (GAP)" (2006).

MRLs are based on residue levels, which result from the approved use of the pesticide, and are set at a level that is as low as possible whilst accommodating the GAP. They are intended primarily as a check that GAP is being followed and to assist international trade in produce treated with pesticides.

The limit of determination (LOD) is the lowest concentration of a pesticide residue that can be measured using routine analysis.

Proper use of a pesticide can leave small traces of residue on the commodity at harvest; therefore, many MRLs are set above the LOD. There are, however, three possible reasons why the MRL might be set at the LOD:

- A particular use is not "supported" in the EU – either because insufficient data have been provided or because no use is intended.
- Scientific data shows that the intended use might leave residues that would pose an unacceptable risk to consumers.
- Scientific data shows that the intended use leaves no determinable residues on the treated commodity at harvest. This could be in cases where, for example, the pesticide is used at early stages of growth as a pre-emergence herbicide or as a seed treatment.

An MRL at the LOD does not necessarily mean that the pesticide use is illegal.

http://www.pesticides.gov.uk/home.asp

EU MRLs for DDT			
Crop Group	**Commodity**	**Maximum Residue Limit (MRL)**	**Limit of Determination (LOD)**
CITRUS	Citrus Fruit Others	0.05	0.05
CITRUS	Grapefruit	0.05	0.05
CITRUS	Lemons	0.05	0.05
CITRUS	Limes	0.05	0.05
CITRUS	Mandarins	0.05	0.05
CITRUS	Oranges	0.05	0.05
CITRUS	Pomelo	0.05	0.05
TREE NUTS	Almonds	0.05	0.05
TREE NUTS	Brazil Nuts	0.05	0.05
TREE NUTS	Cashew Nuts	0.05	0.05
TREE NUTS	Chestnuts	0.05	0.05
TREE NUTS	Coconuts	0.05	0.05
TREE NUTS	Hazelnuts	0.05	0.05
TREE NUTS	Macadamia Nuts	0.05	0.05
TREE NUTS	Pecans	0.05	0.05
TREE NUTS	Pine Nuts	0.05	0.05
TREE NUTS	Pistachios	0.05	0.05
TREE NUTS	Tree Nuts Others	0.05	0.05
TREE NUTS	Walnuts	0.05	0.05
POME FRUIT	Apples	0.05	0.05
POME FRUIT	Pears	0.05	0.05
POME FRUIT	Pome Fruit Others	0.05	0.05
POME FRUIT	Quinces	0.05	0.05
STONE FRUIT	Apricots	0.05	0.05
STONE FRUIT	Cherries	0.05	0.05
STONE FRUIT	Peaches	0.05	0.05
STONE FRUIT	Plums	0.05	0.05
STONE FRUIT	Stone Fruit Others	0.05	0.05
BERRIES AND SMALL FRUIT	Bilberries	0.05	0.05
BERRIES AND SMALL FRUIT	Blackberries	0.05	0.05
BERRIES AND SMALL FRUIT	Cane Fruit Others	0.05	0.05
BERRIES AND SMALL FRUIT	Cranberries	0.05	0.05
BERRIES AND SMALL FRUIT	Currants (Black, Red and White)	0.05	0.05
BERRIES AND SMALL FRUIT	Dewberries	0.05	0.05
BERRIES AND SMALL FRUIT	Gooseberry	0.05	0.05
BERRIES AND SMALL FRUIT	Loganberries	0.05	0.05
BERRIES AND SMALL FRUIT	Other Small Fruit and Berries-Others	0.05	0.05

EU MRLs for DDT			
Crop Group	**Commodity**	**Maximum Residue Limit (MRL)**	**Limit of Determination (LOD)**
BERRIES AND SMALL FRUIT	Raspberries	0.05	0.05
BERRIES AND SMALL FRUIT	Strawberries	0.05	0.05
BERRIES AND SMALL FRUIT	Table Grapes	0.05	0.05
BERRIES AND SMALL FRUIT	Wild Berries and Wild Fruit	0.05	0.05
BERRIES AND SMALL FRUIT	Wine Grapes	0.05	0.05
MISCELLANEOUS FRUIT	Avocados	0.05	0.05
MISCELLANEOUS FRUIT	Bananas	0.05	0.05
MISCELLANEOUS FRUIT	Dates	0.05	0.05
MISCELLANEOUS FRUIT	Figs	0.05	0.05
MISCELLANEOUS FRUIT	Kiwi Fruit	0.05	0.05
MISCELLANEOUS FRUIT	Kumquats	0.05	0.05
MISCELLANEOUS FRUIT	Litchis	0.05	0.05
MISCELLANEOUS FRUIT	Mangoes	0.05	0.05
MISCELLANEOUS FRUIT	Miscellaneous Fruit Others	0.05	0.05
MISCELLANEOUS FRUIT	Olives	0.05	0.05
MISCELLANEOUS FRUIT	Passion Fruit	0.05	0.05
MISCELLANEOUS FRUIT	Pineapples	0.05	0.05
MISCELLANEOUS FRUIT	Pomegranates	0.05	0.05
ROOT AND TUBER VEGETABLES	Beetroot	0.05	0.05
ROOT AND TUBER VEGETABLES	Carrots	0.05	0.05
ROOT AND TUBER VEGETABLES	Celeriac	0.05	0.05
ROOT AND TUBER VEGETABLES	Horseradish	0.05	0.05
ROOT AND TUBER VEGETABLES	Jerusalem artichoke	0.05	0.05
ROOT AND TUBER VEGETABLES	Parsley root	0.05	0.05
ROOT AND TUBER VEGETABLES	Parsnips	0.05	0.05
ROOT AND TUBER VEGETABLES	Radishes	0.05	0.05
ROOT AND TUBER VEGETABLES	Root and Tuber Vegetables others	0.05	0.05
ROOT AND TUBER VEGETABLES	Salsify	0.05	0.05
ROOT AND TUBER VEGETABLES	Swedes	0.05	0.05
ROOT AND TUBER VEGETABLES	Sweet potato	0.05	0.05
ROOT AND TUBER VEGETABLES	Turnip	0.05	0.05
ROOT AND TUBER VEGETABLES	Yams	0.05	0.05

EU MRLs for DDT			
Crop Group	**Commodity**	**Maximum Residue Limit (MRL)**	**Limit of Determination (LOD)**
BULB VEGETABLES	Bulb Vegetables others	0.05	0.05
BULB VEGETABLES	Garlic	0.05	0.05
BULB VEGETABLES	Onions	0.05	0.05
BULB VEGETABLES	Shallots	0.05	0.05
BULB VEGETABLES	Spring onion	0.05	0.05
FRUITING VEGETABLES	Aubergine	0.05	0.05
FRUITING VEGETABLES	Courgettes	0.05	0.05
FRUITING VEGETABLES	Cucumbers	0.05	0.05
FRUITING VEGETABLES	Cucurbits edible peel others	0.05	0.05
FRUITING VEGETABLES	Cucurbits inedible peel others	0.05	0.05
FRUITING VEGETABLES	Gherkins	0.05	0.05
FRUITING VEGETABLES	Melons	0.05	0.05
FRUITING VEGETABLES	Peppers	0.05	0.05
FRUITING VEGETABLES	Solanacea others	0.05	0.05
FRUITING VEGETABLES	Squashes	0.05	0.05
FRUITING VEGETABLES	Sweet corn	0.05	0.05
FRUITING VEGETABLES	Tomatoes	0.05	0.05
FRUITING VEGETABLES	Watermelons	0.05	0.05
BRASSICA VEGETABLES	Broccoli	0.05	0.05
BRASSICA VEGETABLES	Brussels sprouts	0.05	0.05
BRASSICA VEGETABLES	Cauliflower	0.05	0.05
BRASSICA VEGETABLES	Chinese cabbage	0.05	0.05
BRASSICA VEGETABLES	Flowering brassicas others	0.05	0.05
BRASSICA VEGETABLES	Head brassicas others	0.05	0.05
BRASSICA VEGETABLES	Head cabbages	0.05	0.05
BRASSICA VEGETABLES	Kale	0.05	0.05
BRASSICA VEGETABLES	Kohlrabi	0.05	0.05
BRASSICA VEGETABLES	Leafy brassicas others	0.05	0.05
LEAFY VEGETABLES	Beet leaves (chard)	0.05	0.05
LEAFY VEGETABLES	Celery leaves	0.05	0.05
LEAFY VEGETABLES	Chervil	0.05	0.05
LEAFY VEGETABLES	Chives	0.05	0.05
LEAFY VEGETABLES	Cress	0.05	0.05
LEAFY VEGETABLES	Herbs others	0.05	0.05
LEAFY VEGETABLES	Lamb's lettuce	0.05	0.05
LEAFY VEGETABLES	Lettuce	0.05	0.05
LEAFY VEGETABLES	Lettuce and similar others	0.05	0.05
LEAFY VEGETABLES	Parsley	0.05	0.05
LEAFY VEGETABLES	Scarole	0.05	0.05
LEAFY VEGETABLES	Spinach	0.05	0.05
LEAFY VEGETABLES	Spinach and similar (others)	0.05	0.05
LEAFY VEGETABLES	Watercress	0.05	0.05
LEAFY VEGETABLES	Witloof	0.05	0.05

EU MRLs for DDT			
Crop Group	**Commodity**	**Maximum Residue Limit (MRL)**	**Limit of Determination (LOD)**
LEGUME VEGETABLES (FRESH)	Beans (with pods)	0.05	0.05
LEGUME VEGETABLES (FRESH)	Beans (without pods)	0.05	0.05
LEGUME VEGETABLES (FRESH)	Legume vegetables fresh others	0.05	0.05
LEGUME VEGETABLES (FRESH)	Peas (with pods)	0.05	0.05
LEGUME VEGETABLES (FRESH)	Peas (without pods)	0.05	0.05
STEM VEGETABLES (FRESH)	Asparagus	0.05	0.05
STEM VEGETABLES (FRESH)	Cardoons	0.05	0.05
STEM VEGETABLES (FRESH)	Celery	0.05	0.05
STEM VEGETABLES (FRESH)	Fennel	0.05	0.05
STEM VEGETABLES (FRESH)	Globe artichoke	0.05	0.05
STEM VEGETABLES (FRESH)	Leeks	0.05	0.05
STEM VEGETABLES (FRESH)	Rhubarb	0.05	0.05
STEM VEGETABLES (FRESH)	Stem vegetables fresh others	0.05	0.05
FUNGI	Cultivated mushrooms	0.05	0.05
FUNGI	Wild mushrooms	0.05	0.05
PULSES	Beans	0.05	0.05
PULSES	Lentils	0.05	0.05
PULSES	Peas	0.05	0.05
PULSES	Pulses others	0.05	0.05
OILSEEDS	Cotton seed	0.05	0.05
OILSEEDS	Linseed	0.05	0.05
OILSEEDS	Mustard seed	0.05	0.05
OILSEEDS	Oilseeds others	0.05	0.05
OILSEEDS	Peanuts	0.05	0.05
OILSEEDS	Poppy seeds	0.05	0.05
OILSEEDS	Rapeseed	0.05	0.05
OILSEEDS	Sesame seeds	0.05	0.05
OILSEEDS	Soya bean	0.05	0.05
OILSEEDS	Sunflower seeds	0.05	0.05
POTATOES	Early potatoes	0.05	0.05
POTATOES	Ware potatoes	0.05	0.05
TEA	Tea	0.2	0.05
HOPS	Hops (dried)	0.05	0.05
CEREALS	Barley	0.05	
CEREALS	Buckwheat	0.05	
CEREALS	Cereals others	0.05	

EU MRLs for DDT			
Crop Group	**Commodity**	**Maximum Residue Limit (MRL)**	**Limit of Determination (LOD)**
CEREALS	Maize	0.05	
CEREALS	Millet	0.05	
CEREALS	Oats	0.05	
CEREALS	Rice	0.05	
CEREALS	Rye	0.05	
CEREALS	Sorghum	0.05	
CEREALS	Triticale	0.05	
CEREALS	Wheat	0.05	
MEAT	0201 Bovine	1	
MEAT	0202 Bovine, frozen	1	
MEAT	0203 Swine	1	
MEAT	0204 Sheep or goats	1	
MEAT	0205 00 00 Horses, asses, mules,...	1	
EDIBLE OFALL	0206 Bovines,swine,sheep,goats,...	1	
FAT	0209 00 Pig & poultry	1	
DAIRY	0401Milk & cream	0.04	
DAIRY	0402 Milk & cream	0.04	
DAIRY	0405 00 Butter, other fats, oils...	0.04	
DAIRY	0406 Cheese & curd	0.04	
EGG	0407 00 Eggs in shell	0.05	
EGG	0408 Eggs (not in shell) & yolks	0.05	
MEAT, OFFAL & BLOOD	1601 00 Sausage & similar	1	
MEAT, OFFAL & BLOOD	1602 Meat offal or blood (others)	1	
MEAT & EDIBLE OFFAL	0207 Poultry of heading NÂ°0105	1	
MEAT & EDIBLE OFFAL	0210 Edible flours & meals;...	1	
MEAT & EDIBLE OFFAL	ex0208 Oth. meat & edible meat offal	1	

http://europa.eu.int/comm/food/plant/protection/resources/mrl_pesticide.pdf