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Tropical Disease Control for Development

Bolivia: Environmental Assessment of Insecticides as Residual Sprays for Malaria Control

September 8 - October 5, 1993

By

Jesse Hobbs, Sc.D.

VBC Report No. 82211

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1. Executive Summary

USAID/Bolivia intends to continue its support of the Bolivian Malaria Control Program through the Title III local currency program, administered by the PL-480 Executive Secretariat. USAID's assistance will include funds for equipment, vehicles, insecticides and training.

Since 1958, the Bolivian Malaria Control Program has carried out house spraying operations using the insecticide DDT. The use of this insecticide is no longer considered environmentally acceptable for use in anti-malarial spraying, a position taken both by the Latin American and Caribbean Environmental Office of A.I.D. and the World Health Organization. Environmentally acceptable alternative insecticides need to be chosen for use as residual house sprays in Bolivia. Insecticides, such as the pyrethroids lambda cyhalothrin and deltamethrin, are considered in this environmental assessment.

The assessment analyzes the strategy of using residual insecticides for anti-malaria spraying. The conclusion is that this strategy is the most efficient and cost effective method for reducing malaria incidence in Bolivia at the present time.

Prepared in compliance with A.I.D.'s Environmental Procedures 22 CFR 216, the assessment identifies and analyzes the health, safety and environmental issues specific to the proposed use of these insecticides as house sprays. The requirement for this assessment stems from concerns about worker safety and environmental protection associated with the use of toxic insecticides.

The anticipated adverse short-term and long-term effects of the proposed insecticides on humans, domestic animals, birds, fish, honeybees, wildlife and the abiotic environment are considered minimal based on the relatively small quantities of insecticides to be used and the contained nature of use (intra-domiciliary application), provided the recommended staff training, safety precautions, mitigating measures and monitoring are fully implemented.

A detailed mitigation plan is presented to further minimize acute poisoning of spray crews, inhabitants, and domestic animals; contamination of surface and ground water; and poisoning of fish, birds, and wildlife. The plan makes recommendations for training, use of protective clothing, education, and proper disposal of rinsate, waste, and empty containers.

The remaining risks would be miniscule compared to the potential benefits derived from malaria control. Therefore, the following insecticides should be approved for the USAID-financed operational spraying carried out by the Bolivian Malaria Control Program: lambda cyhalothrin and deltamethrin.

2. Background

The purpose of this activity was to conduct an environmental assessment of insecticides that had not previously been used for malaria control for house spraying in Bolivia. The author reviewed the proposed use of various insecticides including lambda cyhalothrin (ICON(R)) and deltamethrin (K.Othrin(R)). These insecticides are considered appropriate replacements for the currently used DDT. Although DDT has been in used in Bolivia for malaria control spraying since 1958 and has been effective in controlling this disease, use of this compound should be restricted. Because of their lack of degradations, their resulting widespread persistence in the environment, DDT and its metabolites should be regarded as hazards to the environment. DDT should not be used when an alternative insecticide is available.

Efforts to control malaria on a country-wide basis began in Bolivia in 1958 with the initiation of the National Service of Malaria Eradication. The major components of this campaign were case detection through active and passive surveillance, medication of the cases detected, and indoor house spraying with DDT at six-month intervals. These efforts were supported financially by the predecessor agencies of A.I.D., UNICEF, and the Pan American Health Organization. In these early years, malaria was markedly reduced by the use of DDT house spraying plus chemotherapy of positive cases.

More recently the malaria control program has experienced organizational changes and reduction in financing by donor agencies as well as by the Government of Bolivia. Spraying operations were at times withdrawn from all but the most malarious localities during times of financial crisis. When spraying had to be suspended, malaria rates generally increased.

In 1985, the malaria control program received much needed assistance from the USAID local currency program administered by the PL-480 Executive Secretariat. Financial assistance was provided for the purchase of vehicles and insecticides, and the organization and presentation of training courses in the various malaria specialties. It is expected that requests for purchase of approved insecticides, equipment, and training will continue in the future.

In the last three years, there have been efforts to integrate the malaria control program into the health system. Integration has been carried out in some regions of the country, but is less advanced in others. It is important for the Health Units to retain a core group of trained and experienced malaria workers to carry out surveillance and spraying operations in high risk areas and to apply emergency measures in focal outbreaks of malaria.

No environmental assessment has been done of the impact of the insecticide DDT in the Malaria Control Program of Bolivia. This is understandable because at the time of the initial use of DDT in the country, this insecticide was being used worldwide for malaria control. Its use was fully approved by the World Health Organization and other donor agencies. In 1989, WHO made the strong recommendation that alternative biodegradable insecticides be used in malaria control programs (WHO 1989).

In 1991, the VBC Project carried out an environmental assessment for Chagas disease control in Bolivia. Lambda cyhalothrin and deltamethrin were among the several compounds recommended for trials (Arata 1991). Since that report was submitted to A.I.D., these trials have been completed and both these pyrethroid insecticides were found to be effective in the control of the vectors of Chagas disease. Because malaria and Chagas disease are co-endemic in parts of Chuquisaca and Santa Cruz, it would be logical to choose an alternative insecticide for malaria control that is also effective in the control of Chagas disease.

3. Analysis of Alternative to Proposed Actions

The discontinuation of house spraying would be inappropriate and even harmful for the future of malaria control in Bolivia. If spraying is withdrawn, malaria rates could increase to their formerly high levels. The use of effective alternative insecticides to replace DDT could provide continued malaria control.

Biological control or environmental management approaches to malaria control have not been considered viable economic substitutes for house spraying in Bolivia, mainly because of the vast extent of static water collections during the rainy season and the scattered nature of the many small villages. These methods are, however, cost effective and appropriate in urban areas, and should be considered in future malaria control plans.

Malaria control through chemotherapy alone is already in practice in areas with low malaria incidence or low risk of transmission. House spraying is stopped when the annual parasite incidence is reduced to 5-10 cases per 1,000 population and in some localities where falciparum malaria has disappeared. In the unsprayed localities, malaria is controlled through case detection and radical treatment.

The objective of antimalarial drug therapy is not only the prompt clinical cure for malaria patients, but also the reduction of the infective reservoir. When these objectives are met through efficient treatment of malaria, combined case detection and treatment activities may serve as a useful control method, particularly in areas where the malariogenic potential is not high.

Based on consideration of available options, the author believes that the current malaria control program, using residual spray insecticides in combination with chemotherapy, is the most balanced approach to environmentally acceptable, economic, and efficient malaria control in Bolivia.

4. Pesticide Use Assessment

The U.S. Environmental Protection Agency (USEPA) registration status, WHO recommendation and USAID approval of each insecticide selected for possible use as an antimalarial house spray in Bolivia are summarized in Table 1.

Lambda cyhalothrin (ICON(R)) is registered in the USA for the control of public and animal health pests, and for agricultural and horticultural pest control. This insecticide has been tested for mosquito control through bed net impregnation in The Gambia (Lindsey et. al. 1991), and for effects on spraymen and inhabitants in Tanzania (Moretto et. al. 1991) and Pakistan (Chester et. al. 1990).

Deltamethrin (K-OTHRIN(R)) registration in the USA is pending. It is used worldwide outside of the USA for vector, agricultural, public health and animal health pest control. Deltamethrin studies were conducted in Mexico for *Anopheles* control using intra-domiciliary low-volume spray (Vaca-Marin et. al. 1991). Bed nets impregnated with deltamethrin were successfully tested for malaria control in Burkino Faso (Robert et. al. 1991) and Burundi (Barutwanayo et. al.1991) (See Table 1.)

The pyrethroid insecticides lambda cyhalothrin and deltamethrin were selected as suitable replacements for DDT in the Malaria Control Program in Bolivia based on their successful use in other countries, safety for householders, spraymen and the environment, and extended residual activity against mosquitos.

Cost per house is approximately twice as much to spray with lambda cyhalothrin as to spray with DDT, using recommended dosages in both cases. This doubling of cost is offset by the extended residual activity of lambda cyhalothrin. Field trials in other countries have indicated that one spraying per year with ICON may be sufficient to effectively control malaria. Field trials now in progress in Santa Cruz Province may also prove this is the case for Bolivia. Houses in malarious areas have been sprayed with DDT on a six-month cycle since the initiation of the malaria program in Bolivia. If ICON is substituted for DDT and is sprayed only once a year, then there is no increase in annual cost for insecticide spraying.

'TABLE 1 – REGISTRATION, RECOMMENDATION AND USE STATUS OF INSECTICIDES

INSECTICIDE	MANUFACTURER	EPA REGISTRATION	WHO RECOMMENDATION	USAID APPROVAL
PYRETHROIDS				
Lambda Cyhalothrin ICON 10 WP	ICI (UK)	Registered for mosquito control Restricted Use Pesticide	Approved for Malaria Vector Control in the Gambia, Uganda, Tanzania, etc.	Recommended for Chagas Disease Vector Control in Bolivia
Deltamethrin K–Othrine 25 WP (2.5%)	Roussel UCLAF (France)	Not Registered; Widely used outside the U.S. for Vector Control, animal health, public health and agricultural pest control	Malaria vector control in Mexico, Kenya, Indonesia, Guatemala, Phillippines, also for bed net impregnation	None

A cost analysis of spraying ICON, K-OTHRINE and DDT was carried out by the Chagas Disease Pilot Project and the comments in the above paragraph are based on this analysis. This analysis has been provided to the Technical Section of the PL 480 Executive Secretariat.

House spraying for malaria control in Bolivia is performed according to the principles of integrated control in that spraying is done only when malaria cases in any given locality reach a certain level. Two of the goals of integrated pest management are to reduce reliance on chemical insecticides and to include the use of non-chemical methods in the control strategy. Bolivia's Malaria Control Program uses chemotherapy in combination with spraying to reduce the malaria incidence in positive localities.

It is suggested that residual spray be applied to the inside walls, ceilings and roof eaves of houses. Insecticide should be sprayed using Hudson X-Pert hand compression sprayers (8-L capacity) fitted with HSS-8002 nozzles. The application techniques will be exactly the same for these new insecticides as have been used for many years by spray personnel.

Applications will be made at the USEPA or WHO approved rates, which are marked on the labels, or at lower efficacious dosages (Table 2). If insecticide is packed in a water-soluble packet with the correct amount for one spray tank, direct mixing in a spray tank is preferred, according to label directions (See Table 2.) Before spraying starts, all sprayers should be checked for leaks and line cracks, all defective parts should be replaced, and sprayers should be calibrated to insure correct flow rate, spray pattern and coverage.

TABLE 2 – APPLICATION RATES OF INDOOR RESIDUCAL SPRAY FOR ALTERNATIVE INSECTICIDES

INSECTICIDE	FORMULATION	RATE APPLIED g ai/m2	PRODUCT (g) PER 10–L WATER	SPRAY CONCENTRATION
Lambda Cyhalothrin ICON 10 WP	ICON 10% WDP	0.03	78.1	0.08%
Deltamethrin	K.OTHRINE 25 WP 2.5%	0.025	250	0.0625%

Toxicological and environmental hazards of lambda cyhalothrin and deltamethrin can best be discussed in comparison to malathion, an insecticide used in many countries for mosquito control with no major adverse effects or hazards (Table 3). In general, acute toxicity to inhabitants of sprayed houses is minimal, because food items are removed before spraying and a re-entry interval of one hour is observed.

Lambda cyhalothrin is a pyrethroid that consists of two of the more active racemic mixtures of the four isomers of cyhalothrin. Lambda cyhalothrin and other pyrethroids interfere with the sodium channels' gating mechanism which is essential for nerve conduction and results in prolonged sodium leakiness of the nervous membrane during depolarization. The effect on the sodium channels is a reversible reaction.

Indoor use of lambda cyhalothrin at a very low rate (50 times less than malathion) poses extremely low risk to non-target species and domestic animals. The risk of systematic toxicity in spray crews and inhabitants is remote because lambda cyhalothrin is rapidly metabolized in humans to much less toxic metabolites. Acute exposure can result in headaches, nausea, muscular twitching and convulsions, but concentrations in the circulatory system fail quickly and recovery is rapid (WHO 1989).

The major health effects have occurred in workers after exposure to spray drifts on non-protected skin, especially on the face when spraying ceilings. The symptoms of exposure are skin sensations (paraesthesia) described as itching and burning and, less frequently, nose and throat irritation, sneezing and coughing (WHO 1989). Cutaneous sensation is reduced if the skin is washed immediately with cold water, and symptoms disappear 24 hours after exposure. Lambda cyhalothrin is also a mild eye irritant. Inhabitants entering houses one hour after spraying should not experience any adverse effects (Moretto et al. 1991).

Lambda cyhalothrin is applied at very low doses on confined interior walls of houses. Therefore, its adverse impact on birds, wildlife, fish and honeybees is negligible, especially when precautions in spraying and handling of equipment rinsate and waste are followed to prevent contamination of aquatic habitat.

Lambda cyhalothrin has very low toxicity to ducks. Although it is highly toxic to fish under laboratory conditions, the toxicity is mitigated by the low rate used, rapid absorption on suspended soil sediment in water, and rapid photodegradation and hydrolysis. Hazards to honeybees are minimal when caution is taken to prevent drifts to any nearby beehives.

Lambda cyhalothrin poses no hazards to air contamination, groundwater contamination, or environmental persistence or accumulation because of its extremely low volatility, low water solubility, strong soil absorption, and short half-life in water and soil.

Deltamethrin, a pyrethroid, has a mode of toxic action similar to that of lambda cyhalothrin, and hence has a high mammalian safety. As is the case with certain other alphacyano pyrethroids, including lambda cyhalothrin, cypermethrin, cyfluthrin and fenvalerate, deltamethrin can cause temporary tingling, burning or numbing sensations. It is also a slight skin irritant.

Although deltamethrin is extremely toxic to fish, aquatic organisms, and honeybees under laboratory conditions, its toxicity is mitigated in the environment by the low rate used, rapid absorption on suspended soil sediment in water, and rapid photodegradation and hydrolysis, as discussed for lambda cyhalothrin. Deltamethrin also poses minimal air, surface and groundwater, and soil contamination because of its extremely low volatility, low solubility and high soil absorption. The impact on outdoor environment should be negligible in intradomiciliary residual spray of houses.

No long-term human toxicity is foreseen in the use of the insecticides under consideration. There are no findings of delayed neurotoxicity, oncogenicity, tetratogenicity, reproductive effects or mutagenicity in test animals. In humans, these compounds are rapidly metabolized and excreted. No evidence of bio-accumulation has been noted. Indoor house spraying of small quantities of insecticide should not result in chronic toxicity for spray personnel and should pose negligible long-term hazard to the inhabitants (See Table 3).

TABLE 3 – COMPARATIVE TOXICITY OF ALTERNATIVE INSECTICIDES

INSECTICIDE	RAT			BIRD (MALLARD)	FISH	HONEYBEE
	ORAL LD50 Mg/Kg	DERMAL Mg/Kg	SKIN/EYE EFFECT	ORAL LD50 (PPM)	LC50 (PPM)	ORAL LC50 Mg/Bee
MALATHION	1,500–2,000	72,000	MILD	1,485	200	0.71
LAMBDA CYHALOTHRIN	56–79	632–696	HIGH	> 3,950	0.24	0.96
DELTAMETHRIN	135–5,000	> 2,000	MILD	> 4,640	< 0.24	0.05

SOURCE: PESTICIDE DATABASE, VBC PROJECT.

Residual spraying for malaria control is based on the fact that most anopheline vectors enter houses seeking a blood meal at night when people are usually inside. After taking a blood meal, mosquitoes usually rest on inside walls before escaping from the house. When these inside surfaces are covered with a coating of residual insecticides, mosquitoes die as a result of contact with the insecticide. If a mosquito has taken an infective blood meal, the chain of transmission is broken when the mosquito is killed.

Both of the recognized vectors of malaria in Bolivia, *Anopheles pseudopunctipennis* and *An. darlingi*, are known to enter houses to feed and rest on inside surfaces after feeding. Residual spraying reduces malaria incidence when an effective insecticide is applied at the correct dosage and the spraying is timed to be effective during the transmission season. Selective spraying invariably reduces malaria cases in endemic areas where vectors bite indoors.

The selected insecticides have been widely used in other countries for mosquito control with human and environmental safety because of three major characteristics of the insecticides and application methods: 1) sprays are confined to and directed on the indoor walls and ceilings of houses and animal shelters; 2) sprays are applied at very low dosages; and 3) sprays have a relatively high insect/mammal selectivity, particularly the pyrethroids (Table 3) Residual spraying is effectively aimed at having a contact poisoning effect on the targeted mosquito species based on its endophilic resting behavior.

Major non-target species affected by house spraying will be arthropods resting on or living in the cracks and crevices of inside walls and ceilings, such as flies, fleas, bedbugs, cockroaches, ants, scorpions, centipedes, and spiders. Toxicity could also occur in domestic animals which feed on dead insects. Because of the controlled and contained nature of the spray, non-target species found outdoors have negligible or no risk of exposure.

Significant environmental risk is associated with transport, storage and mixing/loading of pesticides, and in the washing of buckets and sprayers and disposal of waste. These activities could result in contamination of aquatic habitats. Risk can be mitigated through safe practices in transport, storage, use and disposal of the insecticides (Section 6).

These insecticides may be used in any malarious or potentially malarious area of the country. By definition, this includes any part of the national territory below 2,500 meters of altitude. This area varies widely in topographical and climatic features from inter-Andean valleys to tropical lowlands.

Insecticides will be applied indoors at recommended rates (Table 2). Spray crews will use specified equipment and application methods and follow label directions. The Malaria Control Program will implement control measures for human and environmental safety and provide training, supervision, and monitoring of spray crews (Section 6).

In addition to the two insecticides under consideration here, other compounds are commercially available and have shown themselves to be effective in malaria control through house spraying. Among the carbamates, propoxur has been used successfully in several countries for many years. Bendiocarb is another carbamate insecticide successfully used for malaria control spraying. Other pyrethroid insecticides are available as well. Any decision to use these compounds in the future should be based on careful analysis of field trials carried out in Bolivia as well as in other countries.

Pyrethroid insecticides were considered as suitable replacements for DDT, rather than organophosphate or carbamate insecticides primarily for reasons of safety to users. They are not cholinesterase inhibitors. Organophosphates (malathion, fenitrothion, etc.) are cholinesterase inhibitors, and the use of these compounds should be closely monitored by a regular program of cholinesterase testing of sprayrnen. This is true also for carbamate insecticides (propoxur, bendiocarb, etc.), although the depression of cholinesterase following exposure to carbamates is of shorter duration than that associated with the organophosphates. Both types of compounds can be used in malaria programs, provided that strict safety precautions are observed and these are reinforced by a regular program of cholinesterase testing. Pyrethroids, on the other hand, are safer to use under conditions normally found in malarious areas.

Another reason for choosing pyrethroids rather than other available insecticides is that these compounds can be effectively applied at very low dosage rates (Table 2). This, together with low toxicity for non-target organisms, means that the probability of environmental contamination following spraying with pyrethroids is extremely low.

Although both of these pyrethroids are comparable in their safety for spraymen and householders, some additional facts should be considered in choosing which of the two to use for malaria control in Bolivia. Lambda cyhalothrin has been used for the past two years in the malaria house spraying program in the State of Rondonia, Brazil. Rondonia is adjacent to the Beni Province of Bolivia, and the two regions have the same vector, climate, and malariogenic potential. Malaria program officials in Guayara, Minim, Brazil, informed the author that the spraying of lambda cyhalothrin has controlled malaria, and has not caused any symptoms of poisoning among spraymen or householders.

The Chagas Disease Pilot Project in Bolivia has conducted field trials of both these pyrethroid insecticides for the control of Chagas disease vectors. Both of these pyrethroids were found to be effective although ICON was cheaper per house when sprayed at the manufacturers' recommended dosage. These cost figures could, however, change in the future.

Non-chemical methods of malaria control, such as elimination of breeding places by drainage, are not now being employed by the Bolivian Malaria Control Program. These methods might be considered for inclusion in the future, particularly in urban areas.

Spray personnel are currently given a one-week training or re-training period before the start of each spray cycle. Training covers correct mixing of finished insecticide spray, equipment maintenance and cleaning, and safety precautions to take while spraying or otherwise handling insecticides. Symptoms of poisoning are explained to spray operators as well as first aid and measures to be taken if signs of intoxication appear.

Spray personnel have been applying formulations of DDT to houses in Bolivia for more than 30 years, and there have been no reports of intoxication of users attributable to this insecticide. It is essential, however, to train and retrain spraymen and others who come in contact with these materials in safe handling practices. This is especially true when a new insecticide is introduced into a program. Pyrethroids are relatively non-toxic to users, but may cause skin irritation of unprotected skin. Product labels (Annex C) give details of precautions to be taken when spraying these insecticides, symptoms of poisoning, as well as first aid and medical treatment of cases of intoxication. The information

given on these product labels should be included and emphasized in the training of spray personnel. The technical officers of the Malaria Control Program have conducted this type of training in the past. They are fully capable of organizing and presenting safety training when a new insecticide is introduced in the program.

The correct use of insecticides in the field will be monitored through direct supervision by spray squad leaders and field supervisors. Spraying technique will be checked frequently to make sure that the correct dosage of insecticide is applied to the walls. The hand pressure sprayers will be inspected daily to ensure that they are not leaking or dripping insecticides. Cleanup at the end of the day will be closely supervised to ensure proper disposal of wash water.

The effectiveness of the spray will be monitored by measuring the impact of the spraying on malaria transmission. This will be done by using data from the existing surveillance system. Slides are collected from fever cases by volunteer collaborators, hospitals, and health centers. They are examined for malaria and, in this way, malaria incidence and prevalence can be determined.

5. Environmental Impacts Of The Proposed Action

This section summarizes the environmental impact of the proposed use of the alternative insecticides lambda cyhalothrin and deltamethrin.

Non-target species, primarily arthropods inhabiting or resting on the indoor walls and ceilings of houses, will be poisoned along with the targeted mosquitoes. Domestic animals, particularly ducks and chickens, could also be acutely intoxicated if they feed on dead insects. Sweeping floors and burying dead insects should eliminate this danger. Animals such as goats, cows, and donkeys will receive some contamination through oral, dermal and inhalation routes if animal shelters are sprayed. This exposure will be minimized by removing animals before spraying and maintaining a one hour re-entry period. Honeybees can be intoxicated or killed if they are exposed to trace amounts of insecticide during spraying. A detail mitigation plan is discussed in the next section.

Mixer and spray crew personnel could receive some acute exposure through dermal and inhalation routes. Inhabitants could also be exposed to trace amount of insecticides through contact with sprayed surfaces or inhalation of vapor or spray aerosols. Safety measures to reduce exposure are discussed in Section 6.

Outdoor contamination of surface and groundwater will be minimized if pesticide mixing and cleaning of sprayers occur far from wellheads and open bodies of water, and if rinse water is used for the next spray or buried in a shallow hole away from water sources.

Indoor residual spraying is still the most cost effective method of malaria vector control in Bolivia. The pyrethroids have a high mammalian safety margin. They are applied at an extremely low rate and have a low potential for environmental contamination under normal use conditions. These characteristics and easily implemented precautions will further lessen the pesticide load and reduce the negative impact on the environment in comparison with the effects of other classes of insecticides. The long-term benefits of malaria control, such as increased human productivity, enhanced health and vigor, and reduced premature mortality far outweigh the short-term impact of insecticide use.

The proposed activity will result in irreversible and irretrievable consumption of petrochemicals in the form of insecticides and motor fuel for transport. In the unlikely event that environmental contamination occurs, temporary loss of biota would result. This loss, however, would be rapidly replenished by migration and recolonization from unaffected habitat, because these insecticides dissipate and degrade rapidly in the environment to non-toxic levels and non-toxic metabolites.

6. Environmental Impact Mitigation Plan

This section deals with priorities for safety, safety protocols, safety training, and compliance monitoring of a plan to mitigate any environmental impact that might result from this project.

The malaria control personnel in Bolivia are well versed and experienced in the use of insecticides for house spraying. The staff are familiar with the general safety precautions and procedures for safe transport, storage, mixing, spraying, cleaning and maintenance of equipment, and waste disposal.

The actions listed below should be priorities for malaria control program managers:

- Train spray crews in proper mixing, handling and disposal of insecticides.
- Prevent excessive insecticide exposure to inhabitants.
- Prevent groundwater and surface-water contamination.
- Prevent contamination of food, drink, animal feeds, clothing, furniture, and other household items.
- Prevent poisoning of domestic animals, birds, fish, aquatic invertebrates, honeybees and wildlife.
- Monitor compliance with safety practices and record incidents of human illnesses or injuries or of adverse environmental impact as a result of insecticide use.

Personnel responsible for applying insecticide should take the following precautions and comply with the guidelines listed below:

- Wear protective clothing (coveralls, rubber gloves, rubber boots, masks, face shield, head cover) as specified by the product label and as appropriate to local conditions.

- Beware of heat prostration and heat stroke. Work during the cooler part of the day, take frequent breaks, and keep hydrated. Avoid a long work day.

- To avoid excessive exposure and spills that could occur during pre-mixing in a bucket, mix insecticide directly in the spray tanks (especially when it is packed in water soluble sachets) unless another mixing method is specified on product label.

- Observe good personal hygiene: do not smoke, eat, or drink while using pesticides. Wash hands and exposed skin before going to the bathroom (to prevent dermal transfer to genital area) and before meals. Keep fingernails trimmed.

- Do not rub eyes or mouth or scratch body with contaminated hands or nails.

- Stop spraying if the nozzle is blocked and depressurize the pump before attempting to clear the nozzle.

- If insecticide is splashed on your eyes, immediately rinse them with clean water for 10 to 15 minutes.

- Wash concentrate from skin immediately with soap and water. (Note: be aware of special procedures for certain pyrethroid formulations.)

- Wash clothing immediately if splashed; change clothing and wash it immediately if it becomes soaked in insecticide.

- Avoid spraying the floors of houses.

- Avoid spraying electrical fixtures because a short-circuit might result.

- Discontinue spraying if signs and symptoms of intoxication occur; remove yourself from sources of exposure, decontaminate and treat accordingly. Resume spray work only after full recovery.

- Wash thoroughly after work and change into clean clothes. Wash work clothes separately from household laundry.

Spray crew personnel should protect household occupants by following the steps listed below:

- Inform occupants about the pesticide sprayed, its toxicity to humans and animals, and the safety precautions/mitigation efforts required.

- Keep people and animals away from the house or work site during mixing and spraying.

- Block the doorway immediately after spraying in a way that prevents entry of people and animals yet provides ventilation.

- Open windows to enhanced drying of spray deposit and ventilation of any vapor and aerosols.

- Prohibit re-entry of people and animals for at least one hour after spraying.

- Sweep the floor after one hour and bury sweepings away from the house. Wear a dust mask while sweeping to minimize inhalation of dust particles.

- Post a card on each house to record visits, inspections, date, dosage, and material sprayed.

Spray crews should protect against environmental contamination by taking the following precautions:

- Avoid groundwater contamination. Mix pesticides and wash spray equipment at least 10 meters from drinking water wells and pumps to prevent point source contamination.

- To avoid fish kills, do not spray directly on bodies of water. Do not clean spray equipment or dispose of waste in bodies of water.

- To avoid killing honeybees, do not spray or allow spray to drift on beehives or blooming plants. Advise beekeepers to move or close hives during spraying.

- Rinse empty containers or plastic liners three times and dispose of them by burning (preferred) or burying according to label directions. Do not stand downwind of burning containers. Only burn a few containers at a time and burn them in an open field. Do not reuse containers.

- Minimize exposure during mixing. Use prepackaged insecticide in water-soluble sachets designed to be mixed directly in a sprayer.

- Store pesticide in its original container away from houses, food, beverages, and animal feed in a separate, lockable shelter. Store away from potential flood or fire hazards.

All personnel should have hands-on training in:

- Proper mixing, handling and spraying of insecticide.

- Proper fitting and wearing of protective clothing.

- Proper personal hygiene.

- First aid for splashes, spray, spills and drift.

- Proper cleaning and maintenance of sprayers.

- Proper disposal of empty containers and rinsate.

The monitoring program should follow a good laboratory practices protocol that includes a quality assurance and quality control program for assessing the efficacy of insecticides in vector and disease control.

Supervisors should have a copy of the pesticide label with instructions on first aid and emergency treatment information, which are found on U.S. labels under the headings: "Statement of Practical Treatment" and "Note to Physician." This information needs to be available to the attending physician in case of accidental poisoning.

The human and environmental effects of insecticide use should be assessed immediately after and one day after spraying through follow-up interviews and observation of inhabitants and environment. Any complaints, illnesses or injuries exhibited by inhabitants or spray

personnel should be recorded. Reports should include: 1) a case description (species, age, sex, illness or injury type); and 2) insecticide type, dosage, and time applied, route of exposure, duration of exposure, when exposure occurred, and the activity engaged in during exposure. These are critical data for determining whether mitigating measures are adequate. Ideally environmental monitoring of pesticide residues in the air and swipe samples of walls and floors should be measured to establish more accurate reentry intervals. Biomonitoring of spray crew for insecticides or metabolites should be considered in the future to assess the extent of exposure and the adequacy of protective clothing and safety practices.

7. References and Background Information Reviewed

Arata, A.A. (1991). Environmental assessment of the Bolivian Chagas disease control program of the community and child health project. VBC Report No. 82236.

Arata, A.A. and S.G. Breeland (1989). Environmental assessment: Insecticide use in the malaria control component of the health systems support project. El Salvador, October 1989. VBC Report AR-126-4.

Barutwanayo, M., M. Coosemans, C. Delacollete, S. Bisore, P. Mpitabakana, and D. Seruzingo (1991). Campaign against malaria vectors in the framework of a rural development project in Burindi. Ann. Soc. Belg. Med. Trop. 71 (suppl 1): 113-25.

Bisset, J.A., M.M. Rodriguez, J. Hemingway, C. Diaz, G.J. Small, E. Ortiz (1991). Malathion and pyrethroid resistance in *Culex quinquefasciatus* from Cuba: efficacy of pirimiphos-methyl in the presence of at least three resistance mechanisms. Med. Vet. Entomol. 5(2):223-8.

British, V. and P. Carnevale (1991). Influence of deltamethrin treatment of bed nets on malaria transmission in the Kou Valley, Burkino Faso. Bull. World Health Organ. 69(6): 735-40.

Carnevale, P., V. Robert, R. Snow, C. Curtis, A. Richard, C. Boudin., L.H. Pazart, J.M. Halna, and J. Mouchet (1991). The impact of impregnant mosquito nets on prevalence and morbidity related to malaria in sub-Saharan Africa. Ann. Soc. Belg. Med. Trop. 71(suppl 1): 127-50.

Chester, G., N. Sabapathy, and B.H. Woolpen (1990). ICON IOWP: Assessment of occupational exposure and effect on health during application for malaria vector control in Pakistan. In ICON for the Control of Mosquitoes, ICI, Public Health, England.

Das, M., B.N. Srivastava, C.K. Rao, B.R. Thapar, and G.K. Sharma (1987). Field trial of the effectiveness of indoor spraying with pirimiphos-methyl emulsion for malaria control in a tribal area of Phulbani district, Orissa State, India. Med Vet. Entomol. 5(4): 477-83.

Hobbs, J. and H.G. Larew (1988). Environmental assessment of the Pakistan Malaria Control II Project extension. VBC Report AR-099.

Lindsay, S.W., J.H. Adiamah, J.E. Miller, and J. R. Armstrong (1991). Pyrethroid-treated bednet effects on mosquitoes of the *Anopheles gambiae* complex in the Gambia. Med. Vet. Entomol. 5(4): 477-83.

Loyola, E.G., M.A. Gaca, D.N. Bown, E. Perez, and M.H. Rodriguez (1991). Comparative use of bendiocarb and DDT to control *Anopheles pseudopunctipennis* in a malarious area of Mexico. Med. Vet. Entomol. 5(2): 233-42.

NIMRT (1991). Ministry of Health, Special Education and Social Welfare Annual Report 1991. National Institute of Malaria Research and Training, Pakistan.

Miller, J.E., S.W. Lindsay, and J.R. Armstrong (1991). Experimental hut trials of bednets impregnated with synthetic pyrethroid or organophosphate insecticide for mosquito control in The Gambia. Med. Vet. Entomol. 5(4): 465-76.

Moretto, A. (1991). Indoor spraying with the pyrethroid insecticide lambda-cyhalothrin: Effects on spraymen and inhabitants of sprayed houses. Bull. World Health Organ. 69 (5): 591-4.

Mpofu, S.M., K. H. Kanyimo, and H. Masendu (1991). Potential use of bendiocarb (Ficam VC) for malaria control in an area of Zimbabwe. J. Am. Mosq. Control Assoc. 7(4):536-42.

Robert, V. and P. Carnevale (1991). Influence of deltamethrin treatment of bed nets on malaria transmission in the Kou Valley, Burkino Faso. Bull. World Health Organ. 69(6):735-40.

Vaca-Marin, M., M.H. Rodriguez-Lopez, D.N. Bown, R. Rios (1991). Intra-domiciliary low volume spraying of malathion and deltamethrin for controlling *Anopheles* sp. Salud Publica Mex. 33(5): 482-92.

WHO (1989). DDT and its derivatives. Environmental Aspects Environmental Health Criteria 83.

WHO (1989). Safe use of pesticides. WHO Technical Report Series 813.

ARTICLE IV - STATEMENT OF WORK

In order to achieve the objectives stated in Article III of this delivery, the contractor shall provide a team to conduct the environmental assessment.

The purpose of the technical services described below is to write an environmental assessment (EA) of pesticide use in the malaria program, and to ensure that such use adheres to the guidelines and requirements established in A.I.D. Environmental Procedures. This EA will identify and recommend appropriate pest and pesticide management mitigative actions for incorporation into this or future projects. Following are elements of this task:

a. Review current pesticide usage in the malaria control program, in terms of quantity, application and efficacy; as appropriate, identify improved pest control practices, procedures, and products.

b. Review EPA registration status of current and proposed insecticides, toxicological data, capability of the Ministry of Health program staff to distribute, use, store and dispose of properly, and other requirements of Reg. 216. This will include a discussion of the basis for selection of recommended pesticides; the proposed method(s) of application, including availability of appropriate application and safety equipment; any acute or long-term toxicological hazards, either human or environmental (including non-target organisms) associated with the proposed use, and measures available to minimize such hazards; the effectiveness of the recommended pesticides for the proposed use; compatibility of these pesticides with target and nontarget ecosystems; the provisions made for training of users and applicators, and for monitoring the use and effectiveness of the pesticides.

c. Consider the "no action" option or alternate non-chemical means of vector control (i.e., biological, source reduction, etc.).

d. Develop a mitigation plan to cover required training, storage, safe use, protective clothing required, application methods, etc.

e. Review market prices for current and proposed pesticides being considered and estimated cost for the malaria control program.

f. Assess existing program capabilities to deal with possible pesticide intoxication (e.g. availability of atropine sulfate in areas of project intervention; ability of pesticide users to recognize common physiological symptoms of pesticide intoxication, and administer appropriate treatment). As appropriate, specific recommendations should be made as to how such capability could be enhanced.

g. Conduct a briefing and debriefing session for A.I.D., PL-480 and Ministry of Health program staff, at the initiation and termination of the assignment.

The services described above are to be analytical in nature-under no circumstances will USAID accept purely anecdotal material, or material not substantiated by actual observation, objective interviews with project participants or review (and citation) of project publications and reports. Furthermore, evaluation recommendations must be actionable, i.e., feasible within program, budgetary, personnel and time constraints, and must follow closely the guidelines and format provided under 22 CFR 216.6.

Annex B - Persons Contacted

USAID/Bolivia, La Pas

Dr. Michael Yates, Environmental Officer, ARD
Ms. Ann-Sigrid Anderson, Chief, Health Division

PL-480 Executive Secretariat, La Paz

Sr. Luis Jordan, Technical Manager
Dr. Rene Zumaran, Technical Officer

Ministry of Health, GOB, La Paz

Dr. Johnny Mollinedo, National Director of Epidemiology
Dr. Francisco Macuaga, National Director of Vector Control

Cochabamba

Dr. Saul Villarroel, Zone Chief, Malaria
Dr. Hernan Bermudez, Entomologist, Chagas Program
Sr. Roberto Rodriguez, Entomological Aid, Malaria
Dr. Fernor Balderrama, Director, Chagas Pilot Project

Santa Cruz

Dr. Jose Luis Cespedes, Zone Chief, Malaria
Sr. Justo Suarez, Inspector, Malaria
Sr. Victor Lino, Inspector, Malaria

Guayaramerin

Dr. Juan Carlos Avila, Zone Chief, Malaria
Sr. Carmelo Flores, Administrator, Malaria
Sr. Asir Melendez, Field Operations Chief, Malaria

Riberalta

Dr. Jorge Cuba, Zone Chief, Malaria
Sr. Ignacio Takata, Administrator, Malaria
Sr. Adolfo Cahivani, Field Operations Chief, Malaria
Dr. Rene Cruz, Director, Health Unit

Guaharamerin, Brazil

Sr. Jose Deir Mota Filho, Administrator, Sector Fundacao Nacional Saude (Malaria)

Annex C

Insecticide Product Labels

ICON 10 WP

Safety Precautions

Do not smoke, drink or eat while using this product.

For Safety When Mixing

If you get it in your eyes, wash it out at once. See FIRST AID.
If you get it on your skin, wash it off at once.
If you spill it on your clothes, change and wash them.
Wear a mask covering nose and mouth.

For Safety When Spraying

As with all chemicals, AVOID CONTACT WITH THE SPRAY as much as you can.
Wear a mask covering nose and mouth.
Do not spray directly on to food.
To avoid harming fish, do not spray over water.

For Safety After Spraying

WASH YOURSELF.
Change and wash your work clothes.
Do not dump unwanted ICON in water.
Keep unused 'ICON' 10 WP in original container, locked up out of reach of children and away from food.
Burn or bury empty packets.

FIRST AID

Eye splashes: wash out for 10-15 minutes. Go to a doctor.
IF 'ICON' 10 WP IS SWALLOWED MAKE THE PERSON VOMIT.
Take person, and this pack, to a doctor at once for treatment.
MEDICAL TREATMENT: Perform gastric lavage, taking care to prevent aspiration of gastric contents. Then treat symptomatically.

Icon is a registered trade mark of Imperial Chemical Industries PLC, England.

ICI

ICON 10 WP

ENDORSED BY ICON WHO

Harmful

Contains 100 g lambdacyhalothrin per kg as a wettable powder.

Each sachet contains 62.5 g product.

Before you open the sachet read the safety advice

'ICON' 10WP is a broad spectrum insecticide. The active ingredient, lambdacyhalothrin, is a novel synthetic pyrethroid developed as a result of extensive research. It is exceptionally active against all insects of public health importance. 'ICON' 10WP is SUITABLE FOR USE INDOORS for the control of insects in industrial and domestic premises including restaurants, hotels and kitchens AND FOR OUTDOOR TREATMENTS in public areas such as market places or refuse collection points.

Directions for Use

'ICON' 10WP is intended for dilution in water for application as a residual spray using conventional compression sprayers. The sprayer should be operated at a maximum pressure of 40 psi. Fill the sprayer with 8 litres of clean water. Peel open the outer sachet of 'ICON' 10WP and carefully tip the inner water soluble sachet into the sprayer. Close the sprayer and shake well before use.

8 litres of spray solution should treat approximately $200m^{-2}$.

Vector Mosquitoes (Anopheles sp).

Apply to provide an even coverage to all inside walls and ceilings of houses and out buildings such as animal shelters. For good control all houses in the area should be treated.

Two applications per year should be made.

Cockroaches and Crawling Insects

Apply as a coarse low pressure spray to areas where the insects hide such as corners, around water pipes and drains, behind and under refrigerators, cupboards and similar areas. Particular care should be taken to treat all cracks and crevices thoroughly. Retreatment should be made as necessary, but is unlikely to be required at intervals of less than 12 weeks.

Flies

Apply to all surfaces where flies congregate and rest. Out of doors apply as a residual treatment around refuse dumps and other breeding sites where adult flies congregate.

Icon is a registered trade mark of Imperial Chemical Industries PLC, England.

Gen. Ovs. 799225/1 VIII88

contains:

Deltamethrin ..... 25 g/kg
Inert ingredient ..... 975 g/kg
and formulation additives

directions for use:

For control or mosquito vectors of malaria K-Othrine WP 25 should be applied twice per season, each time at an application rate of 20 mg/m² i.e 80 g of K-Othrine WP25 should be mixed with 5 litres of water and the suspension applied to surfaces at a rate of 5 litres per 100 m² or until surfaces are thoroughly wetted.

As an alternative a single spray per season at 25 mg/m² may suffice i.e 100 g of K-Othrine WP 25 should be mixed with 5 litres of water and the suspension applied to surfaces at a rate of 5 litres per 100 m² or until surfaces are thoroughly wetted.

normal storage stability:

2 years.

The batch number and manufacturing date are shown on the top of the drum.
The date of test is the same than the date of manufacture.
Expiry date: 2 years from date of manufacture.

K-Othrine®

wp 25

INSECTICIDE FOR RESIDUAL TREATMENT
Wettable powder

Net content: 25 kg

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