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The Selection and Use of Pesticides in Bank Financed Public Health Projects

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When there is no alternative to chemical pesticides, they should be used with environmental and biological methods to cut costs, reduce contamination, and lower the possibility of resistance to the pesticide.

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Three methods are available for controlling vector-borne tropical diseases — environmental, biological, and chemical. Environmental control to permanently alter the conditions that allow vectors to breed and develop is the preferred method, but it is not always feasible. Biological control is species-specific and may only be effective under narrow ecological circumstances.

For control of most diseases, therefore, pesticides are the only alternative. Whenever possible, these chemicals should be used along with environmental or biological methods and the appropriate drug or vaccine. This will cut costs, reduce contamination from pesticides, and lower the possibility of resistance to the pesticide.

Public health officials must be concerned that the compound chosen is safe for the user as well as for inhabitants and domestic animals in the treated area. The method of control must be appropriate for each targeted vector, because there are wide biological differences among species.

Some further considerations in the selection of a pesticide for a public health program to control a particular vector of disease are:

- The chemical must be a narrow spectrum pesticide.
- It should be effective in the proposed geographic area.
- The target vector should be evaluated to determine if it is resistant to a given chemical.
- The proposed pesticide must not pose a hazard to species that are not targeted.

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TECHNICAL NOTE

THE SELECTION AND USE OF PESTICIDES IN PUBLIC HEALTH PROGRAMS IN BANK FINANCED PROJECTS

Introduction

1. Vector, snail and rodent-borne diseases are responsible for a great deal of human morbidity and mortality in the tropical developing countries. It is estimated that every year there are some 9? million new cases of malaria and the incidence of other parasitic diseases, such as schistosomiasis, leishmaniasis, Chagas' disease, sleeping sickness, onchocerciasis and filariasis, totals many millions. In addition to the parasitic diseases, the incidence of arboviruses is tens of millions of cases annually, including millions of cases of dengue, hundreds of thousands of cases of dengue hemorrhagic fever and hundreds of cases of yellow fever. The greatest transmission of the vector-borne diseases occurs in rural areas, and the burden caused by these diseases, especially malaria, Chagas' disease, schistosomiasis and onchocerciasis, can have a significant impact on development projects in endemic areas.

2. Increases in vector breeding and higher disease incidence can result from water development projects when inadequate consideration has been given to their public health and environmental impact. The use of pesticides is then required for vector control - particularly for mosquitoes and snails. Another cause for increased vector densities is rapid and often unplanned urban growth in large tropical cities where environmental sanitation is frequently poor. Vector densities can be high enough to maintain disease transmission and disturb the lives of the inhabitants.

Consequently, most of these cities have vector control programs which are heavily dependent on the use of pesticides.

3. Many countries have programs for the control of one or more of these diseases, depending on their importance and prevalence in the country, and a significant proportion of the budgets is allocated to national control programs. Some of these diseases can be controlled or cured by chemotherapeutic drugs or prevented by chemoprophylaxis or vaccination. However, for many diseases there are no vaccines or drugs suitable for mass or even individual treatment. Where no such cure or treatment exists, the most common strategy is control of the disease vector. In some regions, particularly urban areas, control programs target vectors not because of the potential for disease but because of the annoyance and nuisance they cause people. Vector control may sometimes also be the most effective control methodology both in terms of cost and of reduction of disease.

A. The selection of vector control methods

4. Once a vector control program has been decided upon, the method of control needs to be selected. There are three basic methods: environmental, biological and chemical control, or a combination thereof. Environmental control is the preferred method to achieve permanent control. It seeks to alter the conditions allowing the vectors to breed and develop, and thereby avoids or reduces the need for continued pesticide use. Unfortunately environmental control is not feasible against several important species of vectors, -- such as mosquitoes - whose breeding occurs over very large areas, or vector species - for malaria and arboviruses - whose larval habitats are numerous, small and scattered. Equally funds may not be available to eliminate the polluted - mainly sewage water - habitats

where many urban mosquito species breed. Environmental control of tsetse flies by clearing bush or killing host game animals is possible and has been done but is ecologically undesirable. Control of the triatominae vectors of Chagas' disease can be achieved by repairing and improving dwellings with walls and roofs that discourage vector breeding.

5. The use of biological control agents, such as parasites, predators or pathogens, is another potential alternative for vector control. But they are usually highly species specific and may only be effective under narrow ecological circumstances. Some recently developed bacterial toxins can be applied as biological larvicides against mosquitoes and blackflies providing the vector species is susceptible to the toxin and the ecological conditions appropriate for application. Considerable success has been obtained through the use of Bacillus thuringiensis H-14 in the UNDP/World Bank/WHO Onchocerciasis Control Programme in West Africa. Another example of biological control under investigation is the use of non-vector snail species which prey upon or competitively displace vector species. Active research for additional agents is being pursued by the UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases. Among other groups, however, only a few, promising candidates are presently available. Studies are still underway on some plant molluscicides for use against the snail hosts of schistosomiasis, but in operational use they have no particular advantage over chemical molluscicides. Because the great expansion in irrigated areas has actually favored the intensification of schistosomiasis transmission in several endemic areas, control programs using a chemotherapeutic agent in combination with molluscicides are of growing importance. The introduction of certain fish species into vector

environments has also proven a satisfactory method of biological control in some instances.

6. Intensive efforts are being made to develop and use new biological and environmental methods as alternatives to or complementary with chemical pesticides. In certain cases those efforts have met with considerable success; as an example, simple inexpensive traps have been developed for use against tsetse fly vectors of African sleeping sickness, particularly riverine species, and are coming into wide use as an effective, community-implemented alternative to the application of pesticides. Because there are no biological or environmental methods or drug therapy presently available or feasible for the control of many other diseases, there is little doubt that pesticides will be required for the foreseeable future in the majority of vector control programs. Nevertheless, whenever possible the use of pesticides should be integrated with environmental or biological methods and, if possible, with a curative or prophylactic drug or vaccine. This will assist in cost reduction, reduce the environmental contamination from pesticides and also assist in lowering the rate at which resistance will develop against the pesticides used. Where such integration is not feasible or, when epidemic outbreaks occur and control of the vector populations is urgent, it may often be necessary to rely entirely on the application of pesticides.

B. <u>The use of pesticides in public health programs</u>

7. The manner in which pesticides are used and applied for the control of disease vectors differs very sharply from their usage against pests in agriculture. Most vectors of human disease are closely associated with man and his immediate environment, therefore pesticides for vector

control are frequently applied in or around human dwellings. Furthermore, safety of insecticides used in public health is of paramount importance. Pesticide compounds destined for use in public health programs must be demonstrably safe for use both by the spraymen applying the compounds and for the inhabitants and domestic animals of the treated areas.

8. An example of such a compound is DDT which despite popular concern has an excellent safety record in terms of its low acute and chronic toxicity to man. While DDT has had adverse affects on the reproduction of some bird and fish species when used as an agricultural pesticide, there is no environmental contamination when used as an indoor residual spray applied by trained spray personnel in malaria control programs. Nor is there any indication of any adverse acute or chronic affect on the hundreds of millions of people whose homes were sprayed with DDT in the course of the global malaria eradication program or the subsequent widespread malaria control programs carried out by many national ministries of health.[1] Therefore, DDT remains the pesticide of choice for malaria control. The main reason for the reduction in DDT usage is widespread pesticide resistance in many malaria-vector mosquito species exposed to the compound over many years.

9. Two important elements in the the selection of pesticides are the bionomics of the target vector species and the epidemiology of the disease. The control method or material must be individually selected for each vector species as there are wide biological variances among species. As an example, anopheline mosquito vectors of malaria which are active

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[1]WHO, (1971), "The Place of DDT in Operations against Malaria and Other Vector-borne Diseases," Official Records, World Health Organization, Document No. 190:176-182, Geneva.

primarily indoors can be most effectively and economically controlled by applying residual pesticides indoors. However, those anopheline species which are active primarily outdoors are not effectively controlled by indoor treatments and must be controlled by treatment at their larval habitats or by ultra-low volume mist or fogging applications. Aedes aegypti the urban vector of yellow fever in Africa and the Americas and of dengue and dengue hemorrhagic fever in South Asia, the Western Pacific and the Americas breeds primarily in a multitude of fresh water containers such as drums, pots and jars storing drinking water, old tires, empty tin cans etc. Optimal control of this species can be achieved by provision of piped drinking water and environmental sanitation practices including efficient disposal of water-holding waste containers or by application of larvicides (with a very low mammalian toxicity) to larger containers such as drums holding drinking water which can not readily be disposed of or sealed. During epidemic outbreaks of A. aegypti-borne disease in urban areas, the most rapid and efficient, if only temporary, control is through the application of pesticidal space sprays or fogs by aircraft, vehicle or manborne dispersal equipment as well as environmental sanitation methods to control adult female mosquitoes likely to be carrying virus. In every case the appropriate methodology must be determined based on a clear understanding of the bionomics of the particular vector species.

10. Certain vectors and pests live primarily on man; among these are head, body and pubic lice, scabies mites and some species of ticks as well as a number of species of fleas. Body lice can be vectors of epidemic typhus and epidemic relapsing fever. These ectoparasites, particularly lice and mites, must be controlled by the application of pesticidal dusts,

lotions or emulsions directly to man and it is essential that these pesticides and their formulations be of a minimal toxicity so as to cause no hazard to man.

11. In agriculture, vector control need not be total, as long as the degree of damage caused by the residual population is minimal and of low economic significance. However, vector control for human disease or pests requires targeting for the optimal level of effective control of the vector population. If the achieved level of control continues to allow transmission of disease, this would not generally be acceptable, especially if there is some human mortality. In developed countries where vector control - especially in urban areas - is mainly to control pests rather than disease, any continued irritation after treatment from mosquito bites, bed bugs and cockroaches will not easily be tolerated.

C. The selection of pesticides for public health use

12. The selection of a pesticide for a public health program to control a particular vector of disease must consider the following:

(a) The efficacy of the available compounds against the target vector in the proposed geographical area. Selection should only be made of a compound with a known efficiency against the target vector species.[2] Field trials may be necessary if the ecology in the proposed site differs from other areas where the pesticide has been used or if it has not previously been used against the particular species or vector.

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[2]WHO, (1984), "Chemical Methods for the Control of Arthropod Vectors and Pests of Public Health Importance," World Health Organization, Geneva

(b) The susceptibility of the vector population in the target area to the proposed pesticide. The target vector needs to be evaluated to determine if resistance has already developed to the proposed compound. Resistance may have occurred by prior exposure to the proposed compound or cross-resistance to a related one. The proposed compound may already be ineffective for vector control in the target area because of previous applications in agricultural programs. Where resistance already exists to a given chemical group, no use should be made of compounds which are closely related chemically or cross-resistance might occur.

(c) The safety of people exposed to the proposed pesticide. The toxicity of the given compound should be low enough to ensure the safety of the spray personnel applying it and of the inhabitants of the houses or area in which it is being applied. Oral, dermal and inhalation toxicity, as well as both acute and chronic toxicity must be taken into account. The latter may be especially important for the spray personnel who are under prolonged exposure to the compound, frequently under climatic conditions which discourage the use of protective clothing. Adequate training of spray personnel and, if necessary, provision of protective equipment (clothes, hats, masks) should be considered. Reference should be made to the World Health Organization classification of pesticide oral and dermal

toxicities, which also outlines the toxicity and hazard presented by the concentration of the active ingredient in ready-to-use formulations.

(d) The environmental impact of the proposed pesticide. (i) If the compound is to be used in an aquatic environment, (i.e., for the control of mosquito or blackfly larvae) or in a manner in which it may contaminate the aquatic environment (e.g., for the control of riverine tsetse fly species), then the proposed pesticide must be safe enough to pose no hazard to non-target aquatic organisms, especially fish and non-target aquatic invertebrates. Hazard to aquatic organisms is a function of materials, innate toxicity to each species, the concentration of the material in the water and duration of exposure. Each of these factors can be controlled to minimize environmental impact. For example, use of controlled-release formulations can sometimes be used to provide long-term control without an initial high concentration which may be hazardous to non target species. They also provide persistence at point of action without recourse to persistent chemicals. (ii) If the pesticide is to be applied as a space spray for the control of flying insects, such as mosquitoes or house flies, applications should not be made in areas where honeybees can be affected. (iii) If the pesticide is to be applied for the control of rodents, preference should be given to the use

of the compounds of low toxicity to non-to the proposed compound. Resistance may have occurred by target mammals. Rodenticide when used in houses should be applied in bait boxes to prevent easy access by humans or domestic animals.

(e) The selection of narrow spectrum pesticides. Providing that they are as effective against the target vectors as wide spectrum pesticides, every effort should be made to select narrow spectrum pesticides thereby minimizing any effect on non-target species. Careful control of dosage may improve specificity of certain products, particularly in aquatic environments.

(f) The proposed pesticide should be different and preferably not closely related to pesticides used in the target area's agricultural pest control.

(g) Molluscicides must be applied to water ways or collections if they are to control the snail intermediate hosts of schistosomiasis. Only a small number are now commercially available and their use should be carefully supervised.

D. Procurement of Pesticides[3]

13. The invitation to bid and tender documents should use the accepted generic name or names of the active material or materials thereby enabling suppliers - who may market the identical ingredient under one or more trade names - to offer competitive bids. The tender documents should state the WHO specification number; the concentration of the active

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[3]For a more detailed outline of procedures see OPN 11.01.

ingredient and in some cases the content of specific isomers[4]; the inspection and sampling requirements and procedures to ensure compliance with purchaser's specifications, upon completion of the order but prior to acceptance; the name of the inspection agent and/or laboratory; and any special requirements the purchaser might have (e.g., long term storage). Specification of storage life is particularly important in the case of products (e.g., Malathion) which may yield breakdown products considerably more hazardous than the parent material. In any case products which have been stored in hot or humid conditions for long periods should be analyzed before use.

14. For formulated materials, the specification should define the critical characteristics which may affect the performance of the pesticide: for example, for an emulsifiable concentrate: the solvents, emulsifiers, and surfactants; for a water-dispersible powder: nominal content, tolerance permitted, particle size, suspensibility, acidity or alkalinity; and for a dust or suspension: particle size and nominal content. Rodenticides should be formulated with warning colorants or dyes which will persist for the anticipated storage period, handling conditions and any further preparation of the product.

15. The specification should indicate any special features of packaging (box or drum containers) and labeling which are necessary for product protection during handling and storage to ensure effective use. It should require packaging and labeling to be consistent with accepted standards for each country and indicate the language or languages which the

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[4]In the case of HCH, only the pure gamma isomer (Lindane) should be used.

label is to bear. Package sizes should be selected to avoid the need to store open, partially used packages.

16. The containers should be labeled in the country's language, with a clear warning of the contents hazards, instructions for its safe handling and, where appropriate, emergency information in the event of accidental contact or spill. Minimum cautionary notices are included in the WHO specifications. More detailed recommendations on the safe handling of pesticides, the protection of operators, the detection of exposure, and the treatment of intoxication will be found in the sixteenth report of the WHO Expert Committee on Insecticides and in the third report of the WHO Expert Committee on Vector Biology and Control.

17. Some of the WHO specifications require reference materials for standardizing analytical procedures for some pesticides (e.g., bendiocarb, bromophos, chlorpyrifos, DDT, deltamethrin, diazinon, dichlorvos, fenitrothion, gamma-HCH, malathion, propoxur and temephos). The WHO supplies free of charge reference samples to official analytical and quality control laboratories working in the public health field.

18. Wherever possible competitive tenders should be sought for the supply of pesticides. If there is only one manufacturer for a product that is technically superior to other commercial products or the only effective one in controlling a particular vector, then a direct purchase may be resorted to. In such cases inquiries should be made to determine the prices paid by other recent purchasers of the product in order to ascertain whether the price being quoted is a fair one, taking account of the quantity being ordered and delivery requirements.

19. Local purchase can be made if only a small quantity of the product is required and a competitive bidding process would not be feasible. However, quotations should be obtained from at least three different suppliers and the minimum labeling requirements mentioned above should still apply. The limited shelf life of certain active ingredients and formulations should be kept in mind and an effort made to determine the date of manufacture or at least the date pesticide was ordered or received by the supplier.

Attachment 1

Pesticides Used in Public Health

Hazard Classification & Major Uses

Pesticide group	WHO Hazard classification	Major uses[1]	Formulations used[2]
Pesticide			
DDT	II	mos fls lic	res dst lar
gamma-HCH	II	mos tri lic fls	res dst fum
endosulfan	II	tse	res
Organophosphorus			
Azamethiphos	III	hfl	baits
bromophos	III	fl hfl	res lar
chorphoxim	no ac haz[3]	bkf	lar
chlorpyrifos	II	mos ckr	lar
chlorpyrifos-methyl	II	mos	lar
diazinon	II	ckr hfl fls	dst
dichlorvos	Ib	mos hfl	fum
dimethoate	II	hfl	res
fenchlorphos	II	hfl	res
fenitrothion	II	mos fls	res spa dst
fenthion	Ib	mos	lar
iodofenphos	no ac haz	ckr fls bdb lic	dst

malathion	III	mos bdb lic tri	res spa lot
naled	II	mos	spa
phoxim	II	bkf	lar
pirimephos-methyl	III	mos fls ckr bdb	res spa dst
propetamphos	Ib	ckr hfl	res
temephos	no ac haz	mos bkf lic	lar dst

Carbamates

bendiocarb	II	mos tri hfl	res spa dst
cabaryl	II	mos fls lic	res dst
dioxacarb	II	bdb ckr	res
propoxur	II	mos fls ckr	res dst spa

Pyrethroids

allethrin	III	mos hfl	spa
bioallethrin	II	mos hfl lic	spa lot
bioresmethrin	no ac haz	mos	res spa
cypermethrin	no ac ahz	mos hfl	res
deltamethrin	no ac haz	mos tse hfl fls	res spa la
fenvalerate	II	hfl	res
permethrin	no ac haz	mos bkf tse hfl	res spa la
phenothrin	no ac haz	mos hfl	res spa
piperonyl butoxide	no ac haz	mos hfl	spa
resmethrin	III	mos hfl	spa
tetramethrin	no ac haz	hfl	spa

Insect Growth Regulations

diflubenzuron	no ac haz	mos	1a
methoprene	no ac haz	mos	1a

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1 mos=mosquitoes, tse=tsetse flies, hfl=house flies, ckr=coakroaches, fls=fleas, lic=lice, bdb=bedbugs, bkf=blackflies, tri=triatominae

2 res=residual, lar=larvicide, dst=dusts, spa=space sprays, fum=fumigant, lot=lotion

3 no ac haz=unlikely to present acute hazard in normal use.

Remarks

A. The WHO periodically revises and reissues its "Classification of Pesticides by Hazard." This lists technical products by their generic names, tabulating them in categories ranging from "Extremely Hazardous" to unlikely to present acute hazard in normal use. Guidance is given on use of the tables to assess the hazard of particular formulations. Materials listed in Categories Ia Extremely Hazardous or Ib Highly Hazardous are unsuitable for normal use in public health programs.

B. The organophosphorus compounds dichlorvos, fenthion and propetamphos (WHO Hazard Classification Ib = highly hazardous) are unsuitable for use other than by highly skilled and trained personnel under strict supervision.

C. The restrictions for pesticide use in agriculture (OPN 11.01) also apply with one major exception. DDT is the pesticide of choice in

malaria control where there is no resistance to it. Its use as a residual indoor insecticide causes no environmental contamination and does not constitute a health risk.

D. A current copy of the WHO hazard classification and a list of specific reference publications (additional resource list for OPN 11.04) is available for reference in the Sectoral Library.

Additional Resource List

The following resources may be useful in obtaining more specific information.

Usage guidelines

A guide to rodenticides and their use against commensal species of rodents is available from the World Health Organization, (Brooks, J.E. and Rowe, F.P., 1979a). The U.S.A. Environmental Protection Agency has extensive guidelines for the allowable environmental hazard of most pesticides.

Pesticide chemical reference materials

Some of the WHO specifications require reference materials (e.g., bendiocarb, bromophos, chlorpyrifos, DDT, deltamethrin, diazinon, dichlorvos, fenitrothion, gamma-HCH, malathion, propoxur and temephos). The WHO supplies free-of-charge reference samples for standardizing analytical procedures for some pesticides to official analytical and quality control laboratories working in the public health field. (Request samples from Pesticides Development and Safe Use, Vector Biology and Control Division, World Health Organization, 1211 Geneva 27, Switzerland.)

Other laboratories can obtain analytical standards either directly from the manufacturers or from institutions such as the National Physical Laboratory, Teddington, Middlesex, TW1 10LW, England or from the U.S. Environmental Protection Agency, Pesticide & Insecticide Chemical

Repository, Mail Station MD8, Research Triangle Park, North Carolina 27711, USA.

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