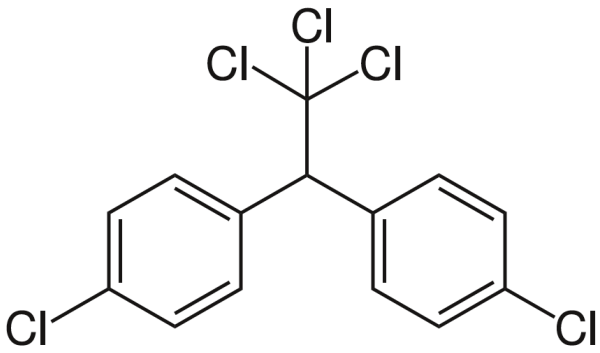
Stockholm Convention on Persistent Organic Pollutants (POPs)

Scientific and Technical Document Series: DDT

TOOLKIT FOR THE SOUND MANAGEMENT OF DDT FOR DISEASE VECTOR CONTROL



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ABSTRACT

DDT is listed in the Stockholm Convention on Persistent Organic Pollutants (POPs). However, the Convention allows use of DDT exclusively for disease vector control as recommended by the World Health Organization (WHO) when locally safe, effective and affordable alternatives are not available to the Party in question. A global survey conducted by WHO in 2011 indicated that the system of life-cycle management of public health pesticides, which includes DDT, is deficient in many countries, with major shortcomings in legislation, regulations, registration, quality control, capacity and risk prevention, thus undermining the effectiveness and safety of DDT and other vector control insecticides.

Because it is likely that DDT will continue to be needed for disease vector control, it is prudent for countries to strengthen their management of DDT, until the reliance on DDT is completely eliminated.

This document aims to provide a one-stop shop for information and resources regarding the life-cycle management of DDT and other vector control insecticides. It does not present new guidelines or new guidance on DDT, but collates information from authoritative guidance documents, primarily those produced by WHO and FAO.

The document covers the management of DDT and other vector control insecticides from production until use and disposal. Specifically, the pesticide life-stages discussed are: production, formulation, import and export; registration; procurement; pesticide quality control; transport and distribution; storage and stock control; application in vector control; and safe disposal.

The life-stages are described in separate chapters, and key points for monitoring and evaluation are presented. It is hoped that the document will assist countries to critically review the management of DDT and other vector control insecticides at country level, in order to plan, implement and monitor constructive improvements.

1. INTRODUCTION

1.1 Stockholm Convention and DDT

DDT is a Persistent Organic Pollutant (POPs) of the Stockholm Convention, which lists chemicals, once released, persist in the environment, undergo long range environmental transport and cause adverse environmental and/or health effects that warrant global actions towards their elimination. DDT is one of the initial Persistent Organic Pollutants (POPs) targeted for global elimination under the Stockholm Convention on POPs [1]. The Convention text specifies that the use of DDT is still accepted for disease vector control, in accordance with guidelines and recommendations of the World Health Organization (WHO) and in conformity with relevant provisions of the Stockholm Convention, until locally appropriate and cost-effective alternatives become available for a sustainable transition from DDT [1, 2]. Therefore it is needed that DDT is appropriately managed throughout its life-cycle stages, if decided to use for disease vector control, to ensure that the risks to human health and the environment are minimized.

The Conference of Parties to the Stockholm Convention evaluates the continued need for DDT for disease vector control during its regular meetings. At its 6th meeting held in May 2013, while noting that DDT is still needed, the Conference of Parties decided, among other things, to encourage donors to ensure that the funding of indoor residual spraying programmes includes funding for activities on the sound management of DDT.

Parties who produce or use DDT for disease vector control are required to register for that purpose and report to the Secretariat of the Stockholm Convention once every three years, using a questionnaire available for that purpose [3]. The purpose of the questionnaire is to provide information on the conditions of production and use of DDT at country level. However, the questionnaire was not designed to facilitate strengthening of sound management of DDT at country level. As DDT continue to be needed for disease vector control, it is prudent to make special effort now to strengthen the management of DDT, until DDT has been fully eliminated.

1.2 Recent trends in the use of DDT

The global use of DDT has not changed substantially since the Stockholm Convention entered into force in 2004 [4, 5]. India remains by far the largest global user of DDT, even though its use has declined in recent years. In Africa, use of DDT has showed a marked increase from 2004 to 2008, which was mainly due to countries initiating or expanding their programmes on indoor residual spraying for malaria control, in which DDT has been (and still is) one of the recommended insecticides [6]. In more recent years, however, the use of DDT in Africa has declined, which is increasingly due to the development of insecticide resistance.

DDT has been primarily used in the control of malaria, but in recent years, the contribution for use against leishmaniasis has been increasing, due to scaling up of IRS for leishmaniasis elimination in India [7]. In malaria vectors, insecticide

resistance is rapidly spreading against pyrethroids, the dominant and most affordable insecticide class currently used for vector control. This leaves malaria-endemic countries with limited options of insecticides for vector control. Consequently, there could be a continued role for DDT in the context of insecticide resistance management, rather than a regular first choice of insecticide. The current situation indicates that there is an urgent need for countries to adopt an integrated vector management (IVM) strategy, with reduced reliance on chemical insecticides for vector control [8, 9].

1.3 Pesticide management

The International Code of Conduct on Pesticide Management (or "Code of Conduct") and two World Health Assembly (WHA) resolutions, WHA 63.25 and 63.26 urge countries to establish or strengthen capacity for sound management of pesticides, which include vector control insecticides, throughout their life cycle [10, 11].

Sound pesticide management requires registration schemes that control the availability of locally safe, effective and good quality pesticides, whereby the responsible authority approves the distribution, sale and use of the products, and enforces compliance. Pesticide procurement should follow an efficient, economical and transparent procedure, but this requires that standard guidelines and legal provisions are in place. Quality control should be able to detect substandard, counterfeit and adulterated pesticide products that do not meet the requirements of labelling, packaging and specifications.

Storage and transport should follow strict rules on storing and marking of stocks/containers, record keeping, location of stores, condition and security of stores. Measures should be in place to ensure secure transport, in order to prevent spillage, illegal trade and misuse of pesticides. The distribution and trade of pesticide products should follow rules on proper packaging, safe handling, and labelling of pesticide products conform to national requirements, with labels clearly indicating use instructions and safety precautions in local languages.

The application of pesticides should follow best practices and correct application technology, use of personal protection equipment, and adequate training for spray operators and supervisors. Decision making on pesticide selection and judicious use must be based on evidence of disease transmission, and the behaviour, seasonal patterns and insecticide susceptibility of disease vectors.

The disposal of expired or discarded pesticides, empty pesticide containers, and other pesticide waste, should be conducted in compliance with international standards. Moreover, a routine system of monitoring of compliance, pesticide exposure, poisoning cases, environmental monitoring and insecticide susceptibility of vectors should be in place.

A recent global survey conducted by the World Health Organization (WHO) indicated that the system of life-cycle management of public health pesticides[i] (including DDT)

[i] Public health pesticides include insecticides for vector control, household pesticides and pest management products for use by professional operators.

is deficient in many countries, with major shortcomings in policy, legislation, registration, quality control, capacity and risk prevention, thus undermining the effectiveness and safety of public health pesticides [12-14]. The situation on pesticide management was weakest in the African Region. As a direct consequence of these shortcomings, resources will be wasted, and the effectiveness and safety of pesticides used for public health will be undermined.

Three strategies for strengthening pesticide management at country level have recently been evaluated: (i) regional policy development, (ii) in-depth country support and (iii) thematic support across countries [15]. Regional policy development helped raise awareness and facilitated national policy development. In-depth country support for situation analysis and action planning was an important starting point to respond to a country's unique institutional context of pesticide management, but demanded much time and effort. Thematic support across countries showed how a prioritized aspect of pesticide management (e.g. capacity for pesticide quality control) could be efficiently addressed with tangible results.

These three strategies appeared to be largely synergistic, by initiating political support, addressing country-specific priority gaps while also tackling common problems across countries. Future investment in pesticide management in public health should capitalize on the available evidence and recent achievements. Country-specific and thematic strategies provide viable options for donor funding and programmatic response. Moreover, work-sharing and harmonization among countries should be encouraged.

2. USE OF THIS DOCUMENT

2.1 Objectives

The objective of this document is to provide a user-friendly access to existing information sources for the life-cycle management of DDT in disease vector control within the context of chemicals and wastes Conventions. This would serve as guidance for Parties establishing adequate systems and institutional capacity for evidence-based decision-making and enhanced reporting to the Stockholm Convention. It is hoped that this document will also be of use for the life-cycle management of other vector control insecticides.

2.2 Target audience

This document was developed for use by decision makers, policy makers, pesticide registrars, risk managers, pesticide manufacturers and programme managers involved in the control of vector-borne diseases, particularly in countries that are still relying on the availability or use of DDT.

2.3 Scope and structure

This document does not present new guidelines or new guidance on DDT, but collates information from a range of existing authoritative guidance documents, primarily those produced by WHO and FAO. The document also provides information relating to the requirements and obligations of relevant chemical and waste Conventions when handling DDT.

The scope covers the management of DDT and other vector control insecticides from production until use and disposal. Specifically, the life-stages discussed are: production, formulation, import and export; registration; procurement; pesticide quality control; transport and distribution; storage and stock control; application in vector control; and safe disposal (Figure 1). The life-stages are dealt with in separate chapters.

Each chapter starts with a description of each key point in a reasonable level of detail. Special emphasis is placed on making the descriptions tangible, and presenting key points for monitoring and evaluation, so that countries will be able to measure the status and monitor the progress of management of DDT. Each chapter ends with a list of key documents concerning aspects addressed in the document, with web linkages.

It is anticipated that this document will be used by countries to access and adopt the available guidelines and best practices on pesticide management, in order to critically review the current status at country level, and plan, implement and monitor constructive improvement of in pesticide life-cycle management, as appropriate.

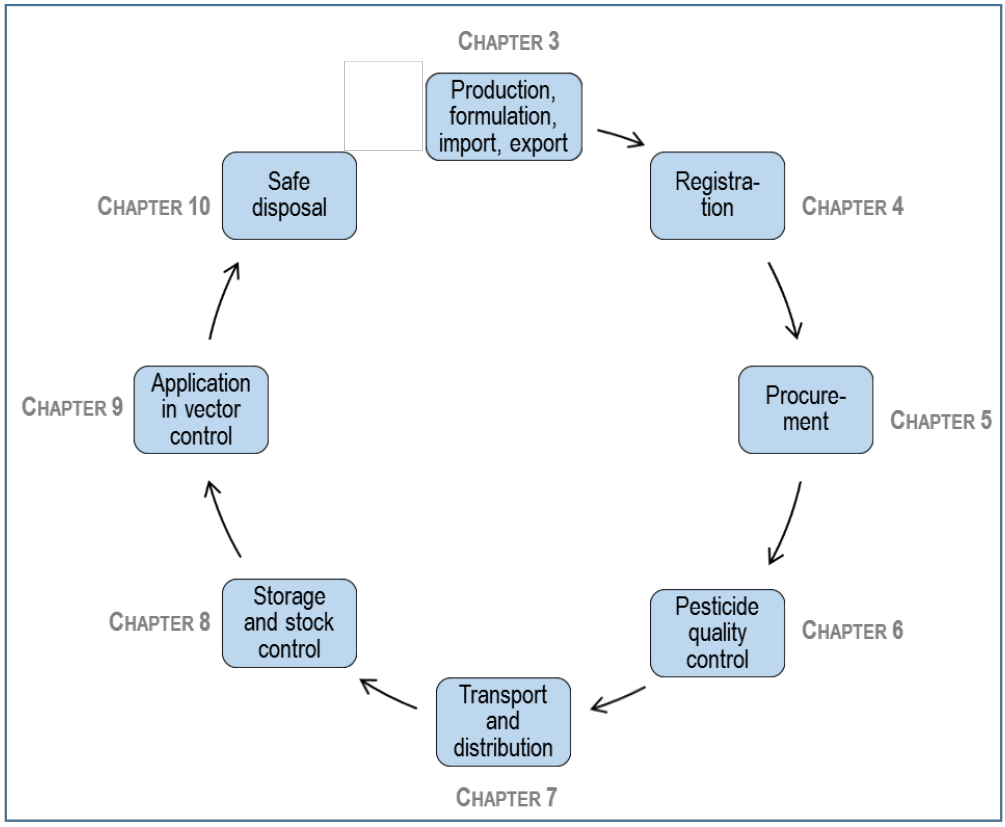

Figure 1. Schematic presentation of the life-cycle stages of the management of DDT and other vector control insecticides. The boxes in the diagram are corresponding to the chapter headings in this document.

3. PRODUCTION, FORMULATION, IMPORT AND EXPORT

3.1 Description

Production and formulation

The Code of Conduct recommends that pesticide production facilities should adopt appropriate engineering standards and operating practices, and ensure availability of protective equipment (Box 1). The production facilities, including those for DDT, should ensure the safe siting of manufacturing and formulating plants and stores. To guard occupational and environmental safety, adequate monitoring and control of emissions, wastes and effluents should be placed, in accordance with national, or regional legislation and regulations, and with relevant international guidelines [16-18]. Production facilities should make all necessary precautions to protect bystanders, surrounding communities and the environment by ensuring that the facility is secure with stringent entry requirements. Workers should be protected , by providing appropriate personal protective equipment, respiratory protective equipment, protective clothing, facilities for welfare and personal hygiene, engineering control measures, emergency procedures, health surveillance and investigation of incidents [18]. Production facilities should maintain quality-assurance procedures to ensure compliance with the relevant standards of purity, performance, stability and safety.

The WHO recommends that countries have policies prescribing that manufacturers or formulators of public health pesticides should be registered, certified, and regulated [19].

Box 1. Code of Conduct, Article 5.5

In establishing pesticide production facilities of a suitable standard in developing countries, manufacturers and governments should cooperate to:

5.5.1 adopt engineering standards and operating practices appropriate to the nature of the manufacturing operations and the hazards involved, and ensure the availability of appropriate protective equipment;

5.5.2 take all necessary precautions to protect workers, bystanders, nearby communities and the environment;

5.5.3 ensure the proper siting of manufacturing and formulating plants as well as their stores and adequately monitor and control wastes, emissions and effluents in accordance with national and regional regulations where available, or in accordance with relevant international guidelines;

5.5.4 maintain quality-assurance procedures to ensure compliance with the relevant standards of purity, performance, stability and safety [10].

Import and export

Trade in DDT and other POPs chemicals are prohibited under the Stockholm Convention for all Parties who have eliminated production and use. These Parties may only export DDT for the purpose of environmentally sound disposal. Nevertheless, there is an acceptable purpose for production and use of DDT in disease vector

control under certain conditions (Box 2). Here, the Convention does allow international trade of DDT, but only between those Parties that have registered for acceptable purposes under the Convention to produce and/or use DDT. The exporting Party should notify the Secretariat of the Stockholm Convention of the intention to produce it for the acceptable purpose and the importing Party should notify the Secretariat of their intention to use it for its acceptable purpose [20].

Box 2. Excerpts from the Stockholm Convention and Rotterdam Convention

Stockholm Convention

Paragraph 6 of Article 3: "*any party that has an acceptable purpose in accordance with Annex B (in this case for DDT) shall take appropriate measures to ensure that any production or use under such purpose is carried out in a manner that prevents or minimizes human exposure and release into the environment."*

"For acceptable purposes that involve intentional release into the environment under conditions of normal use, such release shall be to the minimum extent necessary, taking into account any applicable standards and guidelines."

Paragraph 5, Part II Annex B: "*With the goal of reducing and ultimately eliminating the use of DDT, the Conference of the Parties shall encourage: (a) Each Party using DDT to develop and implement an action plan as part of the implementation plan specified in Article 7. That action plan shall include:*

(i) Development of regulatory and other mechanisms to ensure that DDT use is restricted to disease vector control;

(ii) Implementation of suitable alternative products, methods and strategies, including resistance management strategies to ensure the continuing effectiveness of these alternatives;

(iii) Measures to strengthen health care and to reduce the incidence of the disease.

Rotterdam Convention

Paragraph 1 Article 10: "*Each Party shall implement appropriate legislative or administrative measures to ensure timely decisions with respect to the import of chemicals listed in Annex III."*

Moreover, DDT is subject to the Prior Informed Consent (PIC) procedure under the Rotterdam Convention. Parties under this convention that plan to export DDT are required to insure that exports do not occur contrary to the decision of each importing Party. All Parties to this convention are required to take a decision as to whether or not they will allow future import of DDT. These import responses are published in the PIC Circular which is updated every six months and should be communicated to the exporters of DDT and any other relevant authorities, such as the Department of Customs [21].

A decision guidance document on the PIC procedure is available for DDT to help governments assess the risks connected with the handling and use of the chemical and make more informed decisions about future import and use of the chemical in a country [22]. It is imperative that customs officials are trained on the obligations under each convention in a coordinated manner. Import restrictions under the

Rotterdam Convention are also expected to help prevent the accumulation of unwanted DDT stockpiles and wastes.

3.2 Key points for M&E

- Is the siting of manufacturing and formulating plants and stores safe [17]?
- Is adequate monitoring and control of wastes, emissions and effluents at production facilities in place [18]?
- Are measures in place at production facilities to protect workers, bystanders, surrounding communities and the environment [17, 18]?
- Are quality-assurance procedures maintained to ensure compliance with the relevant standards of purity, performance, stability and safety [23]?
- Are manufacturers or formulators of DDT and other vector control insecticides registered, certified, and regulated?
- Does export and import of DDT abide by the provisions of the Stockholm Convention and Rotterdam Convention [1, 21]?

3.3 Key documents

- UNEP (2011). Stockholm convention on persistent organic pollutants (POPs), as amended in 2009 and 2011. Text and annexes. http://chm.pops.int/TheConvention/Overview/TextoftheConvention/tabid/2232/Default.aspx. Geneva, United Nations Environment Programme.
- UNEP (2011). Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (revised 2011). http://www.pic.int/TheConvention/Overview/TextoftheConvention/tabid/1048/language/en-US/Default.aspx. Geneva, United Nations Environment Programme.
- UNEP (2012). Guidance for the control of the import and export of POPs (draft). http://chm.pops.int/Implementation/NIPs/Guidance/GuidanceforthecontroloftheimexportofPOPs/tabid/3173/Default.aspx. Geneva, United Nations Environment Programme.
- FAO/UNEP (1991). Operation of the prior informed consent procedure for banned or severely restricted chemicals in international trade. Decision guidance documents: DDT. http://www.pic.int/Portals/5/DGDs/DGD_DDT_EN.pdf. Rome, Food and Agriculture Organization and United Nations Environment Programme.

4. REGISTRATION

4.1 Description

Pesticide registration

Pesticide registration is the process for the approval of a pesticide by the responsible national authority for distribution and use, following adequate evaluation of scientific and technical data demonstrating that the product is effective for its intended purposes and does not pose an unacceptable risk to human or animal health or the environment [24].

A registration scheme enables the authorities to exercise control over DDT and other vector control insecticides. The registration scheme determines which products are permitted to be used and for what purposes, and specifies quality standards, use levels, and requirements for labelling and packaging of the chemicals. In most countries with a registration authority is housed within the Ministry of Agriculture, although some countries have separate registration authorities in Agriculture and Health [12, 13].

WHO and FAO have published guidelines on pesticide registration [24], which outline the registration process, post-registration activities, and procedures to fast-track registration to respond to emergencies. These guidelines could be used by countries to establish or strengthen the national mechanism of pesticide registration.

The registration dossier is the set of data that is submitted by the applicant. The registration dossier should ideally be submitted to qualified experts for evaluation for technical evaluation of the data on efficacy, human health and environmental effects. Alternatively, the registration dossiers are reviewed vis-à-vis existing documents on environmental and human health risks of DDT [22, 25] and alternative insecticides [26, 27].

Recommendations of the evaluation should be used by the National Pesticide Board in their final decision on registration for specific purposes. The registration decision is disseminated to the stakeholders, and instruction is given to enforcement officers.

After registration of a pesticide, monitoring and evaluation activities are vital for verification of the efficacy on controlling the intended pest and effectiveness of control measures enforced/implemented to minimize adverse effects of the pesticide.

In some countries, DDT or other vector control insecticides have been registered for many years. However, it is important to submit the insecticides to regular reviews, to determine whether the contemporary requirements and standards are still being met [24].

Data requirements for registration

In-depth technical guidance is available on the types of data needed for the registration process [28]. Briefly, the applicant of the pesticide product should present a dossier as a structured set of data covering all relevant aspects of the product, from

manufacture to use or disposal. The data should describe in detail the conditions of use, protection measures, risks, precautions to protect people and the environment (e.g. re-entry period of house after spraying), methods of disposal, and methods of treatment of accidental exposure.

Moreover, scientific data should be presented by the manufacturer or distributor on the efficacy, human health and environmental effects of the pesticide product. These scientific data should demonstrate the efficacy of the product under field conditions against the target organism (on the vector, or on the disease pathogen), and indicate the status of insecticide resistance in the target vector. Also, scientific data should be presented on human health effects, indicating the acute toxicity levels of the technical material and formulated product (including active ingredient, impurities, and metabolites), and identify pathways of exposure, protective measures, and precautionary label requirements. Data on environmental effects should include the expected levels of environmental exposure, and ecotoxicity (including through bioaccumulation) on key non-target organisms.

Specifications on DDT

WHO has published the technical specifications and evaluation of DDT, which include the active ingredient, relevant impurities, physical properties, and storage stability (refer to Chapter 6). Updated specifications are given for DDT technical material, DDT dustable powder and DDT wettable powder [29].

Specifications on equipment for vector control

DDT and other vector control insecticides for IRS operations are most commonly applied using hand-operated compression sprayers. For this type and other types of vector control equipment, WHO has published specification guidelines [30]. The guidelines describe the requirements for materials of construction, pressure release devices, straps, markings, air pump, discharge system, lance, nozzle tip, and durability of the equipment. Programmes should follow these guidelines, or existing national guidelines, when procuring or maintaining the spray equipment.

Compliance and enforcement

Registration should be supported by necessary legislation and/or regulations. The distribution of pesticides that have not been registered should be prohibited, and use of pesticides must only be allowed for their approved purposes and targets. In accordance, countries should establish effective monitoring and enforcement of pesticide regulations, such as inspection schemes for importers and distributors. Even though it is only allowed in public health, DDT can become an attractive commodity for use in agriculture and for domestic purposes. Therefore, it is important that a linkage between the health sector and agriculture sector are made to coordinate monitoring of unauthorized trade and use of DDT.

Track-and-trace systems, for example by coding and tracking containers, can help with data collection on the use of vector control insecticides [31] and in monitoring misuse (Box 3). In order to improve implementation and effectiveness of adopted

regulations, these could be associated with measures or schemes aiming at ensuring efficient compliance with them and their enforcement. Detailed guidelines on establishing a compliance and enforcement programme have been published by FAO [32].

Box 3. Track-and-trace system of pesticide sachets used in IRS, as promoted by PMI [31]

"On reception at the district office, count all sachets and stamp them with the district stamp, if appropriate, and register the count in the stock book.

The storekeeper issues only enough refills for the day's operations to each spray operator. Each spray operator's code is written on the sachets issued. The spray operator must sign for these sachets in the log book.

At the end of each spray day, all spray operators sign the logbook for their empty and full sachets. Both the storekeeper and the supervisor compare the number of sachets returned with the number issued. Stock remaining should equal the stock issued in the morning, minus the number of sachets used during the day. The number of sachets used should be equal to the number of can refills.

The storekeeper submits insecticide stock balances and sign-in/sign-out logs to the data manager."

4.2 Key points for M&E

- Is a registration scheme for pesticides in place, and if yes, does the registration of DDT and other vector control insecticides follow the required process and instructions [24]?
- Have dossiers on DDT and other vector control insecticides been comprehensively evaluated for registration?
- Have the technical data (e.g. efficacy, human health and environmental effects) of each insecticide been reviewed?
- Have registration decisions on vector control insecticides been disseminated to all stakeholders?
- Have enforcement officers been instructed about registration decisions on vector control insecticides?
- Are the efficacy and, if possible, the adverse effects of DDT or other vector control insecticides locally verified?
- Is the registration of DDT or other vector control insecticides reviewed periodically?
- Is inspection of unauthorized trade and use of DDT and other vector control insecticides conducted routinely?

4.3 Key documents

- WHO/FAO (2010). Guidelines for the registration of pesticides. International code of conduct on the distribution and use of pesticides. http://whqlibdoc.who.int/hq/2010/WHO_HTM_NTD_WHOPES_2010.7_eng.pdf.

Geneva & Rome, World Health Organization & Food and Agriculture Organization.

- FAO/WHO (2013). Guidelines on data requirements for the registration of pesticides. httpcommendations/FAO_WHO_Guidelines_Data_Requirement_Registration.pdf ://www.who.int/whopes/re. Rome and Geneva, Food and Agriculture Organization and World Health Organization.
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- FAO (2006). Guidelines on compliance and enforcement of a pesticide regulatory programme. http://www.fao.org/fileadmin/templates/agphome/documents/Pests_Pesticides/Code/Compliance.pdf. Rome, Food and Agriculture Organization.

5. PROCUREMENT

5.1 Description

Procurement of DDT and other vector control insecticides is usually carried out by government programmes or by international agencies (this does not refer to the procurement of household pesticides). WHO has developed guidelines to assist national programmes and other agencies in preparing their own procurement procedures [33].

The WHO recommends that countries adopt an integrated vector management (IVM) strategy, which emphasizes the evidence-based and efficient use of vector control interventions, including DDT, and which considers the role of alternative methods and sustainability of vector control [8, 9]. IVM encompasses the management of insecticide resistance. Hence, improved decision making in the context of IVM may have implications for the selection of pesticides and the amounts used for IRS. Assessments of the chemical alternatives to DDT have been published by the Persistent Organic Pollutants Review Committee (POPRC) [27, 34]. Non-chemical alternatives for vector control of malaria and leishmaniasis are discussed in a separate document.

Selection of insecticides for IRS

The first step in procurement of an insecticide for IRS is the selection of the product by the specific authority, which is usually the disease vector control programme. The selection of the insecticide product should be a balanced decision based on contemporary evidence on the effectiveness, cost, residual activity, susceptibility status of target vectors, insecticide resistance management strategy, public acceptability, risks to human health and the environment, and information on special requirements (e.g. handling, application, transport and disposal).

Guidance documents are available to assist programmes in selection of insecticides for IRS [35]. Insecticide selection should be consistent with the principles of the Global Plan for Insecticide Resistance Management (GPIRM) [36]. For example, in geographic areas with high coverage of households with pyrethroid-impregnated bed nets, the use of pyrethroids for IRS should be avoided.

WHO maintains a regularly updated list of recommended insecticides for IRS against malaria vectors, with recommended dosages and estimated residual periods [37]. WHO also keeps an updated statement on its position on the use of DDT, stipulating the strict conditions that must be met when using DDT for disease vector control in the context of the Stockholm Convention [2].

Regarding the risks to human health and the environment, a classification is available for pesticides by hazard; the classification covers all insecticides that are recommended for use in IRS [38]. Recent literature reviews have highlighted the risks of adverse effects of exposure to DDT on human health [39, 40]. A risk assessment of the use of DDT in indoor residual spraying on human health, carried out by WHO, concluded that “for households where IRS is undertaken, there was a wide range of

DDT and DDE serum levels between studies. Generally, these levels are below potential levels of concern for populations". However, the report also noted that: "In some areas, the exposures in treated residences have been higher than potential levels of concern. Efforts are needed to implement best practices to protect residents in treated households from exposures arising from IRS. Of particular concern would be women of childbearing age who live in DDT IRS-treated dwellings and transfer of DDT and DDE to the fetus in pregnancy and to the infant via lactation" [25]

Quantity and quality

The quantity of pesticides is an important consideration in the procurement process. The required amounts should be carefully estimated based on information about populations to be covered, expected disease incidence, existing stocks, and shelf life. Over-estimation can result in accumulation of obsolete stocks.

Procured pesticide product should be of good quality, with accurate content of active ingredient, lest its use could result in ineffective vector control. Quality control of the procured pesticides should take place before the shipment through an independent contract with a certified or accredited laboratory. This may be followed by inspection upon arrival. The quality control should use a recommended sampling procedure to obtain representable and accurate results [33]. Legal action could be necessary against the bidder in case false or misleading information about the pesticide product has been provided, for example, by including a condition in the tender for reshipment at the supplier's cost. Quality control is discussed in Chapter 6.

Legislations and Regulation

Countries should have laws and regulations to ensure that the procurement process is efficient, transparent and fair [33]. This should include provisions for tendering and independent review.

Procurement methods

Methods of tendering, conditions of tenders, specifications of the products being procured, relevant information, such as requirements for packaging and labelling, and other conditions related to the supplier are essential components of proper procurement of DDT as well as other insecticides. WHO has developed guidelines on pesticide procurement covering such aspects [33].

Offers to the tender should undergo an independent technical and financial evaluation by a tender sub-committee, using a comprehensive set of criteria, as outlined in the above guidelines [33]. As far as feasible, a comparison should be made between the cost-effectiveness of the different products; for example by comparing the cost of each product to maintain insecticidal activity per m^2 of wall during the annual period of disease transmission, on the assumption that vector populations are susceptible to the products used. The costs include insecticide cost, operating costs and personnel costs, all of which may vary between different insecticide products. Comprehensive cost-effectiveness analysis, including the quantification of effect on the disease, is more complex, and has been discussed in a separate guidelines document [41].

The technical and financial recommendations are then reviewed by the tender committee. One of the offers is selected, using clear decision-making criteria.

Traceability

It is important that procured pesticides can be traced back to the stores and warehouses to which it is distributed. Systematic record keeping of products received, distributed and used will promote good store keeping and will prevent unauthorized trade or use of the pesticides [31]. Also, traceability will allow for a product to be recalled if necessary.

5.2 Key points for M&E

- Is the selection of insecticide products for IRS in accordance with the WHO recommendations, and consistent with the Global Plan for Insecticide Resistance Management [2, 36]?
- Is the amount of the procured pesticides carefully estimated based on information about populations to be covered, expected disease incidence, existing stocks, and shelf life?
- Are legislations and regulations as well as guidelines in place to ensure that the procurement process is efficient, transparent and fair [33]?
- Do offers to procurement tenders undergo an independent technical and financial evaluation [33]?
- Is quality control of the procured pesticides conducted through an independent and certified laboratory [42, 43]?
- Are systematic records kept on the distribution and use of the procured products?

5.3 Key documents

- WHO (2012). Guidelines for procurement of public health pesticides. http://whqlibdoc.who.int/publications/2012/9789241503426_eng.pdf. Geneva, World Health Organization.
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6. PESTICIDE QUALITY CONTROL

6.1 Description

States and the industry have responsibility to ensure that pesticides being traded meet the national quality standards [10]. Adulterated, counterfeit and substandard pesticides (see definitions in Box 4) have serious consequences for the effectiveness of vector control interventions, result in waste of resources, and have increased risks for human health and the environment.

Box 4. Definitions of adulterated, counterfeit and substandard pesticides [43]

Adulterated pesticide: A pesticide any component of which has been substituted wholly or in part, or any constituent of which has been wholly or in part abstracted, added or modified in quantity compared with the regulatory specification on record.

Counterfeit pesticide: A pesticide made by someone other than the approved or registered manufacturer, by copying or imitating an original product without authority or right, with a view to deceive or defraud, and then marketing the copied or forged product as the original.

Substandard pesticide: A pesticide the physical-chemical properties of which do not meet the minimum quality standard.

Pesticide quality control involves inspection of pesticide products to investigate whether the products meet required standards and specifications. The inspection should cover the chemical and physical quality of the pesticide, its packaging and labelling. An effective system of quality control should have ongoing activities of inspection, testing and corrective action against the import, trade and use of inferior pesticide products.

Guidelines are available to assist countries with the basic requirements of pesticide quality control [43, 44].

Specifications

A pesticide specification is a description of the physical appearance, content of active ingredient, relevant impurities, physical properties and storage stability of a pesticide [45]. FAO and WHO through their Joint Meeting on Pesticide Specifications (JMPS) establish and publish specifications for technical material and formulations of recommended pesticide products. Specifications for pesticide products provide an internationally accepted point of reference for registration authorities or commercial enterprises to assist them in quality control and to help reduce the trade in inferior products.

During preparation of a specification for a new product, a reference profile is produced based on physical, chemical and toxicological properties of the product. The reference profile enables the possibility of fast-track acceptance of similar products by generic manufacturers according to the degree of ‘equivalence’ with the reference product (Box 5) [45, 46]. Specifications have been published for the insecticides currently recommended for use in IRS. All these specifications, with the exception of those for DDT, have followed the new procedure of formal and transparent evaluation

[47]. The available specifications for DDT were developed using the old procedure [23].

Box 5. Equivalence

Determination of the similarity of the impurity and toxicological profile and physical and chemical properties of supposedly similar technical material originating from different manufacturers; used to assess whether they present similar levels of risk [33].

Legislation and Regulation

The management of DDT and other vector control insecticides should be supported by adequate legislation and regulation to ensure that the products procured and used meet the basic quality requirements.

Legislation and regulation of the registration of pesticides are seen as the first line of defence against inferior pesticides, aiming to ensure thorough evaluation before a product is allowed for importation or procurement. As a baseline standard, products should be approved for import and procurement only if they comply with WHO specifications, and if the quality is verified during the registration process. Measures should be in place to ensure that the product quality meets the established specifications on individual consignment basis. Moreover, products should have good quality packaging, to avoid leakage during handling, transport or storage, and use national requirements for labelling.

Legislation and regulation should also be in place to ensure that post-registration activities of pesticide management conform to the national standards. Legislation must be supported by adequate surveillance – by taking pesticide samples for analysis on quality standards, and enforcement – by formulating regulations and imposing corrective or punitive action against non-compliance [43]. Comprehensive guidelines on developing pesticide legislation on quality control have been developed by FAO [48].

Quality control in practice

During the registration process of a pesticide, the active ingredient, physical and chemical properties and relevant impurities should be verified using accredited test methods [43]. Packaging and labelling should be checked, and be compliantwith standards made.

After registration, inspection of pesticide samples should be conducted of products being procured and/or imported, those in storage and those being used in vector control operations. This would involve efficient sampling of DDT and other vector control insecticides by assigned inspectors, followed by laboratory testing, record keeping, reporting and corrective actions. Proper and safe methods of taking pesticide samples for analysis, outlining preparatory requirements and sampling procedure, have been described elsewhere [43, 45, 49]. Enforcement measures require a strong coordination between inspectors and Departments of Customs, Trade and the Police.

Laboratories

Pesticide quality control hinges on the availability of funds and laboratory capacity to identify the active ingredient, and to determine the physical-chemical properties and relevant impurities of the pesticide product [45]. However, there are clear indications that countries endemic with vector-borne diseases lack adequate laboratory capacity [13]. An assessment in 12 countries indicated that functional laboratories for pesticide quality control were few; most of the existing laboratories could determine active ingredients, but could not determine the physical-chemical properties or impurities [15].

One option to improve this situation is to strengthen the national laboratory capacity, but this will only be feasible to maintain if a country has sufficient samples to keep the laboratory occupied on a continuous basis. Another option is to establish laboratory capacity at sub-regional or regional level through sharing of resources and expertise between countries. Yet other options are to seek the assistance of the WHO Collaborating Centre for Quality Control of Pesticides (located in Gembloux, Belgium); to send samples for analysis to accredited laboratory overseas; or to have the bidder submit an independent analysis report by an ISO accredited agency (for verification in the actual batch of the shipped product).

A guidelines document is available for strengthening the capacity for pesticide quality control in agriculture and public health [50]. The guidelines cover staff qualifications for national laboratories, training requirements, and requirements for laboratory facilities, equipment and supplies. The guidelines discuss access to information, safe handling, storage, and disposal of waste. Also discussed are management aspects of laboratories, development of a quality assurance scheme, requirements of documentation, data recording and internal quality audits, and collaboration with foreign laboratories and international networks.

6.2 Key points for M&E

- Is a regulatory system in place to have active ingredient, physical and chemical properties and relevant impurities of registered vector control insecticides independently verified using accredited test methods [24, 43]?
- Is post-registration inspection, laboratory testing and corrective action conducted for DDT and other vector control insecticides?
- Does inspection cover the quality of pesticide, its packaging and labelling [43]?

6.3 Key documents

- FAO/WHO (2011). Guidelines for quality control of pesticides. http://whqlibdoc.who.int/hq/2011/WHO_HTM_NTD_WHOPES_2011.4_eng.pdf. Rome & Geneva, Food and Agriculture Organization of the United Nations & World Health Organization.
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7. TRANSPORT AND DISTRIBUTION

7.1 Description

Transport and distribution of DDT and other vector control insecticides take place from the central store to local stores, and from local stores to the sites of field operations. Transport and distribution should follow a set of strict national rules and regulations. DDT is used at much higher dosage, or application rate, than other vector control insecticides, particularly pyrethroids [4]. Consequently, where DDT is used for vector control, transport capacity and safety measures must be in place to handle the large amounts of insecticide.

Careless transportation may result in damaged pesticide packaging or damaged pesticide labels that could influence the safety and efficacy of spray operations. Moreover, during transportation, the pesticides may cause contamination of goods, leakage and spills, posing risks to human health and the environment.

A truck should never transport food, animal feed or general consumer goods together with pesticides. Pesticide packages or containers for transport should always be intact and closed. Upon loading of pesticide containers onto the truck, care should be taken that containers are securely stacked and fixed so they will not move, damage or fall off the truck. The vehicle transporting pesticides should display clearly visible warning notices and symbols. During transport, regular checkups are needed to see if any damage or leakage has occurred, in which case the leak should be stopped and spillage cleaned.

Truck drivers need to be trained on the transport of vector control insecticides, their intended use, toxicity, security issues, how to deal with contamination, spills, and emergencies (see guidelines in [51]). In case of rented vehicles that are used for multiple purposes, the vehicle bed should be cleaned following recommended methods in order to prevent pesticide runoff [31].

In the event of an accident during transport, the spillage may cause fire and injury to people and contamination of the environment. The driver and other personnel should know how to deal with a pesticide accident and be familiar with information on the pesticide label [31, 51]. With a major spill, people should be kept away from the spill. The spill should not be washed away with water, but covered with earth until appropriate rehabilitation and remediation measures are taken for the contaminated soil [52]. Accidents or incidents involving pesticides must be accurately reported to the authorities.

Further guidance on the rules for pesticide transport are available [19, 51, 53]. These rules should be used in accordance with the classification of pesticide hazard [38] and should be in compliance with international regulations on the transport of dangerous goods [54].

7.2 Key points for M&E

- Is legislation and/or regulation in place to ensure safe transport of pesticides?

- Are basic safety rules for pesticide transport applied at all times?
- Are pesticide truck drivers trained on safety rules for pesticide transport?
- Is personnel prepared to deal with a pesticide accident or spillage involving DDT or other vector control insecticides in accordance with safety standards?

7.3 Key documents

- FAO (2001). Guidelines on good practice for ground application of pesticides. http://www.fao.org/docrep/006/y2767e/y2767e00.htm. Rome, Food and Agriculture Organization of the United Nations.
- FAO (1996). Pesticide storage and stock control manual. http://www.fao.org/docrep/V8966E/V8966E00.htm. Rome, Food and Agriculture Organization of the United Nations.

8. STORAGE AND STOCK MANAGEMENT

8.1 Description

The conditions of storage and the management of stocks play an important role in the effective and safe use of DDT and other vector control insecticides. FAO has published a manual for pesticide storage and stock control [51].

Pesticide stores and storage

IRS operations often require that vector control insecticides are distributed from a central store to local or district storage facilities where smaller amounts of insecticide and equipment can be stored for local use [31]. Any store selected or build should comply with standard safety and security requirements [31, 51]. The store should not be located close to houses, public meeting places, animal feed depots, water courses or in areas prone to flooding. The store building should be well-ventilated, have an impermeable concrete floor, and have adequate space to store empty containers and obsolete products. The store should be securely fenced-in and locked, displaying warning signs, and have easy access for delivery vehicles and firefighting.

Stock management

Stocks should be managed according to the principle of 'first-in-first-out', to prevent the accumulation of out-of-date stocks. Newly arrived consignments should be checked for damage, and repacked if needed. A supply of empty containers should be available for repacking of damaged ones. Arrangements of storage and stacking of containers should be according to recommended methods [31, 51].

The pesticide shelf-life should be routinely checked. Daily insecticide use should be tracked and inventory records kept up to date and organized. Hence, new orders will be timely and accurate, and older pesticides will effectively be used before they expire. A record system of coding insecticide containers enables storekeepers to accurately monitor daily use vis-à-vis stock balances, and helps in pinpointing possible misuse of pesticides.

Old stocks that are out of specification should be reviewed by experts on a case-by-case basis to determine whether they still could be used. For example, an old pesticide product with reduced potency of active ingredient may still be usable at adjusted dosage rate, unless toxic impurities have formed during storage [43]. Signs of deterioration or corrosion of pesticide containers should be regularly inspected.

Information on training methods on pesticide storage is provided elsewhere [55].

Spills, leaks and emergencies

Spills of pesticides could occur as a result of damaged pesticide packages or when pesticides are repacked into new containers. Liquid spills are cleaned by applying absorbent materials such as sawdust or sand, which soaks up the pesticide, and is subsequently shovelled up and stored in containers marked as toxic waste. It is important that spills are not diluted or washed away with water, because this will only

spread the contamination problem [51]. Wettable powders such as DDT can cause dust when swept, which is prevented by applying absorbent material. Any remains should be scrubbed with a cloth and soapy water. Appropriate protective gloves and face mask must be worn during the clean-up [51, 55].

Pesticide stores are at risk of major emergency situations, in the event of fire, flooding or destruction. Without sufficient ventilation, fumes from solvents used in pesticide formulations could accumulate and sparked into a fire. Functional fire extinguishers and running water should always be available to be prepared for emergencies. Fire fighters should be protected against inhaling toxic fumes. Flooding can cause major environmental contamination when products packed in paper are soaked and burst, resulting in the release of pesticides in water. Clearly, site selection of the store is key to the prevention of flooding.

Personal safety

Personal safety requires good hygiene practices, such as not eating, drinking or smoking when working inside the store, and to properly wash up after work in the store. When handling DDT or other pesticides, protective clothing is required according to the hazard classification of the product in question [38].

Generally, protective clothing should cover arms, body and legs, footwear should cover feet, and should be washed after daily use with soap, and separate from other clothing [51]. Chemical-resistant gloves should protect hands when handling pesticides, and need routine checking for signs of tear. Eyes should be protected by wearing goggles of face shields. Disposable masks should be in stock for covering mouth and nose when handling pesticide dusts or powders, such as DDT powder. Soap and clean water should be available at the store at all times.

8.2 Key points for M&E

- Do central store and all local stores comply with standard safety and security requirements [51]?
- Are stocks managed according to the ‘first-in-first-out’ principle [51]?
- Are non-contaminated, empty containers available for repacking of damaged ones [51]?
- Is vector control insecticide use routinely tracked and inventory records kept up to date and organized?
- Are signs of deterioration or corrosion of pesticide containers regularly inspected?
- Are spills dealt with according to safety standards and is contaminated material treated as toxic waste [51, 55]?
- Are stores adequately prepared for emergency situations (e.g. fire) [51, 55]?
- Are personal protection and good hygiene practices applied by store personnel at all times [51]?

8.3 Key documents

- FAO (1996). Pesticide storage and stock control manual. http://www.fao.org/docrep/V8966E/V8966E00.htm. Rome, Food and Agriculture Organization of the United Nations.
- FAO (1995). Prevention of accumulation of obsolete pesticide stocks. ftp://ftp.fao.org/docrep/fao/009/v7460e/v7460e.pdf. Rome, Food and Agriculture Organization of the United Nations.

9. APPLICATION IN DISEASE VECTOR CONTROL

9.1 Description

Selection and uses of DDT

The only acceptable use of DDT is for indoor residual application for disease vector control [1, 2]; other uses, for example, in mosquito coils, for household pests, as larvicides, or for outdoor spraying, are prohibited under the Stockholm Convention.

In the context of Integrated Vector Management (IVM), decisions on the use of DDT and IRS should be made based on key criteria, including the effectiveness, situation of insecticide resistance, community acceptability, affordability, safety, and policy support [9]. Decision making should also include an appraisal of the available alternative vector control methods, which could potentially be used in combination with IRS or as substitute of IRS (see separate document).

The main purpose of IRS is to cause an immediate killing effect on the vector, thus reducing vector density and reducing the average life span of the vector [6]. The intervention of indoor residual spraying is only effective in disease control where the major disease vectors exhibit a behaviour of resting on walls and ceilings inside people's homes (thus getting into contact with the insecticide) and where the vectors bite predominantly indoors rather than outdoors [6]. The vector population must be susceptible to the insecticide used, lest IRS may not achieve its intended killing effect. Consequently, adequate information is needed on the resting behaviour, indoor versus outdoor feeding, and insecticide susceptibility status. The evidence should be up to date, because disease vectors are able to adapt to the intervention, for example, by biting earlier in the evening, or resting outdoors.

Personal protection of spray operators

Pesticides can be absorbed through the skin, mouth or lungs. Therefore, protective clothing and equipment, corresponding to the instructions on the insecticide, product label must be worn by spray operators. Protection from exposure is required in two stages of pesticide use: the handling of the concentrated formulation, and the application of the diluted formulation [56]. WHO has listed safety precautions to avoid exposure by spray operators in IRS (p.32 in [6]).

Protective equipment for IRS should include a mask, a helmet, face shield or goggles, long-sleeved overalls, rubber boots, and long rubber gloves. Overall should be worn outside of the boots but the gloves should be worn outside of overall sleeves (p.13 in [57]. Pregnant women or nursing mothers should not participate in any spray operations. Personal hygiene during and after spray operations is a key safety measure, and supervision over washing of protective clothes and equipment should follow standard procedures (p.14 in [57]). Methods for training on personal protection in IRS are discussed elsewhere [31, 55].

Spray equipment

IRS operations are commonly conducted using hand-operated compression sprayers. Before a spray operation, compression sprayers should be tested and spray amounts calibrated, following WHO guidelines [30] (see also [31]). Equipment requires regular maintenance, prompt replacement of damaged nozzle tips, filtering of water to fill the tank, and proper storage when not in use [57].

When using a wettable powder such as DDT, spray operators should regularly shake up the spray pump in order to prevent powder depositing on the bottom of the pump and, consequently, resulting in insufficient dosage of insecticide being applied unto structures.

IRS application methods

Application methods for IRS, which apply to DDT and other vector control insecticides, are described in detail in WHO's guidelines [6]. Some key aspects are outlined here.

Spray operators and their supervisors require certified training and refresher courses on the recommended methods of IRS. Prior to spray operations, communication should take place with village leaders and households about the purpose of the intervention. Households should be prepared for the spraying event by removing or covering all household items [6]. A particular consideration with the use of DDT is that it leaves stains on walls, which may cause household members to repaint or replaster the walls – thus eliminating the protective effect of the intervention [58]. Education and communication could address this concern.

The spray operator should make all the preparations for spraying, following the WHO guidelines (p.70 in [6]). This includes wearing of protective clothing and gear; checking the sprayer; mixing the insecticide; preparing the sprayer; filling, shaking and pressurizing the spray tank; checking the nozzle; and safely handling the sprayer. Proper spray techniques, insecticide concentration and amounts should be used. Spray records should be kept, data reported and supervision visits made.

After the spray operation, all spray equipment and protective gear should be cleaned using the progressive rinse method to save and recycle water and to prevent environmental pollution with pesticides (p.78 in [6]). Insecticide spillages should be cleaned, and contaminated materials and empty insecticide containers or sachets should be properly disposed as hazardous waste. The clean-up activities require routine supervision and monitoring. Special attention should be paid that insecticide-contaminated rinse water is not released into water bodies or the environment. Water contaminated with DDT must only be disposed and collected in a specially constructed evaporation tank [31]. Solid waste of DDT must be disposed through high-temperature incineration [59] (see Chapter 10).

Monitoring insecticide resistance

Insecticide resistance is an increasing threat to current control programmes of malaria and several other vector-borne diseases [60]. Resistance to DDT and pyrethroids is

spreading into new areas and countries, and is expected to reduce the effectiveness of interventions [61]. A Global Plan for Insecticide Resistance Management (GPIRM) has recently been developed by WHO and its partners [36]. The Plan emphasizes the need for routine entomological monitoring, including bioassays for insecticide susceptibility of the local vector populations at representative sentinel sites.

Standard bioassay test procedures for insecticide resistance monitoring in malaria vector mosquitoes have recently been updated [62]. The standardized test kits and insecticide-impregnated papers can be ordered from the Universiti Sains Malaysia (USM), Georgetown, Malaysia, which prepares the test kits on behalf of WHO. WHO described the procedures and conditions for procurement of test kits in a separate document [63].

The development of resistance should be prevented or delayed as much as possible. Guidance documents are available to assist programmes in selection of insecticides for IRS [35] and judicious use of those insecticides [64].

Monitoring of adverse pesticide effects

The health of spray workers should be routinely monitored for signs and symptoms of pesticide poisoning, using diagnostic methods in accordance with the insecticide product being used [55]. The surveillance should cover health records and medical checks, so that medical authorities can be notified of any health changes that could be due to pesticide spraying. Monitoring should also indicate whether the practices and equipment of personal protection are acceptable for the products being used or whether improved risk reduction measures are needed.

In addition, it is important to monitor the adverse effects of indoor insecticide spraying on the targeted human population and the environment. Guidelines are available for developing a pesticide incident reporting system. This is a system of surveillance and systematic collection of information on adverse effects arising from pesticide application on human health and the environment [65]. Data generated by such system should be utilized to inform future decisions on risk reduction measures.

9.2 Key points for M&E

- Are decisions on the deployment of IRS made based on contemporary evidence on the biting and resting behaviour of the main local disease vectors [6]?
- Is personal protective equipment (PPE) mandatory and actually used by spray operators during IRS operations [56, 57]?
- Is spray equipment regularly tested, calibrated and serviced, and properly stored when not in use [30]?
- Do spray operators and their supervisors receive certified training and refresher courses on methods of IRS [6]?
- Are IRS spray records kept, data reported and supervision visits made [6]?
- Does the clean-up after spraying use the progressive rinse method [6]?

- Is DDT-contaminated rinse water re-used, or disposed and collected in an evaporation tank [31]?
- Is insecticide resistance routinely monitored at sentinel sites, using standard bioassays, and is a resistance management strategy in place [36]?
- Is the health of spray workers routinely monitored for signs and symptoms of pesticide poisoning [55]?
- Is a pesticide incident reporting system in place for the surveillance of adverse pesticide effects on human health and the environment [65]?

9.3 Key documents

- WHO (2010). Equipment for vector control – Specification guidelines. http://www.who.int/whopes/equipment/en/ Geneva, World Health Organization.
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10. SAFE DISPOSAL OF WASTE AND OBSOLETE STOCKS

10.1 Description

DDT has a very low rate of degradation and, when released into the environment, it will bio-accumulate in organisms and bio-magnify through the food chain. Therefore, all wastes and unwanted stocks of DDT must be disposed of in an environmentally sound manner.

Pesticide waste can originate from daily spraying operations, as rinsate, small leftover amounts and empty pesticide containers (refer to Chapter 9). Waste can also be created by spills or accidents, requiring appropriate rehabilitation and remediation measures [52]. Possibly the largest source of pesticide waste is through accumulation of obsolete stocks that simply develop over time when products expire; this is caused by poor stock management, miscalculations of insecticide donations or procurement, or the banning of an insecticide [66].

Managing empty containers

Empty pesticide containers are a by-product of spray operations and should be treated as hazardous waste. Empty pesticide containers will always have traces of pesticide and should be appropriately managed or disposed of, and should be prohibited for use for unintended purposes (e.g. for storing food items). To prevent reuse, empty pesticide containers should be smashed, punctured or crushed before being sent for disposal or recycling [51]. An exception to this rule is when containers will be needed for the purpose of repacking the contents of damaged containers or for storing cleaned-up spills and contaminated material before their final disposal. Simply burning the empty plastic pesticide containers, sachets or contaminated waste in an open fire may result in toxic emissions into the environment, and should be prohibited.

Several examples exist of countries that have established functional schemes for managing and recycling of pesticide containers [67]. Where the recycling or disposal of containers is conducted abroad, it should be ensured that the transboundary movement of the waste materials is allowed under the Basel Convention [68].

Managing waste

Pesticide waste management starts with practices of stock management that prevent the accumulation of obsolete or expired pesticides [66]. Clearly, pesticides should be used for their intended purposes, according to the first-in-first out principle, and stock orders should be made regularly – in order to adjust to changes in requirements. When stocks do pass their expiry date, there could still be the possibility that they may continue to be used, for example at a modified dosage, but this requires expert review on a case-by-case basis [43].

When stocks are unusable or no longer registered for their intended purpose they become obsolete. Obsolete pesticides should be safely and securely stored until they are centralized, safeguarded and shipped for disposal [16]. For some pesticide

products there could be the option of returning the products to the supplier. Any spray equipment that is no longer serviceable should be removed from the inventory, decontaminated, disassembled and disposed. Repackaged and safeguarded waste of DDT and other obsolete pesticides should be clearly labelled as specified by FAO [69].

Most Parties to the Stockholm Convention have data available on their national inventories of DDT stocks and obsolete DDT, as part of their National Implementation Plans on POPs [70]. Some countries have recently disposed of their DDT stocks, or part of their stocks, for example, in the context of the Africa Stockpiles Programme or under other GEF-funded projects.

Disposal of unwanted stockpiles and waste

Methods of disposal of DDT and other vector control insecticides should ensure compliance with international standards for hazardous materials. Solid waste of DDT should be disposed through incineration at high temperature carried out at appropriate facilities [59]. Only certain countries have the capacity for high-temperature incineration, which implies that transboundary shipments of stocks and waste will be inevitable for the final disposal.

The Basel Convention can assist in managing disposal of unwanted stockpiles of DDT, waste contaminated with DDT, and other obsolete pesticides [68]. DDT is covered under the Basel Convention as an eco-toxic substance, which can bio-accumulate and/or have toxic effects upon biotic systems. The Basel Convention aims to minimize the transboundary movement of hazardous wastes and stipulates that any transboundary movement is conducted in a way which protects human health and the environment [68].

Under the Convention, transboundary movements of hazardous wastes or other wastes can only take place if certain conditions are met and certain procedures are followed. Transboundary movement is only approved among Parties to the Convention. A country may export the hazardous waste only if it does not itself have the capacity for environmental sound disposal. Countries have the right to prohibit import of hazardous waste for disposal.

Moreover, transboundary movement should follow the strict requirements of the Prior Informed Consent Procedure (PIC) of the Basel Convention. This procedure consists of four stages: (i) notification of the importer about the proposed shipment; (ii) written consent and issuance of the movement document; (iii) transboundary movement; and (iv) confirmation of disposal provided to the exporting country.

10.2 Key points for M&E

- Is there a legislation and/or regulation to prevent re-use of empty pesticide containers [67]?
- Is stock management in place that prevents the accumulation of obsolete or expired pesticides [66]?

- Are accurate and updated inventory data available for obsolete DDT and other vector control insecticides?
- Are obsolete pesticides safely and securely stored until they are centralized, safeguarded and shipped for disposal [16]?
- Are waste and obsolete stocks of DDT being prepared for disposal at a high-temperature incineration facility?
- If DDT is exported (or was recently exported) for disposal, is (was) this done in accordance with the conditions and requirements of the Basel Convention [68]?

10.3 Key documents

- FAO/WHO (2008). Guidelines on management options for empty pesticide containers. http://www.who.int/whopes/recommendations/Management_options_empty_pesticide_containers.pdf. Rome & Geneva, Food and Agriculture Organization of the United Nations and World Health Organization.
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ANNEX. SET OF KEY POINTS FOR M&E

Production, formulation, import and export	1	Is the siting of manufacturing and formulating plants and stores safe?
	2	Is adequate monitoring and control of wastes, emissions and effluents at production facilities in place?
	3	Are measures in place at production facilities to protect workers, bystanders, surrounding communities and the environment?
	4	Are quality-assurance procedures maintained to ensure compliance with the relevant standards of purity, performance, stability and safety?
	5	Are manufacturers or formulators of DDT and other vector control insecticides registered, certified, and regulated?
	6	Does export and import of DDT abide by the provisions of the Stockholm Convention and Rotterdam Convention?
Registration	7	Is a registration scheme for pesticides in place, and if yes, does the registration of DDT and other vector control insecticides follow the required process and instructions?
	8	Have dossiers on DDT and other vector control insecticides been comprehensively evaluated for registration?
	9	Have the technical data (e.g. efficacy, human health and environmental effects) of each insecticide been reviewed?
	10	Have registration decisions on vector control insecticides been disseminated to all stakeholders?
	11	Have enforcement officers been instructed about registration decisions on vector control insecticides?
	12	Are the efficacy and, if possible, the adverse effects of DDT or other vector control insecticides locally verified?
	13	Is the registration of DDT or other vector control insecticides reviewed periodically?
	14	Is inspection of unauthorized trade and use of DDT and other vector control insecticides conducted routinely?
Procurement	15	Is the selection of insecticide products for IRS in accordance with the WHO recommendations, and consistent with the Global Plan for Insecticide Resistance Management [2, 36]?
	16	Is the amount of the procured pesticides carefully estimated based on information about populations to be covered, expected disease incidence, existing stocks, and shelf life?
	17	Are legislations and regulations as well as guidelines in place to ensure that the procurement process is efficient, transparent and fair?
	18	Do offers to procurement tenders undergo an independent technical and financial evaluation?
	19	Is quality control of the procured pesticides conducted through an independent and certified laboratory?
	20	Are systematic records kept on the distribution and use of the procured products?
Pesticide quality control	21	Is a regulatory system in place to have active ingredient, physical and chemical properties and relevant impurities of registered vector control insecticides independently verified using accredited test methods?
	22	Is post-registration inspection, laboratory testing and corrective action conducted for DDT and other vector control insecticides?
	23	Does inspection cover the quality of pesticide, its packaging and labelling?
Transport and distribution	24	Is legislation and/or regulation in place to ensure safe transport of pesticides?
	25	Are basic safety rules for pesticide transport applied at all times?
	26	Are pesticide truck drivers trained on safety rules for pesticide transport?
	27	Is personnel prepared to deal with a pesticide accident or spillage involving DDT or other vector control insecticides in accordance with safety standards?

Storage and stock management	28	Do central store and all local stores comply with standard safety and security requirements?
	29	Are stocks managed according to the 'first-in-first-out' principle?
	30	Are non-contaminated, empty containers available for repacking of damaged ones?
	31	Is vector control insecticide use routinely tracked and inventory records kept up to date and organized?
	32	Are signs of deterioration or corrosion of pesticide containers regularly inspected?
	33	Are spills dealt with according to safety standards and is contaminated material treated as toxic waste?
	34	Are stores adequately prepared for emergency situations (e.g. fire)?
	35	Are personal protection and good hygiene practices applied by store personnel at all times?
Application in disease vector control	36	Are decisions on the deployment of IRS made based on contemporary evidence on the biting and resting behaviour of the main local disease vectors?
	37	Is personal protective equipment (PPE) mandatory and actually used by spray operators during IRS operations?
	38	Is spray equipment regularly tested, calibrated and serviced, and properly stored when not in use?
	39	Do spray operators and their supervisors receive certified training and refresher courses on methods of IRS?
	40	Are IRS spray records kept, data reported and supervision visits made?
	41	Does the clean-up after spraying use the progressive rinse method?
	42	Is DDT-contaminated rinse water re-used, or disposed and collected in an evaporation tank?
	43	Is insecticide resistance routinely monitored at sentinel sites, using standard bioassays, and is a resistance management strategy in place?
	44	Is the health of spray workers routinely monitored for signs and symptoms of pesticide poisoning?
	45	Is a pesticide incident reporting system in place for the surveillance of adverse pesticide effects on human health and the environment?
Safe disposal of waste and obsolete stocks	46	Is there a legislation and/or regulation to prevent re-use of empty pesticide containers?
	47	Is stock management in place that prevents the accumulation of obsolete or expired pesticides?
	48	Are accurate and updated inventory data available for obsolete DDT and other vector control insecticides?
	49	Are obsolete pesticides safely and securely stored until they are centralized, safeguarded and shipped for disposal?
	50	Are waste and obsolete stocks of DDT being prepared for disposal at a high-temperature incineration facility?
	51	If DDT is exported (or was recently exported) for disposal, is (was) this done in accordance with the conditions and requirements of the Basel Convention?