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Item 5 (d) of the provisional agenda**

Matters related to the implementation of the Convention: implementation plans

Draft guidance on preparing inventories of dicofol

Note by the Secretariat

As is mentioned in the note by the Secretariat on the implementation plans (UNEP/POPS/COP.10/10), the annex to the present note sets out a draft guidance on preparing inventories of dicofol. The present note, including its annex, has not been formally edited.

* Face-to-face resumed meetings of the conferences of the Parties to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade and the Stockholm Convention on Persistent Organic Pollutants are tentatively scheduled to take place in 2022.

** UNEP/POPS/COP.10/1.

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Annex

Draft guidance on preparing inventories of dicofol

March 2021

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The feedback from Parties and observers to the Stockholm Convention on Persistent Organic Pollutants are highly appreciated.

Disclaimers:

In the event of any inconsistency or conflict between the information contained in this non-binding guidance document and the Stockholm Convention on Persistent Organic Pollutants (POPs), the text of the Convention takes precedence, taking into account that the interpretation of the Stockholm Convention remains the prerogative of the Parties.

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1. Introduction[1]

1.1 Dicofol under the Stockholm Convention

In May 2013, the European Union submitted a proposal to list dicofol in Annex A, B and/or C of the Stockholm Convention (UNEP/POPS/POPRC.9/3, UNEP, 2013b). This proposal was considered by the Persistent Organic Pollutants Review Committee (POPRC) at its ninth and tenth meetings held in October 2013 and 2014.

At its twelfth meeting in September 2016, POPRC reviewed and adopted a revised draft risk profile on dicofol. The POPRC concluded that dicofol is likely, as a result of its long-range environmental transport, to lead to significant adverse human health and environmental effects such that global action is warranted. At its thirteenth meeting in October 2017, by its decision POPRC-13/1, the Committee adopted a risk management evaluation for dicofol (UNEP/POPS/POPRC.13/7/Add.1, UNEP, 2016) and decided, in accordance with paragraph 9 of Article 8 of the Stockholm Convention on Persistent Organic Pollutants, to recommend to the Conference of the Parties to the Stockholm Convention that it consider listing dicofol in Annex A to the Convention without specific exemptions.

At its ninth meeting in May 2019, after considering the risk profile and the risk management evaluation for dicofol as transmitted by POPRC and taking note of the recommendation by the Committee, by its Decision SC-9/11, the Conference of the Parties amended part I of Annex A to the Stockholm Convention on Persistent Organic Pollutants to list dicofol without specific exemptions.

1.2 Purpose of the guidance

Under Article 7, paragraph 1 (a) of the Stockholm Convention (UNEP, 2018), it is a mandatory requirement that all Parties develop and endeavour to implement a plan for the implementation of its obligations under the Convention. Furthermore, Article 15, paragraph 1 of the Convention requires each Party to report to the Conference of the Parties on the measures it has taken to implement the provisions of the Convention and on the effectiveness of such measures in meeting the objectives of the Convention.

To develop effective strategies for dicofol and the environmentally sound management of stockpiles and wastes containing this chemical, Parties need to acquire a sound understanding of their national situation concerning its production, uses and releases. Such information can be obtained through an inventory of products and waste containing dicofol and sites that may be contaminated with dicofol.

The critical issues in developing an emission inventory are two-fold, firstly the availability of accurate and detailed information needed in development of inventories; and secondly the approach adopted to ensure the inventory is i) robust and defensible and ii) comparable to work of other nations also developing inventories. Therefore, the development of guidance documentation in this regard is of high value to support this work.

The purpose of this document is, therefore, to provide the necessary information and guidance to policy makers to enable them to fulfil their nation's obligations under the Stockholm Convention. Specifically, this guidance provides details in relation to how Parties to the Stockholm Convention can develop inventories of dicofol to assist in the elaboration of a national implementation plan for dicofol.

The structure and organisation of the inventory is always dependent on local circumstances and priorities of the country. Therefore, this guidance is not prescriptive but rather provides ideas for tailoring the approach.

1.3 Other guidance documents to be consulted

The users of this guidance should also consult *General guidance on POPs inventory development* (UNEP/POPS/COP.9/INF/19/Add.1, UNEP, 2019b) and other guidance documents to support review and updating of national implementation plans available on the website of the Stockholm Convention.[2] Users may also wish to consult FAO guidance on pesticide inventories, including *The preparation of inventories of pesticides and contaminated materials* (FAO, 2010).[3]

[1] This chapter has been adapted from the Guidance on preparing inventories of pentachlorophenol and its salts and esters (UNEP, 2019).

[2] http://chm.pops.int/tabid/7730/Default.aspx.

[3] http://www.fao.org/agriculture/crops/obsolete-pesticides/resources0/en/.

1.4 Objective of the inventory

The main objective of the inventory is to obtain information needed for the implementation of Parties' obligations of the Stockholm Convention. More specifically, the objectives are to:

- Establish a country baseline with respect to dicofol import or production, formulation, use, stockpile, disposal and the presence of any contaminated sites;
- Provide the basis for development of a strategy in the National Implementation Plan (NIP) (i.e., identify the economic sectors that should be prioritized and the type of actions required for those sectors);
- Report to the Conference of the Parties to the Stockholm Convention on progress made to eliminate dicofol through national reporting; and
- Identify areas where financial or technical support are needed (when resources are limited, to fulfil the obligations of the Convention).

The information obtained about dicofol through the inventory includes the following:

- Past and current production and/or formulation of dicofol at the national level;
- Uses of dicofol;
- Import/export of dicofol for use;
- Alternatives to dicofol available/used in the country;
- Waste management practices for dicofol products;
- Any stockpiles of dicofol or wastes containing dicofol;
- Import/export of dicofol containing waste for environmental sound destruction; and
- Sites identified as being potentially contaminated with dicofol.

Information collected on the above will provide a broad understanding of the sources of dicofol, the scope of their impacts and the risks that they pose to human health and the environment in a country. The information is important for Parties to evaluate whether they comply with obligations under the Convention regarding dicofol and identify areas where they need to develop effective strategies and action plans for managing dicofol in order to meet the obligations.

Information collected as part of the inventory will also provide a valuable basis for Parties to report to the Conference of Parties on measures taken to implement the provisions of the Convention and the effectiveness of such measures (reporting under Article 15).

The inventory process is usually iterative. In establishing the inventory of PCP for the first time, Parties will also identify resources and technical capacity needed to further improve the accuracy of the inventory.

2. How to develop an PCP inventory [4]

2.1 Introduction

Please refer to General guidance on POPs inventory development (UNEP/POPS/COP.9/INF/19/Add.1, UNEP, 2019b) for general approach to developing national inventories. The guidance describes general process to be taken in making an inventory. In summary, the following steps are taken:

Step 1:	**Initiating the inventory development process**
	Establishing a national inventory team
	Identifying relevant stakeholders
	Defining the scope of the inventory
	Developing a workplan

[4] This chapter has been adapted from the Guidance on preparing inventories of pentachlorophenol and its salts and esters (UNEP, 2019).

Contacting the stakeholders

Step 2: Choosing data collection methodologies

Indicative method

Qualitative method

Quantitative method

Step 3: Collecting and compiling data

Tier I: Initial assessment

Tier II: Main inventory

Tier III: In-depth inventory

Step 4: Managing and evaluating the data

Step 5: Preparing the inventory report

A process flow chart is found in Appendix 1.

2.2 Step 1: Initiating the inventory development process

For general description of Step 1, please refer to Chapter 2.2 of General guidance on POPs inventory development (UNEP/POPS/COP.9/INF/19/Add.1, UNEP, 2019b).

In initiating the inventory development process, Parties are advised to establish a multi-stakeholder national inventory team. It is important to clearly define the responsibilities of the national inventory team in developing the inventory as to streamline the work.

To define the scope of the inventory, the national inventory team should identify relevant stakeholders who will be contacted for the information in the process. Potential sectors and stakeholders involved in the life-cycle of dicofol are listed in Table 1 below.

Table 1: Sectors and stakeholders involved in the production, use or impact of dicofol

Production	Stakeholders
General stakeholders	Ministry of environment and ministry of industry Ministry of agriculture and food Pesticides authority and/or registrar Ministry responsible for waste management NIP coordinator and steering committee Basel Convention[5] focal point (and stakeholders in Basel) Rotterdam Convention[6] focal point (and stakeholders in Rotterdam) Custom authorities NGOs

[5] The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (UNEP, 2020a), hereby referred to as "The Basel Convention", is an international treaty signed in 1998 that was designed to reduce the movements of hazardous waste between nations, and specifically to prevent transfer of hazardous waste from developed to less developed countries. As part of the wider work on 'POPs', the Basel, Rotterdam and Stockholm conventions share the same executive body.

[6] The Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (UNEP, 2020b), hereby referred to as 'The Rotterdam Convention', is an international treaty signed in 1998 that was designed to promote shared responsibility and cooperative efforts among Parties in the international trade of certain hazardous chemicals in order to protect human health and the environment from potential harm and to contribute to their environmentally sound use, by facilitating information exchange about their characteristics, by providing for a national decision-making process on their import and export and by disseminating these decisions to Parties.

Production	Stakeholders
Dicofol importation, production and/or formulation	Authorities granting importation and/or production permits Industry importing, manufacturing, formulating products Custom authorities
Distribution and sale of dicofol containing products	Formulators, distributors, retailers Agricultural extension workers Agricultural cooperatives Agricultural/farmers' unions
Use of dicofol	Agricultural extension workers Agricultural cooperatives Agricultural/farmers' unions
End-of-life	Formulators, distributors, retailers (who take back containers) Recyclers, waste handlers Owners/operators of waste disposal facilities/sites Agricultural extension workers Agricultural cooperatives Agricultural/farmers' unions

2.3 Step 2: Choosing data collection methodologies

There are a number of different approaches that have been used for gathering information for POPs inventories, such as indicative methods, qualitative methods and quantitative methods. For more information on those methodologies, please refer to Chapter 2.3 of General guidance on POPs inventory development (UNEP/POPS/COP.9/INF/19/Add.1, UNEP, 2019b).

Questionnaires are valuable instruments for primary data collection in inventory programs. Based on contact and consultation meetings with stakeholders, questionnaires with explanatory notes can be developed and sent to the relevant stakeholders to gather the information needed to compile data for a Tier II or Tier III assessment. Appendix 2 provides sample questions that could be used to gather information on dicofol. Data may also be available in a national inventory of obsolete pesticide stocks.

2.4 Step 3: Collecting and compiling data

For general description of Step 3, please refer to Chapter 2.4 of General guidance on POPs inventory development (UNEP/POPS/COP.9/INF/19/Add.1, UNEP, 2019b).

An initial assessment (Tier I) is carried out to obtain an overview of the relevant uses and stakeholders to be contacted in the key sector under investigation. Tier I methods usually rely on available literature and statistics in combination with calculations based on already existing information, such as the risk profile (UNEP/POPS/POPRC.12/11/Add.1, UNEP, 2016) and risk management evaluation (UNEP/POPS/POPRC.13/7/Add.1, UNEP, 2017b) adopted by the POPs Review Committee.

The main inventory (Tier II) will follow to generate data on the main sectors through interviews and questionnaires to the national stakeholders, and further identify missing information. This could also include actions such as desk study on pesticides storage facility contents.

If needed, and resources are available, a more in-depth inventory (Tier III) can be initiated after evaluation of the data gathered in the main inventory.

The inventory team should investigate whether the following data exist in the country:

- Former and current production or formulation of dicofol;
- Sectors using or formerly using dicofol;
- Products containing dicofol in use or previously used;
- Imports and exports of products and articles containing dicofol;
- Disposal practices for products and articles containing dicofol when they become wastes;

- Articles (i.e., containers) that contained dicofol that were recycled, the possible extent of recycling, and the types of articles produced from recycling, including the life-cycle of dicofol and its potential for releases;
- Stockpiles and wastes from current and former production, formulation and use in industries (countries that produced/produce dicofol or used/use dicofol); and
- Sites with activities that could have potentially contaminated the sites or environment with dicofol.

It is desirable to collect and compile the following numerical data in the inventory:

- Quantities of dicofol formerly and currently produced, traded nationally and exported;
- Quantities of dicofol currently or historically used in agriculture and domestic settings.
- Quantities of products containing dicofol (i.e., pesticide containers) recycled and quantities of products made from recycling;
- Quantities of waste generated containing dicofol.

Data collection approaches will vary from country to country based on the data gathered in steps 1 and 2; they may be by estimation, using statistical data, industry provided data or possibly measurement.

The focal sectors to be investigated in the national inventory fall under following key areas:

- Dicofol production and formulation;
- Dicofol sales and extent of use in agriculture and domestic settings;
- Used dicofol containers collected, recycled and disposed of; and
- Identification of contaminated sites and hot spots.

2.5 Step 4: Managing and evaluating the data

For general description of Step 4, please refer to Chapter 2.5 of General guidance on POPs inventory development (prescriptive) (UNEP/POPS/COP.9/INF/19/Add.1, UNEP, 2019b).

The compiled data (draft inventory) should be assessed by stakeholders and possibly by an external expert. Depending on the feedback, further information may need to be gathered.

2.6 Step 5: Preparing the inventory report

The final stage of the inventory is preparation of the inventory report. This report includes results of inventories of all key sectors investigated by the country compiled in a single document.

The essential elements of the report are:

- Objectives and scope;
- Description of data methodologies used and how data were gathered, including all the assumptions and conversion factors adopted as a result of expert judgment;
- Final results of the inventory for each sector considered a priority for the country (see Appendix 3 for a possible format);
- Results of the gap analysis and limitations identified for completion of the inventory;
- Further actions (e.g., stakeholder involvement, data collection strategies) to be taken to complete the inventory and recommendations.

Other information (e.g., stakeholder list) could be included in the report depending on national preferences.

3. Information on dicofol

3.1 Production of dicofol

3.1.1 Description of the characteristics of dicofol

The following information taken from the dicofol risk profile (UNEP/POPS/POPRC.12/11/Add.1, UNEP, 2016) provides a brief overview of the physical data for dicofol and its degradation products.

Table 2: Chemical identity of dicofol

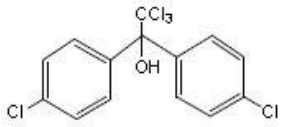
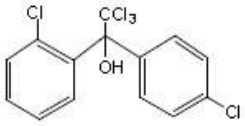
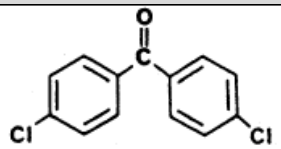
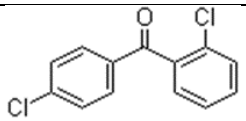
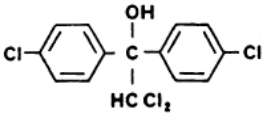
Common name **IUPAC name** **CAS chemical name**	Dicofol 2,2,2-trichloro-1,1-bis(4-chlorophenyl)ethanol Benzenemethanol, 4-chloro-α-(4-chlorophenyl)-α-(trichloromethyl)- (CAS Registry)[7] 4-chloro-alpha-(4-chlorophenyl)-α-(trichloromethyl) benzene-methanol (WHO, 1996) 1,1-bis(4'-chlorophenyl)2,2,2-trichloroethanol (UNEP/POPS/POPRC.9/3)
Other names	1,1-bis(4-chlorophenyl)-2,2,2-trichloroethanol and 1-(2-chlorophenyl)-1-(4-chlorophenyl)-2,2,2-trichloroethanol (*p, p'*- and *o,p'*-isomer) (US EPA, 1998)
CAS registry number	115-32-2 (dicofol; *p,p'*-dicofol); 10606-46-9 (*o,p'*-dicofol)
Trade name	1,1-bis(chlorophenyl)-2,2,2-trichloroethanol; 4-chloro-α-(4-chlorophenyl)-α-(trichloromethyl)-; Acarin; Benzenemethanol; Carbax; Cekudifol; CPCA; Decofol; Dicaron; Dichlorokelthane; Dicomite; Difol; DTMC; ENT 23648; FW293; Hilfol; Hilfol 18.5 EC; Kelthane; Kelthanethanol; Kelthane A; Kelthane (DOT); Kelthane Dust Base; Kelthane 35; Milbol; Mitigan; *p,p'*-dicofol; NA2761 (DOT); NCI-C00486 (WHO, 1996).
Molecular formula	$C_{14}H_9Cl_5O$
Molecular weight	370.49
Structural formulas of the isomers	 p,p'-dicofol CAS No. 115-32-2  o,p-'dicofol CAS No. 10606-46-9

Table 3 Chemical identity of environmental degradation products of dicofol

Chemical (CAS Number)	Chemical Name	Molecular weight (g/mole)	Structure
p,p'-DCBP (90-98-2)	4,4'-dichlorobenzophenone	251	
o,p'-DCBP (85-29-0)	2,4'-dichlorobenzophenone	251	
p,p'-FW-152	1,1-bis(4-chlorophenyl)-2,2-dichloroethanol	336	

[7] http://www.cas.org/content/chemical-substances.

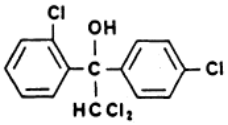
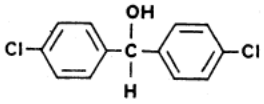
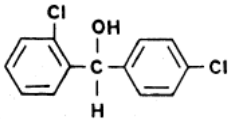
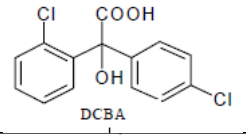
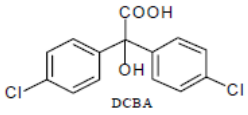
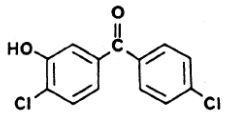
Chemical (CAS Number)	Chemical Name	Molecular weight (g/mole)	Structure
o,p'-FW-152	1-(2-chlorophenyl)-1-(4'-chlorophenyl)-2,2-dichloroethanol	336	
p,p'-DCBH (90-97-1)	4,4'-dichlorobenzhydrol	253	
o,p'-DCBH (43171-49-9)	2,4'-dichlorobenzhydrol	253	
o,p'-DCBA	2,4'-dichlorobenzilic acid	297	
p,p'-DCBA (23851-46-9)	Bis(4-chlorophenyl)(hydroxy)acetic acid, 4,4'-dichlorobenzilic acid	297	
3-OH-*p,p'*-DCBP	3-hydroxy-4,4'-dichlorobenzophenone	267	

Table 4 Selected physical and chemical properties of dicofol

Property	Results	Source
Melting point, ºC	77.5 78.5 - 79.5	Mackay et al. (2006) Tomlin (2001) in Rasenberg (2003)
Boiling point, °C	180 193 225	0.1 mmHg, Mackay et al. (2006) 360 mmHg, tech., Mackay et al. (2006) 665 Pa, UNEP/FAO/RC/CRC.2/14/Add.4 (UNEP, 2005)
Density, g/cm³	1.45	Tomlin (1994) in Mackay et al. (2006)
Solubility in water, mg/L, at 25°C	0.8 1.32	Mackay et al. (2006) US EPA (2009)
Vapeur Pressure, Pa, at 25ºC	5.3 x 10-5 2.5 x 10-4	Mackay et al. (2006) PPDB (2012) in UNEP/POPS/POPRC.8/INF/13 (UNEP, 2012)
Henry's Law Constant	5.66 x 10-5 Pa m3/mol (25ºC) 2.45 x 10-2 Pa m3/mol (25ºC) 1.44 x 10-7 atm m2/mol	Mackay et al. (2006) PPDB (2012) cited in UNEP/POPS/POPRC.8/ INF/13 (UNEP, 2012), Saito et al. 1993 in Zhong et al. (2014) US EPA (1998)
Partition coefficient octanol/water (log KOW)	3.5 3.54 – 4.28 4.08 – 5.02 5.02 6.06	Kelly et al. (2007) Mackay et al. (2006) Rasenberg (2003) Li et al. (2014a), measured value recommended by EPI SUITE TM US EPA (2009), measured value
Partition coefficient organic carbon/water (log KOC)	3.8	US EPA (2009)
Partition coefficient air/water (log KAW)	-5.01	UNEP/POPS/POPRC.8/INF/13 (UNEP, 2012) (measured value recommended by EPI Suite v 4.0)
Partition coefficient air/octanol (log KOA)	8.9 9.3	Kelly et al. (2007)

Property	Results	Source
	10.03	UNEP/POPS/POPRC.8/INF/13 (UNEP, 2012) (estimated value, EPI Suite v 4.0) Li et al. (2014a)

Table 5. Selected physical and chemical properties of dicofol degradation products

Name	Water solubility	Log K_{OW}	Log K_{AW}
DCBP	3.8 mg/L at 25°C [b] 7.8 mg/L[b]	4.44[a] 4.62 (experimental)[b]	-5.005[a]
FW-152	1.6 mg/L at 25°C 1.8 mg/L	4.85[a]	-4.436[a]
DCBH	28.3 at 25°C[b] 19.2 mg/L[b]	4.0[a]	-6.404[a]
DCBA	99.7 at 25°C [b] 306.09 mg/L[b]	3.54[b]	-7.903[b]
3-OH DCBP	30.2 mg/L at 25°C (WSKOWv1.42)[c] 235.9 mg/L[c]	3.96[a] 4.15[b]	-8.343[a]

[a] US EPA (2009), maximal value derived in EPIsuite.
[b] Chemspider (2015).
[c] EPISUITE (2015).

3.1.2 Dicofol as a source of DDT, dioxins and furans

Dicofol has been manufactured from technical DDT by hydroxylation of DDT. DDT content ranging from 0.1% to 24.4% have been reported (UNEP/POPS/POPRC.12/11/Add.1). In several countries, regulations exist with respect to the ΣDDT content of commercial dicofol. The FAO/WHO Specification 123/TC/S/F (1992) requires ΣDDT to be less than 0.1%. Dicofol is produced in a closed system but improper production practices may result releases. A study of a closed system dicofol production process in China found DDT in the indoor air, waste water and final product. Most of the DDT released to the environment was associated with the use of the dicofol and was estimated to be 9,480 kg ΣDDT and 1,080 kg p,p'-DDT per year (Li et al., 2014b). Atmospheric concentrations of DDT over the Taihu Lake, near Shanghai, were identified as being linked with the manufacture of dicofol at a plant on the north side of the lake (UNEP/POPS/POPRC.13/7/Add.1, UNEP, 2017b).

Polychlorinated dibenzo dioxins and furans (PCDD/F) are a family of chemicals, which, because of their physical properties and toxicity, represent a risk to human health and the environment. Such are the concerns for these substances that they were two of the twelve POPs targeted by the Stockholm Convention since its entry into force in 2004, with a listing in Annex C. While dioxins and furans have no known commercial use, they are created unintentionally by a number of activities, with combustion in particular an important pathway for the generation and release to environment of dioxins and furans.

As dioxins and furans are listed in Annex C to the Stockholm Convention, there are obligations placed upon Parties to develop and report source inventories and release estimates for these substances, and to take action to minimise and ultimately eliminate their release. A study of releases of PCDD/F from a closed system dicofol production process in China suggested that that the major pathway for PCDD/F formation involves precursor synthesis during the production of dicofol in the closed-system process (UNEP/POPS/POPRC.12/11/Add.1, UNEP, 2016). The estimated annual release of PCDD/F to the environment was estimated to be 0.17 g I-TEQ (toxicity equivalent value) from this particular facility (UNEP/POPS/POPRC.12/11/Add.1, UNEP, 2016). Dioxins and furans were not only found in waste water and waste acid, but also in the dicofol products itself (UNEP/POPS/POPRC.13/7/Add.1, UNEP, 2017b).

This guidance document is intended to aid the reader in the development of inventories for dicofol. Guidance on the development of estimates for dioxins and furans is available within the UNEP Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP, 2013b). While Table III.2.2 of the Toolkit includes a value of 84 µg TEQ/t of dicofol production, there was insufficient information to derive a default emission factor.

3.1.3 Intentional production and trade of dicofol

Dicofol is an organochlorine miticidal pesticide, used to control mites on a variety of crops. Dicofol was introduced commercially in 1955. The substance has been used primarily in East and Southeast Asia, the Mediterranean coast,

as well as in Northern and Central America. Intended uses of dicofol cover fruits, vegetables, ornamentals, field crops, cotton, tea, and Christmas tree plantations. Between 2000 and 2007, global production of dicofol was estimated to have been 5,500 t/y but production has declined sharply as a number of countries have phased out production and usage, including Benin, Brazil, Canada, Columbia, EU Member States, Guinea, Indonesia, Japan, Mauritania, Oman, Saudi Arabia, Sri Lanka, Switzerland and USA. Production of dicofol now predominantly takes place in a small number of nations, with key production remaining in South Asia. (UNEP/POPS/POPRC.13/7/Add.1, UNEP, 2017b)

Until recently, China was one of the major global producers of technical DDT and dicofol, producing approximately 97,000 t of technical DDT between 1988 and 2002, of which about 54,000 t was used to manufacture dicofol (40,000 t of dicofol produced). In 2014, the last remaining technical dicofol producer in China ceased production of technical dicofol. Dicofol is produced in India in a closed system in batches, at a level of 93 t in 2015-2016. Production also ceased in Brazil in 2014. Remaining stock in Brazil are expected to have been fully used/destroyed by 2015. There is currently no production in Europe. Spain was the major manufacturer and consumer (90 t in 2006) of dicofol in Europe until 2006 Production of dicofol ceased in the US in 2011 and the US EPA issued a cancelation order that mandated that the sale and distribution of dicofol end by 31 December 2013 and all use of dicofol by 31 October 2016 (UNEP/POPS/POPRC.13/7/Add.1, UNEP, 2017b).

In its decision SC-7/1 (UNEP/POPS/COP.7/36) the COP extended the exemption to produce and use of DDT as a closed-system site-limited intermediate in the production of dicofol until May 2024. Based on the information available to the POPRC, production is now predominantly limited to a facility based in India (UNEP/POPS/POPRC.13/7/Add.1, UNEP, 2017b).

Dicofol is subject to a number of agreements, regulations and action plans (UNEP/POPS/POPRC.13/7/Add.1, UNEP, 2017b):

- In December 2009 dicofol was proposed to be added to Annex I (prohibition of production and use) of the Aarhus Protocol on Persistent Organic Pollutants (POPs) under the Convention on Long-Range Transboundary Air Pollution (LRTAP). The POPs Task Force (except for one expert) concluded that dicofol met the indicative numerical values of the Executive Body decision 1998/2. However, no finalised action for dicofol under the LRTAP POPs Protocol was taken pending further consideration under the Stockholm Convention. In December 2013, the Executive Body of LRTAP decided to defer any discussion of dicofol until after COP7 of the Stockholm Convention in 2015 (USA, 2015 as cited in UNEP/POPS/POPRC.13/7/Add.1, UNEP, 2017b);
- The Oslo and Paris Conventions (OSPAR) Commission included dicofol in the List of Chemicals for Priority Action (by 2004);
- In 2012, the Chemical Review Committee of the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade considered if dicofol met the requirements of the Convention. The Committee had before it two notifications and supporting documentation on dicofol submitted by the European Union and Japan. The Committee decided that, as only one of these notifications of final regulatory action from one prior informed consent region had met the criteria set out in Annex II, so dicofol could not be recommended for inclusion in Annex III to the Convention at the current time;
- Since 2009 the specific exemptions for DDT listed in Annex B of the Stockholm Convention as an intermediate in the production process of dicofol have expired and no new registrations may be made with respect to such exemptions. However, after a request from India (UNEP/POPS/COP.7/INF/3, UNEP, 2015b), the expiry date for the production and use of DDT as a closed-system site-limited intermediate that is chemically transformed in the manufacture of other chemicals that, taking into consideration the criteria in paragraph 1 of Annex D, do not exhibit the characteristics of persistent organic pollutants has been extended from June 2014 to May 2024, upon notification to the Secretariat. In March 2014, India submitted a notification to the Secretariat relating to the production and use of 150 t DDT. To date, this is the only submission of notification to the Secretariat. The exemption for use of DDT as a closed-system site-limited intermediate to produce dicofol expired for Brazil in 2014 and China withdrew their exemption for this use the same year.

3.2 Uses of dicofol

Dicofol is used as miticidal pesticide in many countries around the world and reported to be applied to food, feed, and cash crops including apple, citrus, lichi, longan, pear, leafy vegetables, tea, and cotton. It is also used on

ornamentals such as orchids. In Senegal, dicofol is used on onion, watermelon, potato and pimento crops. In Mexico, there are 17 registrations for dicofol, which is authorized for the application on aubergine, chilli, strawberry, lime, apple, orange, pear, watermelon, mandarin, grapefruit, vine, citrus fruits, ornamental shrubs, ornamental plants and nursery gardens. In Brazil dicofol was used an acaricide for cotton, citrus and apple crops. However, this usage was banned after the registration for use of dicofol as a pesticide was removed in 2015. It is reported to be restricted or prohibited in most developed countries. In Canada, use has not been permitted since 2011, and in the USA, use will not be permitted after 2016. Dicofol is banned in Benin, Côte d'Ivoire, the European Union, Guinea, Iraq, Indonesia, Japan, Mauritania, Oman, Saudi Arabia, and Switzerland (UNEP/POPS/POPRC.12/11/Add.1, UNEP, 2016).

The declining use since 2000 suggests that global dicofol use is currently well below 1,000 t/y and likely closer to 50 t/y, the production level in Asia. It is estimated that global use of dicofol declined about 80% from 3,350 t in 2000 to 730 t in 2012. Over that period, use decreased by 75% in China (from 2,013 t to 530t), 69% in India (from 145 t to 43 t) and 90% in the USA (from 323 t to 33 t). A total of 28,200t of dicofol was used globally in the 13-year period (2000 to 2012) with largest use occurring in Asia (21,719 t; 77% of global usage), followed by North America (1,817 t), Europe (1,745 t), Latin America (1,538 t), Africa (1,434 t) and Oceania (13 t). China was the main user of dicofol during this time (69% of global total). The major consuming countries in Europe in 2000 were Spain, Italy, Turkey, Romania, and France (UNEP/POPS/POPRC.12/11/Add.1, UNEP, 2016).

3.3 Dicofol in stockpiles, products and waste

There is little information on stockpiles, products and waste containing dicofol. In Canada, sales of dicofol were voluntarily discontinued in Canada in December 2008 and remaining stocks were to be used by 31 December 2011. After production ceased in the US, existing stocks provision allowed the registrant to reformulate it into end-use products and sell it until 31 October 2013. Sale and distribution by others were allowed until 31 December 2013, and use prohibited after 31 October 2016 (UNEP/POPS/POPRC.13/7/Add.1, UNEP, 2017b). Once production ceased in Brazil in 2014, according to the agreement between the Brazilian government and producers, remaining stockpiles in Brazil would have been fully used/destroyed by 2015 (UNEP/POPS/POPRC.12/11/Add.1, UNEP, 2016).

Dicofol has been formulated into products for agricultural (commercial) and domestic (residential or home and garden) use.[8] In its 1998 Reregistration Eligibility Decision the US EPA determined that residential risk is not a concern since all residential uses had been voluntarily cancelled (US EPA, 1998).

The management of obsolete stock of dicofol presents a challenging issue due to the complexity of the supply chain and end users. Dicofol products have been designed both for use on crops within larger scale operations, and for use on ornamentals such as orchids and rosebushes. Product size can also vary significantly from as small as 1 litre containers to 200 kg containers. This makes the identification, collection, and secure destruction of dicofol stocks particularly challenging due to the disperse nature and the locations of remaining stock. A study that reviewed the management of obsolete stocks of pesticides in Kenya found the presence of dicofol-based products at three sites (UNEP/POPS/POPRC.13/7/Add.1, UNEP, 2017b).

Although global production and use of dicofol has undergone significant reductions, there may potentially be stock of dicofol remaining in a number of locations across the globe. Additionally, the continued manufacture and sale of dicofol is still ongoing in a limited number of countries. Production of dicofol especially in open systems represents a high risk, both from direct exposure of workers and also the generation of wastes contaminated with both dicofol and DDT (UNEP/POPS/POPRC.13/7/Add.1, UNEP, 2017b).

3.4 Sites potentially contaminated by dicofol

Contaminated sites, particularly at former manufacturing sites, remain a concern. Dicofol has been produced and formulated by a number of operators in a wide set of geographies spanning most continents. Chen and Kwan (2013) highlighted the significance of dicofol manufacture for the emissions to environment of dicofol, and contamination of soil, sediment and biota (UNEP/POPS/POPRC.13/7/Add.1, UNEP, 2017b). The ratio of o,p'-/ p,p'-DDT has been used in literature to distinguish between DDT and dicofol as source of ΣDDT. But to use isomer ratios for the estimation of their emission source, the environmental fate of the two isomers should also be taken into consideration (e.g. differing volatility from soil to air, stability in soil, air water fluxes and bioaccumulation) (UNEP/POPS/POPRC.12/11/Add.1, UNEP, 2016).

Dicofol was detected in in 69% of 36 samples taken from surrounding surface soils of an industrial site in Pakistan with a mean level of 10.75 ng/g (UNEP/POPS/POPRC.12/11/Add.1, UNEP, 2016); it was not quite clear to what

[8] For example, refer to Canadian historical labels https://pr-rp.hc-sc.gc.ca/ls-re/index-eng.php.

extent these levels were due to the industrial production processes (including waste dumping) or from agricultural use in this area. The closing two facilities in China that produced dicofol through an open-system process is estimated to have ended the generation of 1,350 t of DDT-containing wastes annually (UNEP/POPS/POPRC.13/7/Add.1, UNEP, 2017b). Dicofol has been detected in soil cores in concentrations ranging from 0.5 to 1440 mg/kg, with the highest concentrations found in the middle of the production facility area. This was despite the fact that the original surface had been a concrete floor approximately 0.5 m thick. Soil cores were taken from surface level to a depth of 5 m, with the highest dicofol concentrations found in the 2.5-3 m range.

3.5 Summary of potential emission sources

Table 4 below provides an overview of the potential key sources for dicofol to environment. Care should be taken when reviewing this table as potential key sources will vary on a nation-by-nation basis and some sources may not be relevant for a given nation.

Table 4: Summary of key emission sources for dicofol[9]

Intentional production, trade and use	
Potential Source	**Current or no longer used**
Production of technical dicofol	Ongoing
Formulation of products containing dicofol	Ongoing
Distribution and sale of products containing dicofol	Ongoing
Agricultural and other commercial use of dicofol	Ongoing
Domestic (home/residential) use of dicofol	Unknown
Disposal of containers	Ongoing
Other sources of environmental release	
Potential Source	**Major or minor**
Accidental release (spills)	Minor
Contaminated sites	Minor

3.6 Inventory of dicofol based on production, use, and waste cycle aspects

3.6.1 Introduction

This chapter provides a detailed overview for all potential emission sources using a life cycle approach. This covers the manufacture of technical dicofol, formulation of products for sale to end users that contain dicofol, use of dicofol in field, protected or domestic settings, recycling and disposal of used containers, and identification of stocks unused or obsolete stocks and their disposal. It also includes comment on potential hot spots and need to identify and inventory these sites.

3.6.2 The intentional production of dicofol

Manufacture and formulation of dicofol

Dicofol can be manufactured by the hydroxylation of DDT or directly, without isolation of DDT by the reaction of chloral (trichloroacetaldehyde) with monochlorobenzene in the presence of oleum (SO_3 and H_2SO_4) followed by dehydrochlorination, chlorination and hydrolysis. Production of dicofol is now limited to companies in a small number of countries. In 2015-2016 production at the facility based in India was 93 t (India, 2016) with dicofol produced in a closed system as a batch process (UNEP/POPS/POPRC.13/7/Add.1, UNEP, 2017b). The expiry date for the production and use of DDT as a closed-system site-limited intermediate in the production of dicofol has been extended until May 2024 by decision SC-7/1 (UNEP/POPS/COP.7/36, UNEP, 2015a). Additionally, in Israel the company Adama (formerly Makhteshim Agan) has a registered product containing dicofol (Acarin T 285). However, whether production of dicofol continues to occur or has ceased has yet to be confirmed

[9] Under the Stockholm Convention dicofol was added to Annex A (elimination) with no specific exemptions. However, for those Parties that have made a declaration in accordance with paragraph 4 of Article 25 and have not yet ratified, accepted, approved or accessed the amendment, the obligations of Annex A with respect to PCP and its salts and esters do not apply. This means that it is also possible for uses to be ongoing (at least in the short to medium term).

(UNEP/POPS/POPRC.13/7/Add.1, UNEP, 2017b). As noted above, the manufacture of dicofol could result in releases of dicofol, including soil contamination.

Technical grade dicofol or pesticides that are purchased in bulk may be formulated and repackaged prior sale to end users. These facilities could be sources of releases of dicofol to the environment.

No emission rates for dicofol during production or formulation have been identified. Guidance is available for estimating releases from organic chemical manufacturing in several countries as part of reporting to national pollutant release and transfer registries.[10] Dicofol is one of the substances subject to reporting under the US Toxics Release Inventory.[11]

The intent of the assessment of manufacturing and formulation activities is to obtain information on annual and total quantities of dicofol manufactured and/or formulated in the country, if it is ongoing or has ceased, estimates of releases to air, water, and soil and quantities of waste generated, and identify if any of the sites where these activities occurred is contaminated. Environmental monitoring data, if available, can highlight potential contamination and help in setting priorities for action.

Distribution and sale of products containing dicofol

Various actors are involved in the distribution network for pesticides, including importers, exporters, manufacturers, formulators, distributors, and retailers. These may be government agencies, private sector companies and/or agricultural cooperatives. They can provide information on quantities traded. These facilities will hold stocks of dicofol, some of which may be obsolete or improperly stored. These sites also have the potential to be contaminated. Data from these facilities can be collected through questionnaires and/or site visits.

The unauthorised distribution and sale of dicofol products is more difficult to assess. However, there may be some documentation available from past investigative reports. Inspections of retail markets and distribution facilities and in-person surveys with users by community or labour organisations could be used to obtain some data on the extent of use of unauthorised products.

The output of the assessment of distribution and sale are annual and total quantities of dicofol imported, exported, and sold in the country. It may identify sites where stocks of dicofol are held as well as sites that may be contaminated.

3.6.3 The intentional use of dicofol

Agriculture

Dicofol products have been used in field, greenhouse and other protected agricultural applications. The objective is to obtain information on use patterns of dicofol – where, on what crops and how much. This information is useful in assessing the need for, and training on, alternatives.[12] It may also identify areas where contamination has occurred. If environmental monitoring data are available, these can be used to guide priorities for intervention. Figure 1 illustrates how the field use of pesticides results in movement of dicofol into different environmental compartments. The US Environmental Protection Agency has developed air emission factors for pesticide applications should there be a need to estimate the release of dicofol into the air from outdoor spraying activities.[13]

[10] For example: Australia's Emission estimation technique manuals http://npi.gov.au/reporting/industry-reporting-materials/emission-estimation-technique-manuals; EMEP/EEA air pollutant emission inventory guidebook 2019 https://op.europa.eu/en/publication-detail/-/publication/ce310211-4bc5-11ea-8aa5-01aa75ed71a1; US EPA's AP-42 – Compilation of Air Emissions Factors https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors

[11] https://www.epa.gov/sites/production/files/2020-02/documents/ry_2019_tri_chemical_list_0.pdf

[12] See Appendix 4 for a list of possible alternatives.

[13] US EPA (1994) Emission Factor Documentation for AP-42Section 9.2.2 Pesticide Application. https://www3.epa.gov/ttn/chief/ap42/ch09/bgdocs/b9s02-2.pdf.

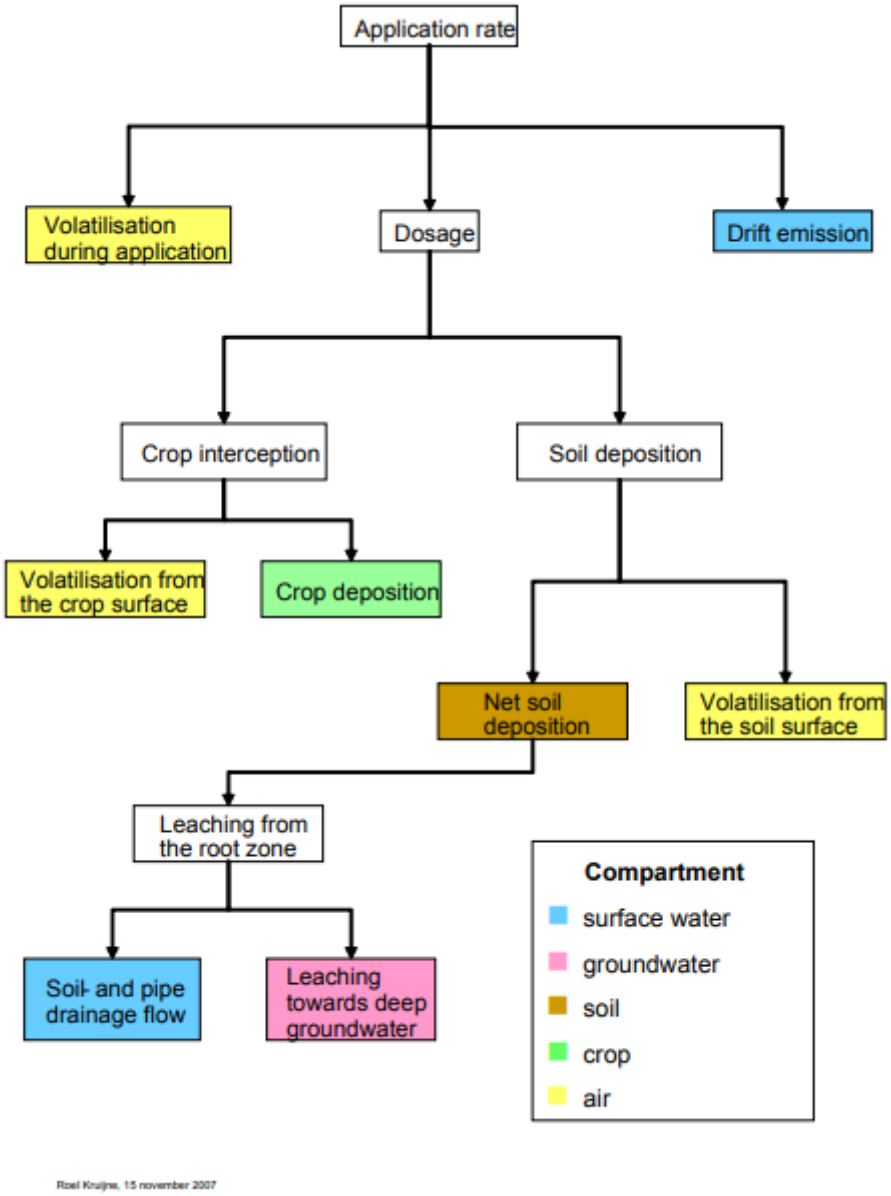


Figure 1: Environmental pathways for field applications of pesticides

(Source: https://www.rivm.nl/bibliotheek/rapporten/607600002.pdf)

Domestic

Some products containing dicofol have been registered for domestic (home or residential) use. Information on these products may only be readily available from retailers. However, an awareness campaign aimed at the consumer would contribute to the collection and appropriate disposal of dicofol containing products.

3.6.4 Wastes containing dicofol

Sources of wastes containing dicofol include wastes generated during manufacturing and formulation (refer to 3.6.2), used containers, obsolete stocks, and materials contaminated due to spills. The aim is to obtain information on the extent of recycling of pesticide containers that would have contained dicofol products, appropriate disposal of these containers, amount of existing stocks of dicofol that have or may become obsolete and will need to be disposed of, and if possible, an estimate of the quantities of soil that have been contaminated and may need to be remediated.

3.6.5 Hot spots

A hot spot is an area that is contaminated and has high concentrations of pesticides including dicofol. These areas may need to be secured to prevent exposure and, in the long run, decontaminated and remediated. The FAO

Environmental Management Tool Kit for Obsolete Pesticides (Cobban et al., 2020) outlines a process to identify these sites and to prioritize them for assessment and management.

Sites that may have been contaminated with dicofol include pesticide production and formulation facilities, sites where mixing or formulation occurred, pesticide storage sites (current and former), including stocks held by farmers and other end-users, waste disposal sites including pesticide burial locations. Sites where dicofol was applied may have high residues. Government records, industry and distribution operators, and non-governmental organizations (NGOs) may have information on hot spots. Information on potential hot spots could be obtained through inspections of retail markets and distribution facilities and in-person surveys with users by community or labour organisations. An awareness campaign aimed at the consumer could also encourage the reporting of potentially contaminated sites.

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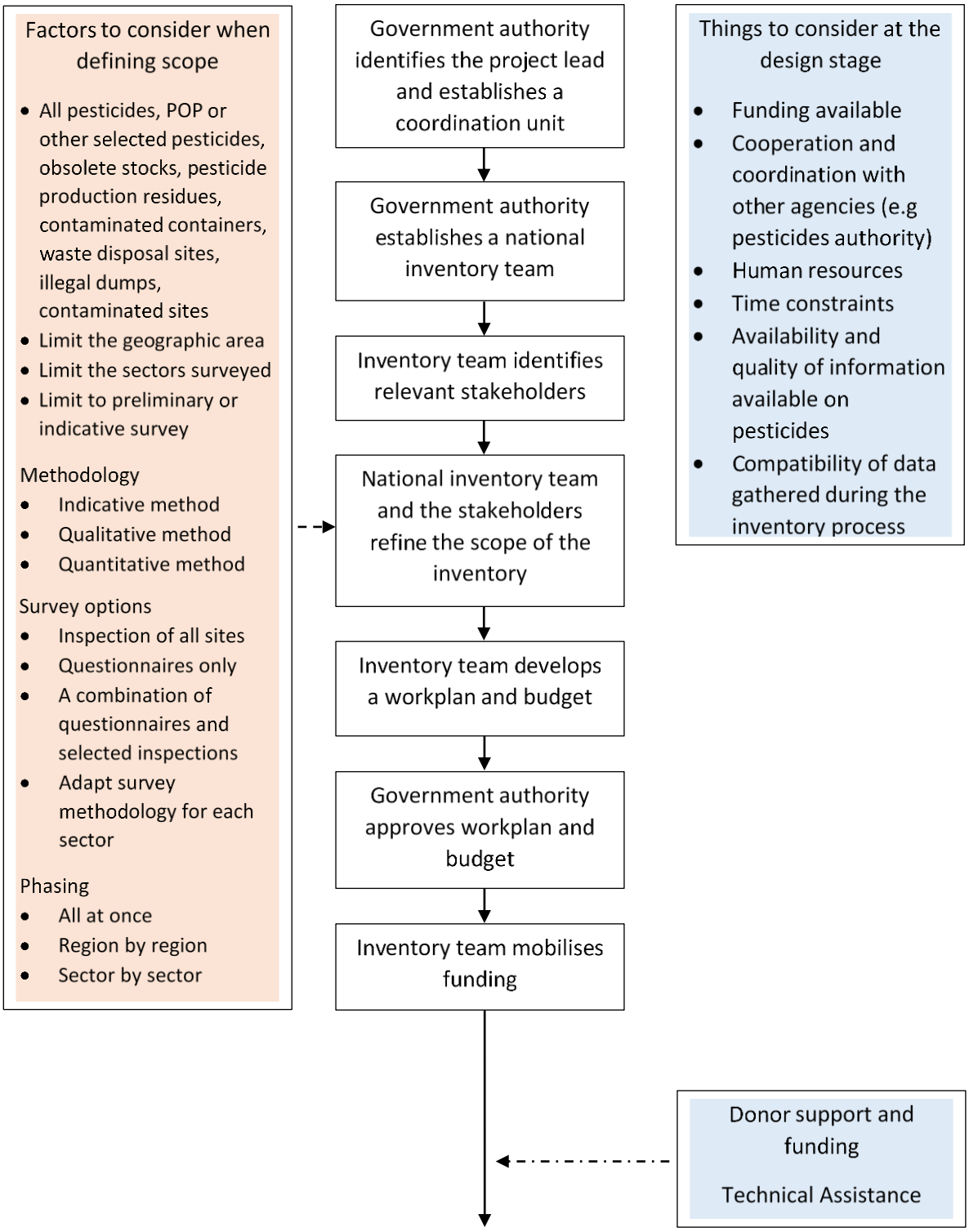
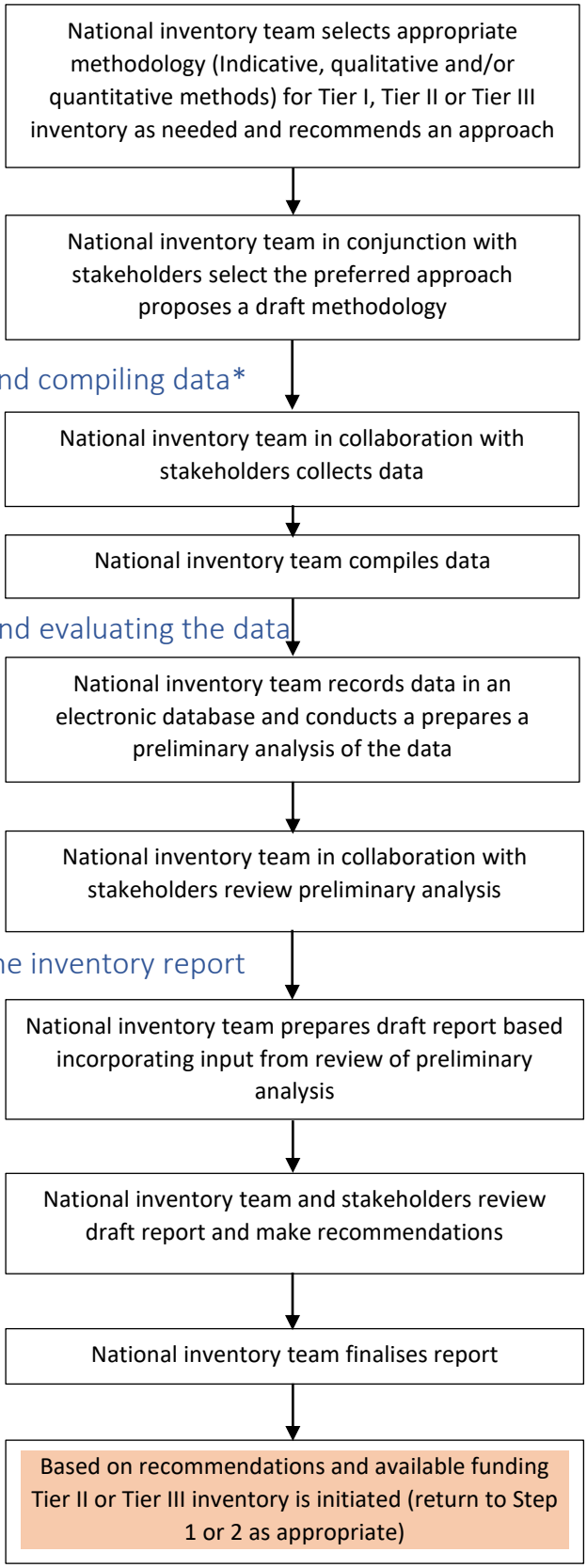
Appendix 1. Steps in the inventory process

Adapted from FAO (2010) The Preparation of Inventories of Pesticides and Contaminated Materials

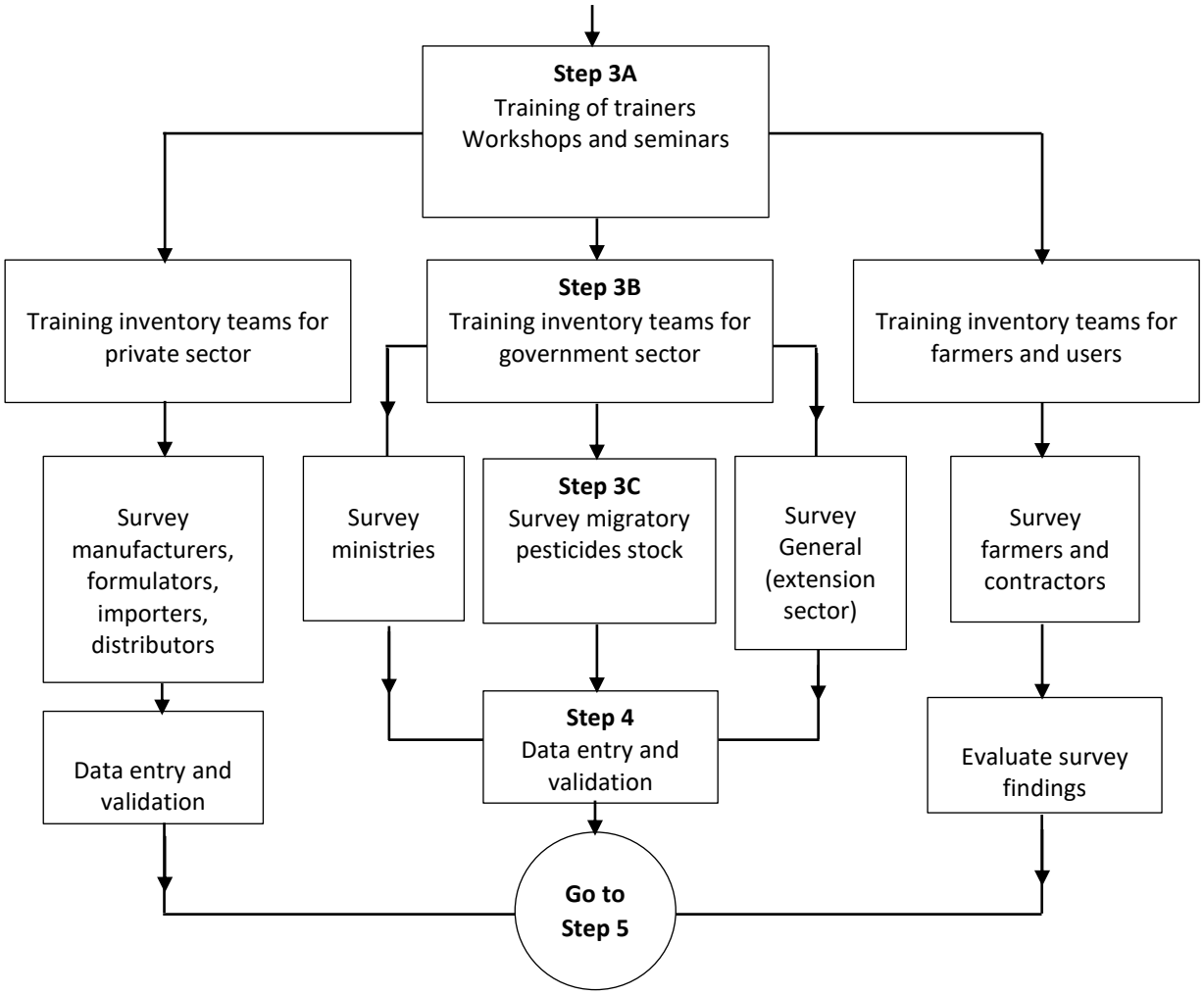
Step 1 Initiating the inventory development process



Step 2: Choosing data collection methodologies



* Details for Steps 3 and 4



Appendix 2. Questionnaire for compiling information on the production, formulation and import/export of dicofol and products containing dicofol

Persistent organic pollutants (POPs) are toxic chemicals that adversely affect human health and the environment. They persist for long periods of time in the environment and can accumulate in the food chain and finally contaminate people. The Stockholm Convention is a global treaty which supports the phase out of POPs.
In 2019 dicofol was listed as POPs in Annex A, with no exemptions.

Therefore, the government is assessing the current production, formulation import, export and use of dicofol to determine what actions will be needed to comply with the requirements of the Convention and develop a national implementation plan.

The following survey has been developed to gather relevant information from producers, formulators, importers and exporters of dicofol and products containing dicofol.

Name of establishment Registration number	
Address	
Name of respondent	
Position	
Telephone/Mobile	
Email	
Signature/date	

This questionnaire is divided in 4 sections

Section A: General

Section B: Production and formulation

Section C: Import and export

Section D: Distribution and retail sale

Section E: Use of dicofol

Section F: Recycling, stocks, contaminated sites

Please fill in the section(s) below which are relevant for your activity domain (manufacturer/importer/user/recycler/waste manager etc.).

Section A: General

1. **Are you aware that dicofol is listed as POPs in the Stockholm Convention and all production and use of dicofol will be banned?**
   - ☐ Yes
   - ☐ No

2. **Please indicate if you:**

   - ☐ Never produced, formulated, imported and/or exported dicofol or products containing dicofol
   - ☐ Currently produce dicofol
   - ☐ Have stopped the production of dicofol in _____year

- ☐ Are planning to stop the production in _____month/year
- ☐ Currently formulate products containing dicofol
- ☐ Have stopped the formulation of dicofol products in _____year
- ☐ Are planning to stop the formulation in _____month/year
- ☐ Currently import dicofol or products containing dicofol
- ☐ Have stopped importing dicofol or products containing dicofol in _____year
- ☐ Are planning to stop importing in _____month/year
- ☐ Currently export dicofol or products containing dicofol
- ☐ Have stopped exporting dicofol or products containing dicofol in _____year
- ☐ Are planning to stop exporting in _____month/year

Section B: For <u>producers and formulators</u> of dicofol

3. Since when have you produced dicofol and/or formulated products containing dicofol?

_____

_____

_____

4. List the products you have produced or formulated?

	Trade name	**Concentration of dicofol (%)**
Technical dicofol		
Products for agricultural use*		
Products for domestic use*		

***** Add rows as needed

5. Please fill the table below on the quantities of dicofol produced or formulated

Year	**Produced** Tonnes of dicofol	**Formulated** Tonnes of dicofol
2021 (estimate)		
2020 (estimate)		
2019		
2018		
2017		

If you have ceased production of dicofol or formulation of products containing dicofol

Year production ceased	**Total amount produced (all years)** Tonnes of dicofol	**Total amount formulated (all years)** Tonnes of dicofol

6. **Please elaborate on your method of production.**

Is it a closed loop process?

- ☐ No
- ☐ Yes

Section B-I: Environmental management

7. **Do you produce any waste during production or product formulation that may contain dicofol?**

- ☐ No
- ☐ Yes

If yes:

Year*	**Total quantity of wastes (tonnes) that contain dicofol**	**Type of waste** (e.g. effluent, containers)	**How treated/handled** (e.g. incinerated, landfilled, treated, discharged)

***** Add rows as needed

8. **Please elaborate on the waste management of waste from production and use.**

a. What wastes are generated from dicofol production/formulation and how are they managed?

b. Do you contribute to the end-of-life management and treatment of dicofol products you sold? How?

9. Does your facility carry out any routine monitoring for dicofol releases?

- ☐ No
- ☐ Yes

If yes:

Emission monitoring data as emission rates / annual totals	Emissions to air (g/m^2)	
	Emissions to water (g/l)	
	Emissions to waste (kg/tonne)	
	Annual emissions to air kg	
	Annual emissions to water kg	
	Annual quantities of dicofol in waste as kg	

10. Have you ever conducted an environmental audit? If yes, please elaborate more (date, internal, external, consultancy firm….)

_____

_____

_____

11. Has your facility conducted any environmental sampling for dicofol?

- ☐ No
- ☐ Yes

If yes:

Year*	**Site**	**Medium** (e.g. air, water, soil)	**Results** (Concentrations found)

***** Add rows as needed

12. Do you have ISO 14001?

- ☐ No
- ☐ Yes
- ☐ Similar certificate

Section C: Import and export of dicofol

13. Please fill the table below on the quantities of dicofol or products containing dicofol imported or exported

Year	**Imported** Tonnes of dicofol	**Exported** Tonnes of dicofol
2021 (estimate)		
2020 (estimate)		
2019		
2018		
2017		

13 a) If you have ceased import or export of dicofol or products containing dicofol

Year import/export ceased	Total amount imported Tonnes of dicofol	Total amount exported Tonnes of dicofol

Section D: Distribution and Retail Sale

14. List the products you have distributed

Trade name*	Concentration of dicofol (%)	Year	Amount sold (litres)

***** Add rows as needed

15. List the products you have sold?

Trade name*	Concentration of dicofol (%)	Year	Amount sold (litres)

***** Add rows as needed

Section E: Use of dicofol

16. Have you used product containing dicofol?

- ☐ No
- ☐ Yes
- ☐ Don’t know / Not sure

If yes:

17. What did you use it for?

- ☐ Control mites
- ☐ Control other pests
- ☐ Don’t know / Not sure

18. Where did you use it?

- ☐ In the field
- ☐ In a greenhouse or other protected setting
- ☐ Around the home
- ☐ Don't know / Not sure

19. On what did you use it?

- ☐ Vegetables
- ☐ Fruits
- ☐ Cotton
- ☐ Tea
- ☐ Ornamental plants (e.g. flowers, trees)
- ☐ Other – specify:
- ☐ Don't know / Not sure

20. When did you use it?

Year*	Product name (if known)	Once	Twice	Three or more times	Don't know / not sure
2021		☐	☐	☐	☐
2020		☐	☐	☐	☐
2019		☐	☐	☐	☐
No longer use		☐	☐	☐	☐

* Add rows as needed

Section F: Recycling, stocks, contaminated sites

21. Do you recycle/reuse any dicofol containers?

- ☐ No
- ☐ Yes

If yes:

Year*	Number of containers reused	Number of containers recycled

***** Add rows as needed

22. Do you dispose of dicofol containers?

- ☐ No
- ☐ Yes

If yes:

Year*	Number of containers disposed of	Method of disposal

***** Add rows as needed

23. Do you have any stocks of dicofol?

Date*	Manufacturer	Product name	Registration number	Container size	Number of containers	Total volume	Condition**
							☐ Good ☐ Obsolete
							☐ Good ☐ Obsolete
							☐ Good ☐ Obsolete

* Add rows as needed

** Indicate if the condition is good, or if the stock is obsolete (no longer suitable for use because of damaged container, expired product, banned, or other reason). If some of the stock is good and another part obsolete, use two rows.

24. Are you aware of any sites that may be contaminated with dicofol?

☐ No

☐ Yes

If yes:

Location (Address)	Description	Investigation report(s) available

* Add rows as needed

Appendix 3. Sample format for summary inventory tables

The following tables are possible summary tables for the national dicofol inventory. Information could be collated at the regional/provincial level if desired and the collated to the national level. Quantity used could be categorised (e.g.: Open field application, Greenhouse/protected agriculture, Commercial, Residential/home use)

Year	Quantity (kg active ingredient) Manufactured	Quantity (kg active ingredient) Imported	Quantity (kg active ingredient) Exported	Quantity (kg active ingredient) Sold	Quantity (kg active ingredient) Used
Total					

Year	Number of containers sold	Number of containers recovered and recycled	Quantity of dicofol waste produced (kg)	Quantity of dicofol waste disposed of in an environmentally sound manner (kg)
Total				

Year	Number of contaminated sites/hotspots	Size/area of hotspot	Estimated quantity of waste (kg)	Estimated quantity of dicofol in waste (kg)	Remediated? Yes/no
Total					

Appendix 4. Selected alternatives to dicofol

The table below lists selected pesticides that are registered for use to control mites in one or more countries. More information on these potential alternatives can be found in the draft Guide to Potential Alternatives to Dicofol (UNEP, 2021).

Name of active substance	CAS number
Biopesticides	
Beauveria bassiana strain GHA	--
Beauveria bassiana strain ATCC 74040	--
Beauveria bassiana strain PPRI 5339	--
Burkholderia species	--
Chromobacterium subtsugae	--
Hirsutella thompsonii	--
Isaria fumosorosea	--
Metarhizium anisopliae	--
Verticillium lecanii	--
Biochemical pesticides	
Abamectin	71751-41-2
Azadirachtin	11141-17-6
Chemical pesticides	
Acequinocyl	57960-19-7
Bifenazate	149877-41-8
Bifenthrin	82657-04-3
Clofentezine	74115-24-5
Cyantraniliprole	736994-63-1
Cyflumetofen	400882-07-7
Cyfluthrin	68359-37-5
Etoxazole	153233-91-1
Fenazaquin	120928-09-8
Fenbutatin oxide	13356-08-6
Fenpyroximate	111812-58-9
Formetanate	23422-53-9
Hexythiazox	78587-05-0
Propargite	2312-35-8
Pyridaben	96489-71-3
Spirodiclofen	148477-71-8
Spiromesifen	283594-90-1
Tebufenpyrad	119168-77-3
Thiamethoxam	153719-23-4