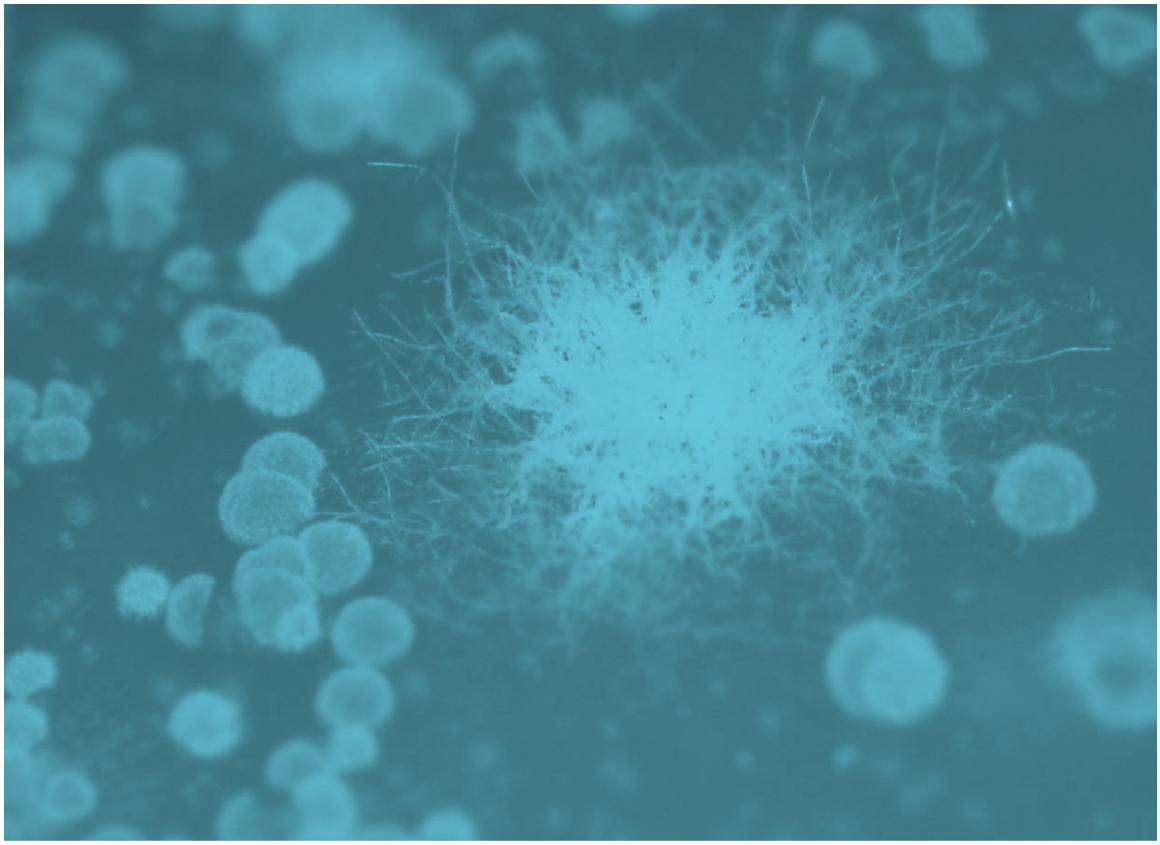
Thailand's POPs Inventory Assessment Report

Part 1:
Thailand's 2017
POPs Pesticides Inventory



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Part 1: Thailand's 2017 POPs Pesticides Inventory

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List of Acronyms and Abbreviations

Acronym	Meaning
ACQ	Alkaline copper quaternary
CAR	Corrective action request
CS	Capsule suspension
DDT	1,1,1-Trichloro-2, 2-bis, 4-chlorophenyl ethane
DIW	Department of Industrial Works
DMS	Department of Medical Sciences
DOA	Department of Agriculture
DOAE	Department of Agricultural Extension
EMRL	Extraneous maximum residue limits
FDA	Food and Drug Administration
GAP	Good agricultural practices
GMP	Global Monitoring Plan
HCB	Hexachlorobenzene
HSA	Hazardous Substances Act
IPM	Integrated pesticide management
MAC	Maximum allowable concentrations
MoAC	The Ministry of Agriculture and Cooperatives
MOE	The Ministry of Energy
MOI	The Ministry of Industry
MoPH	The Ministry of Public Health
MRL	Maximum residue limits
MWA	Metropolitan Waterworks Authority
NGO	Non-government organizations
NIP	National implementation plan
NSW	National single window
OCPs	Organochlorine pesticides
PCD	Pollution Control Department
PCP	Pentachlorophenol
PeCB	Pentachlorobenzene
PFOS	Perfluorooctane sulfonic acid
PFOSF	Perfluorooctane sulfonyl fluoride
PIC	Prior informed consent
POPs	Persistent organic pollutants
PWA	Provincial Waterworks Authority
RFD	Royal Forest Department

SC	Stockholm Convention
SRT	State Railway of Thailand
TACFS	Thai agricultural commodity and food standard
TAS	Thai agricultural standard
TEI	Thailand Environment Institute
WG	Working group
HCH	Hexachlorocyclohexane
α-HCH	Alpha hexachlorocyclohexane
β-HCH	Beta hexachlorocyclohexane
γ-HCH	Gamma hexachlorocyclohexane or lindane

1 POPs Pesticides

Summary of assessment findings

Thailand ratified the Stockholm Convention (SC) on Persistent Organic Pollutants (POPs) on 31 January 2005 with obligations coming into force for Thailand on 1 May 2005. At the initial stage of the SC, there were 9 'initial' SC POPs Pesticides listed in the convention. Subsequently, during 2009-2015, the Conference of the Parties of the SC added 7 'new' SC POPs Pesticides to the list. These 16 entries are included in this current inventory study.

According to Thailand's SC POPs Pesticides first inventory report published in 2006 (based on 2004 reference year data), all of 9 initial SC POPs Pesticides had been previously banned under Hazardous Substances Act (HSA). However, there were still evidences of obsolete stockpiles of certain SC POPs Pesticides at the time. To fulfill its obligations under the SC, the Thai Government proceeded to formulate and implement its National Implementation Plan (NIP) to eliminate POPs Pesticide obsolete stockpiles. However, the 2010-2013 survey conducted by the Pollution Control Department (PCD) showed the small amount of 3 SC POPs Pesticides substances still in the possession of 2 government agencies. Since that last study was conducted over 10 years ago, updating the obsolete stockpiles and the environmental monitoring data of the 9 initial SC POPs Pesticides was necessary to reflect the country's current situations. In addition, since Thailand's inventory for the 7 new SC POPs Pesticides has not yet been compiled before, their preliminary inventory was necessary in order to establish their baseline information.

The objective of this study is to update the status of the 9 initial SC POPs Pesticides and to establish a baseline information for the 7 new SC POPs Pesticides, based on data from the reference year 2017 (except otherwise specified). This updated SC POPs Pesticides inventory will also help responsible national authorities evaluate the current situation and prioritize plans and measures to manage the risks associated with SC POPs Pesticides.

Initial SC POPs Pesticides

All 9 initial SC POPs Pesticides have never been produced in Thailand, and over the 1981-2004 period all of these initial SC POPs Pesticides became successively banned as Category 4 hazardous substances under the HSA. Based on this inventory team's 2018 data gathering, no registration or import/export data for initial SC POPs Pesticides exist in the annual registration records and the annual import/export records of hazardous substances during the years following their effective bans, as reported by the relevant regulatory agencies -- the Department of

Agriculture (DOA), the Food and Drug Administration (FDA), and the Department of Industrial Works (DIW).

Based on Thailand's first inventory, there were still about 220 kg of obsolete initial SC POPs Pesticide stockpiles in the country in 2004. During 2010-2013, the PCD conducted a follow-up inventory of obsolete SC POPs Pesticides. A combined 54 kg of chlordane were found in the chemical storage of the DOA and the Department of Agricultural Extension (DOAE), and 7 liters of dieldrin were held by the DOA. Subsequently, this study found that only about 31 kg of chlordane were still held by the DOAE as of year 2018. On the contrary, all obsolete SC POPs Pesticides previously stocked by the DOA had already been collected and destroyed in an environmentally sound manner by industrial waste incineration because the DOA has a collection and disposal mechanism in place for obsolete pesticides.

New SC POPs Pesticides

All 7 new SC POPs Pesticides have never been produced domestically. Five of these (except chlordecone and PeCB) have been imported into the country in the past. During 1993-2012, 6 of these 7 new SC POPs Pesticides -- α-HCH, β-HCH, γ-HCH (lindane), chlordecone, endosulfan, and pentachlorophenol (PCP) -- became successively banned under the HSA.

Technical endosulfan (with an exception for CS-type) has been banned since 2004 by the DOA and FDA. However, 2 specific forms of endosulfans – α-endosulfan and β-endosulfan– have been classified as Category 3 hazardous substances under DOA since 2002, which means that their production, import, export, or possession require prior authorization. According to DOA's annual import records of agricultural hazardous substances, approximately 8,700 tonnes of technical endosulfan were imported into Thailand during 1996-2003. No import figures for all endosulfan were present in the subsequent annual records following the 2004 general ban.

In terms of obsolete stockpiles, the previous Thai inventory reported a combined amount of 2.9 tonnes of endosulfan stocks in 2004. The following 2010-2013 PCD survey indicated a smaller amount (49 liters) of endosulfan being held by the DOA. No record of endosulfan stock was found for this study as all previous endosulfan stock belonging to DOA had already been collected and destroyed by industrial waste incineration.

α-HCH and β-HCH have been banned since 2001 by the DOA, DIW and the Thai FDA. Lindane (γ-HCH) has been banned by the DOA since 2001 and by the FDA since 2012 (with an exception for medical use as a second-line treatment for scabies and lice in humans). However, approximately 0.9 tonnes of lindane stock still remained in the warehouse of a private pharmaceutical company and PCD and FDA are planning to destroy them, pending disposal.

Pentachlorophenol (PCP) has been banned by the DOA since 1993 and has also been later banned by the FDA and the DIW since 2000 and 2001, respectively. According to the DOA, PCP has never been approved for agricultural use in Thailand. The current study found no records on the registration, import, or export of PCP from the above regulatory agencies, and no PCP stock was found. No information on the domestic use of PCP in wood products such as utility poles, fences, railway sleepers, etc. was found from relevant documents or from the interviews with the Royal Forest Department (RFD) and the State Railway of Thailand (SRT).

Moreover, the DOA and the Rice Department have suggested alternative chemicals for technical endosulfan including CS formulation. The FDA recommended permethrin as a substitute for lindane as the second-line treatment for scabies and lice in humans [1].

Environmental monitoring

There are guidelines on the maximum allowable concentrations (MAC) for SC POPs Pesticides in surface water, ground water, soil and MRL/EMRL for agricultural products, leading to the monitoring of SC POPs Pesticide contamination in Thailand. Thai government agencies as well as academic institutions have monitored SC POPs Pesticides in the environment and food, based on these guidelines. Most monitoring efforts conducted by DOA, PCD, Metropolitan Waterworks Authority (MWA), Provincial Waterworks Authority (PWA) and Department of Medical Sciences (DMS), showed that the residue levels of SC POPs Pesticides were within the standard limits. Especially, in 2017 the DMS assessed the population's exposure to toxic substances including 6 initial POPs and 4 new POPs in cooked food. The results showed that POPs Pesticide residues in all of the sampled food groups were below the detection limits. However, four academic research works have shown that DDT and metabolites, HCHs, technical endosulfan and metabolite, aldrin, dieldrin, heptachlor, and lindane also exist above the applicable MAC and MRL/EMRL in specific agriculture areas.

1.1 Introduction

The Stockholm Convention (SC) on Persistent Organic Pollutants (POPs) aims to protect human health and the environment by eliminating or reducing the releases of POPs. Thailand ratified the SC on POPs on 31 January 2005 with obligations coming into force for Thailand on 1 May 2005. The 9 initial SC POPs Pesticides include aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, hexachlorobenzene (HCB), mirex, and toxaphene. During 2009-2015, 7 new SC POPs Pesticides were subsequently added to the list, including alpha hexachlorocyclohexane (α-HCH), β-HCH, γ-HCH (lindane), chlordecone, pentachlorobenzene (PeCB), technical endosulfan and its related isomers, and pentachlorophenol (PCP), its salts, and esters. In 2009, sulfluramid produced from perfluorooctane sulfonyl fluoride (PFOSF) and used in insecticides was covered under the listing of perfluorooctane sulfonic acid (PFOS), its salts and PFOSF. In 2019, the SC added dicofol to its listing of POPs.

1.2 Purpose of the study

The objective of this study is to update the status of the 9 initial SC POPs Pesticides and to establish the baseline information for 7 new SC POPs Pesticides based on data from the reference year 2017 (except otherwise specified). This SC POPs Pesticides inventory will also help responsible national authorities evaluate the current situation and prioritize plans and measures to manage the risks associated with SC POPs Pesticides.

1.3 Methodology

MTEC was assigned by the PCD and endorsed by the National Environment Board's Stockholm Convention Sub-committee on POPs ("Thai SC-subcommittee") to carry out this inventory assessment. The inventory team was assisted by an external expert on SC POPs Pesticides.

Working group

The SC POPs Pesticides Working Group (WG2), with 12 representatives from relevant public and private organizations, was officially established and endorsed by the Thai SC-subcommittee to support the inventory study and to work toward the formulation of the NIPs. The director-general of the DOA was appointed as the chair of this WG, with PCD and MTEC jointly serving as secretary. WG2 was presented with relevant pertinent data, accumulated by MTEC's preliminary research, in order to define the scope of the inventory and formulate a practical work plan at the start of the project

Inventory procedure

To establish the SC POPs Pesticides inventory, a 2-step data collection method was carried out, namely initial assessment and preliminary assessment.

The initial assessment involved gathering of data from desk study/literature survey, such as related guidance documents, annual reports, academic articles, statistical data (import/export), chemical registration data, related pollution status reports, etc. The information acquired from this step helped determine the scale and scope of the task for the second step.

The inventory team collected the specific information from target groups by official inquiries, meetings, or interviews through telephone calls and e-mails. Data were explored in greater depth than during the initial assessment step. A number of stakeholders were involved in this process. These include government agencies (such as DOA, DOAE, FDA, PCD, DIW, Customs department, RFD, SRT, MWA, and PWA), private agencies, non-government organizations (NGOs), research institutes, laboratories, and universities. The main data sources were the national data from the responsible governmental bodies, for examples:

- Records of the agricultural hazardous substance imports, reported by DOA, 2007-2017 [2]
- Records of the registration of agricultural hazardous substances, reported by DOA, 2011-2017 [3]
- Records of the hazardous substance imports/exports, reported by DIW, 2009-2016 [4]
- Online database of hazardous substance registration system, under FDA [5]
- Thailand State of Pollution annual reports, by PCD, 2007-2017 [6]
- Records of the raw water and tap water samples, by MWA, 2007-2017
- Records of the raw water and tap water samples, by PWA, 2017-2018

The national level data related to SC POPs Pesticides that have been gathered consist of past and current use/production, imports/exports, stockpiles, disposal practices for obsolete stocks, existence of alternatives, potential contaminated sites, monitoring in environmental media, food, and human, and the country’s capability to manage SC POPs Pesticides.

Data management and evaluation

Data and information gathered during the data collection period were compiled and analyzed by the inventory team. The resulting draft SC POPs Pesticides inventory assessment was presented to WG2 for their comments. Following the revision, the draft inventory was presented to the public and relevant stakeholders at the SC POPs Pesticides Inventory Validation Workshop on 1 August 2019, which was attended by 67

participants from 27 organizations. Feedbacks received during the workshop and the 1-week comment-gathering period were incorporated into the inventory revision process, and the resulting final draft was once again circulated to WG2 for their endorsement.

Inventory report preparation

The inventory team was in charge of preparing this inventory report. The final (draft) version of the inventory report was reviewed by the Working Group on Project Supervision and Coordination (WG1) prior to being submitted to UNIDO for the review by international expert(s).

1.4 Inventory findings

1.4.1 Import, export, and domestic supply chain

Thailand has enacted the Hazardous Substance Act (HSA) since 1992 to control the production, importation, exportation, marketing, and possession of hazardous chemicals in Thailand. Three government departments are responsible for issuing and enforcing notifications according to the 3 relevant fields of applications. SC POPs Pesticides used for crop production are controlled by the DOA; SC POPs Pesticides in food, drugs, and household chemicals are controlled by the FDA; and SC POPs Pesticides used as industrial chemicals are controlled by the DIW [7].

The Thai Government classifies hazardous substances according to the needs for control, as follows

Category 1 Hazardous substances of which production, import, export, or possession must comply with the specified criteria and procedures.

Category 2 Hazardous substances of which production, import, export, or possession must first be notified to the authority and must also comply with the specified criteria and procedures.

Category 3 Hazardous substances of which production, import, export, or possession must obtain prior permission.

Category 4 Hazardous substances of which the production, import, export or possession are prohibited.

Hazardous substances for agricultural purposes, which are regulated under the DOA, are controlled as Category 2, 3 or 4. This act encompasses a list of single chemicals that are specified by their CAS number, as well as groups of chemicals intended for agricultural use [8, 9, 10, 11].

Import/export control

As required by the Ministry of Agriculture and Cooperatives (MoAC) Notification B.E. 2551 (2008), those who wish to import or export HSA Category 3 or Category 2 agricultural substances must pre-register those substances before proceeding further [12]. Such pre-registration process

entails evaluation of substance efficacy and their potential effects on humans and the environment, as well as specifying the production origins of the substances. The concentrations and formulations must also be declared in accordance with the DOA Notification B.E. 2554 (2011), 2556 (2013), 2557 (2014), and 2560 (2017) [13]-[18].

Subsequently, those who wish to import or export HSA Category 3 agricultural substances must request prior authorization from the DOA [13, 14]. An approved authorization specifies the allowed import/export amount of the controlled substance over a specific time period. In the case of import, the facilities where the pesticides are to be repackaged or reformulated must also be authorized.

The Thai Customs Department maintains an import/export database that is linked to the DOA's substance registration and authorization system, in order to verify and approve the import/export of these substances. The Customs Department has also defined HS codes for HSA-controlled substances. The HS codes for SC POPs Pesticides are shown in Table 1-11 in the Annex.

Domestic distribution control

Imported pesticides are transferred to domestic manufacturing facilities where they are repackaged and/or used to make other formulations. Such domestic manufacturers must also have prior authorization from the DOA. Pesticides are then distributed to wholesalers and retailers who must also be authorized by the DOA. End-users of pesticides do not require authorization, however.

Pesticides in the possession of manufacturers and suppliers are also subject to control by the agricultural inspectors who operate under the DOA. Samplings are conducted for quality inspection. If the pesticides are found to be illegal or below quality standards, such pesticides will be confiscated and there will be further legal proceedings. Based on data obtained from the agricultural inspectors, a total of 204 cases occurred during the 2017-2019 period. 150 of these cases are pending further legal prosecution, 15 are still under consideration, and 39 cases have already been terminated.

To manage pesticides imported before being banned as Category 4 hazardous substances, the DOA will issue public notices to inform those in possession of such pesticides that they can transfer their stocks to the DOA within certain time periods. The DOA will then be responsible for stock collection and transfer to hazardous waste incinerators for proper disposal.

9 initial SC POPs Pesticides

All 9 initial SC POPs Pesticides have never been produced in the country. Based on the first inventory report, most initial SC POPs Pesticides (except HCB and mirex) had been imported into the country in the past, but their total import amounts were not specified. During 1981-2003, all of them became successively classified as Category 4 hazardous

substances and are controlled by DOA, FDA, and DIW, as shown in Table 1-1. This latest survey found no import data on initial SC POPs Pesticides during 2007-2017 from the annual records of the of agricultural hazardous substances imports of the DOA. Additionally, according to the FDA's database of hazardous substance registration, no registration of initial SC POPs Pesticides have been recorded.

7 new SC POPs Pesticides

All 7 new SC POPs Pesticides have never been produced in Thailand. Five of these (except chlordecone and PeCB) have been imported into the country in the past. However, during 1993-2012, 6 of the 7 new SC POPs Pesticides, including α-HCH, β-HCH, γ-HCH (lindane), chlordecone, technical endosulfan, and PCP, became successively banned under the control of DOA, FDA and DIW (see Table 1-1 in the following page.)

Technical endosulfan and its related isomers

Technical endosulfan (except capsule suspension (CS) type) has been banned since 2004 by the DOA and the FDA. In 2002, α-endosulfan and β-endosulfan were classified as Category 3 hazardous substances under the DOA, which means prior authorization is mandatory for their production, import, export, and possession. According to the annual records of agricultural hazardous substance imports of the DOA, approximately 8,700 tonnes of technical endosulfan were imported during 1996-2003, as shown in Table 1-2. The annual records show no imports of technical endosulfan into Thailand since the year it was banned in 2004 [2]. No import of α-endosulfan and β-endosulfan were found during 1996-2017.

α-HCH, β -HCH and γ-HCH (lindane)

Lindane (γ-HCH) has been banned by the DOA since 2001. It has also been banned by the FDA since 2012, with an exception for medical use as a second-line treatment for scabies and lice in humans. Accordingly, in 1984 the FDA granted a lindane import license to a private pharmaceutical company; however, the import license was voluntarily withdrawn by the company in 2015 after lindane was removed from the National List of Essential Medicines for treatment of scabies and lice in humans by FDA in the year 2012. This current survey found no import records of lindane from the 2 regulatory government agencies (DOA and FDA).

However, based on interviews with relevant authorities, approximately 0.9 tonnes of lindane stock still remains in the warehouse of a private pharmaceutical company in 2017, pending disposal

α-HCH and β-HCH have been banned since 2001 by the DOA and since 2003 by DIW and FDA. Because Thailand has never produced SC POPs Pesticides and because α-HCH and β-HCH are by-products from the production of lindane, it can be deduced that these 2 substances have never been individually produced or imported.

PCP

Pentachlorophenol (PCP) was banned by the DOA in 1993 and was also later banned by the FDA and the DIW in 2000 and 2001, respectively. According to the DOA, PCP has never been approved for agricultural uses in Thailand. For this study, no import record was found from the government agencies (DOA, FDA and DIW). No report of any use of PCP in wood products in Thailand such as utility poles, fences, railway sleepers, and others was found in the literature or from the interviews with RFD and SRT. Finally, a search for reports on PCP detection in Thailand in scientific literatures did not yield any result. The inventory team, therefore, concludes that there is no evidence of PCP usage as pesticide in Thailand.

Table 1-1: Legal status of SC POPs Pesticides control by the DOA, FDA and DIW under the Hazardous Substance Act

No	SC POPs Pesticides	Year of ban			Year of SC listing
		DOA	FDA	DIW	
	Initial List				
1	Aldrin	1988	1995	-	2001
2	Chlordane	2000	1995	-	2001
3	DDT	1983	2003	-	2001
4	Dieldrin	1988	1995	-	2001
5	Endrin	1981	1995	-	2001
6	Heptachlor	1988	1995	-	2001
7	Hexachlorobenzene (HCB)	2001	2001	2001	2001
8	Mirex	2001	1995	2001	2001
9	Toxaphene	1983	2004	-	2001
	New List				
1	alpha hexachlorocyclohexane (α-HCH)	2001	2001	2001	2009
2	beta hexachlorocyclohexane (β-HCH)	2001	2001	2001	2009
3	gamma hexachlorocyclohexane (γ-HCH) or Lindane	2001	2012	-	2009
4	Chlordecone	2000	1995	-	2009
5	Pentachlorobenzene (PeCB)	-	-	-	2009
6	Technical endosulfan	2004	2004	-	2011
	CS type of technical endosulfan, α-endosulfan, β-endosulfan	2002*	2004	-	
7	Pentachlorophenol (PCP)	1993	2000	2001	2015

*Classified as Category 3 since 2002 by the DOA

Table 1-2: Import amounts of technical endosulfan during 1996-2017

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004-2017
Amount Imported (tonnes)	714	822	963	1,055	1,067	1,155	1,183	1,765	0

Ref: Data obtained from Bureau of Plant and Agricultural Material Control, DOA

1.4.2 Obsolete stockpile update

Existing data along Thai supply chain

The DOA oversees most activities along the pesticide supply chain, from import/export, formulation, repackaging, to sales (but not end-use). This puts the DOA in a position to record data for Thai pesticide supply chain. However, based on interviews with DOA officers, the inventory team found that quantitative data are collected only for import/export activities, but data for the subsequent domestic activities such as incoming/outgoing volume or remaining stocks for relevant domestic stakeholders have not yet been systematically gathered. So far, Thai pesticide distribution data along the supply chain (beyond the import/export amounts) have been obtained via occasional questionnaires and field surveys of relevant parties.

The 2006 inventory report stated that during 2000-2001, the DOA together with the DOAE and the Food and Agriculture Organization of the United Nations surveyed obsolete pesticide stocks in Thailand via questionnaires. Then, in 2004 the PCD conducted follow-up field survey, which was extended to cover the chemical warehouses of government agencies that had not been surveyed in the 2000-2001 study.

Survey approaches

Thailand's first NIP (2007) called for the environmentally sound management and elimination of all remaining SC POPs Pesticide stocks. As such, the Thai government had implemented actions to achieve this obligation, as follows.

During 2010-2013, the PCD surveyed the inventory of obsolete pesticides using questionnaires to collect data such as types, amounts, and storage locations. The questionnaires were sent to relevant parties as suggested by the DOA, including government agencies and regional affiliates (588 entities), private companies (451), wholesalers (15,500), and academic institutions (105). The numbers of questionnaires replies received by PCD were 416 from government agencies and regional affiliates, 119 from private companies, 2,669 from wholesalers, and 43 from the academia.

Among these questionnaire respondents, PCD further identified entities with potential SC POPs Pesticides possession for on-site surveys. Subsequent field surveys were then conducted at 32 government agencies (under DOA, DOAE, and the Rice Department), 3 private companies, 3 agro-chemical shops, and 1 academic institution.

In 2017, this inventory team followed up on the status of SC POPs Pesticides stocks based on PCD's 2010-2013 survey results.

In general, no data are available for obsolete SC POPs Pesticide stocks that may be in the possession of end-users (farmers). This inventory team assumed that all SC POPs Pesticides has already been used up by farmers because all initial SC POPs Pesticides had been banned by 2004, and because there has been no import of new SC POPs Pesticides after 2012.

The results of these SC POPs Pesticides surveys are summarized as follows.

2004 Inventory

The 2004 POPs Pesticide inventory by PCD [15] reports approximately 0.22 tonnes of combined obsolete initial SC POPs Pesticides (chlordane, DDT, and heptachlor) and about 2.9 tonnes of endosulfan in the chemical storages of DOA and DOAE, as shown in Table 1-3. The report explains that these stocks existed because DOA and DOAE were engaged in pesticide research as sub-standard pesticide control activities.

2010-2013 Inventory update

The PCD found a combined 54 kg of chlordane being held by both the DOA and the DOAE, and 7 liters of dieldrin and 49 liters of technical endosulfan belonging to the DOA. Thus, in comparison with the 2004 inventory, the total amounts of obsolete stockpiles had decreased.

Current inventory update (2018)

As shown in Table 1-3, some chlordane previously owned by the DOAE was still found, but at a smaller amount (only 31 kg). This is, partly due to the fact that in 2003 the DOAE ceased its former function of supporting pesticides to farmers in times of urgent needs, but still lacks a system to collect and dispose of its obsolete pesticide stockpiles. On the contrary, all of the obsolete SC POPs Pesticides stocks previously owned by DOA had already been collected and destroyed via hazardous waste incineration in 2005, 2008, and 2018.

In addition, the inventory team also found that a pharmaceutical medical company still had a stock of lindane in possession. The company had previously been granted an FDA import license for lindane, which was later voluntarily withdrawn. Currently, 0.9 tonnes of lindane remains in the company's warehouse, pending disposal.

Table 1-3: Summary of SC POPs Pesticides obsoleted stock

No	Substance	Obsolete stocks (tonnes)		
		2004	2010-2013	2018
	Initial List			
1	Aldrin	-	-	-
2	Chlordane	0.03	0.054[1]	0.031[3]
3	DDT	0.18	-	-
4	Dieldrin	-	7 liters[2]	-
5	Endrin	-	-	-
6	Heptachlor	0.01	-	-
7	HCB	-	-	-
8	Mirex	-	-	-
9	Toxaphene	-	-	-
	New List			
1	α-HCH	-	-	-
2	β-HCH	-	-	-
3	γ-HCH (lindane)	-	-	0.9[4]
4	Chlordecone	-	-	-
5	PeCB	-	-	-
6	Techinical endosulfan and its related isomers	2.9	49 liters[2]	-
7	PCP	-	-	-

Remark: - = No stock found, [1] = Both DOA and DOAE, [2] = DOA, [3] = DOAE, [4] = A private company

Elimination

The DOA has a collection and disposal mechanism in place to manage its obsolete pesticide stocks including SC POPs Pesticides. Obsolete pesticides are gathered by agricultural inspectors who are responsible for the control and supervision of production, and distribution of agricultural chemicals in accordance with the HSA. Pesticides that are found obsolete or below standards are confiscated by the local agricultural inspectors, who in turn inform their affiliated DOA regional offices for future disposal. In 2005, 2008 and 2018, the DOA sent about 59.7, 32.9, and 48.5 tonnes of obsolete pesticide stocks for destruction by industrial waste incineration. Pesticide wastes are incinerated at temperatures above 850 °C in a rotary kiln, and the resulting gases are subsequently destroyed in secondary combustion chamber at 1,100-1,300 °C before being rapidly cooled in an evaporative cooler to prevent dioxin formation. Lime and activated carbon are sprayed to reduce acid gases, dioxin and heavy metal in the exhaust gases. Bag filter house, selective catalysis NOx reduction system, and acid scrubbing system are installed to reduce pollutants. Exhaust gases are released via a stack at temperatures below 85 °C. Bottom ashes are stabilized and sent to sanitary landfill.

1.4.3 POPs Pesticide Alternatives

Alternative chemicals for initial SC POPs Pesticides have been commercially available, such as organophosphates, carbamates and pyrethroids. For new SC POPs Pesticides, substitutes have been proposed for technical endosulfan and lindane. The Rice Research and Development Office of the Rice Department has issued recommendation for the removal of golden apple snails by using tea seed meal, niclosamide, metaldehyde, and copper sulfate to replace technical endosulfan [16]. DOA suggested a group of substitutes for non-CS technical endosulfan such as omethoate, buprofezin, imidacloprid, carbosulfan, triazophos, lambda-cyhalothrin, and malathion, while substitutes for CS-formulation technical endosulfan include omethoate, buprofezin, imidacloprid, carbosulfan [17]. FDA recommended permethrin as a substitute for lindane as the second-line treatment for scabies and lice in humans [1].

Other alternative solutions of pest control recommended and promoted by DOA and DOAE are such as organic farming, IPM, GAP, and the use of bio-pesticides. Although organic agriculture is increasing in Thailand, certified organic agriculture currently accounts for only 0.41 % of all agricultural areas [18].

1.4.4 Environmental monitoring of SC POPs Pesticides

There are several guidelines that serve as a basis for the monitoring of POPs Pesticide contamination in Thailand. The National Environment Board has issued guidelines for maximum allowable concentrations (MAC) for SC POPs Pesticides in environmental media including surface water, groundwater, seawater, and soil (Table 1-8 and Table 1-10 in the Annex) [25]-[28]. In addition to these standards, there are other MAC standards for SC POPs Pesticides such as municipal tap water quality criteria by the MWA and the PWA [19, 20]; water quality criteria for the conservation of aquatic animal resources by the Department of Fisheries; and quality criteria for groundwater and soil within factory boundaries by the DIW [21] (see Table 1-8 to Table 1-10 in the Annex) [22]. In order to control pesticide residues in food and animal feed, the MoAC issued the Thai Agricultural Commodity and Food Standard (TACFS 9003-2004) on pesticide residues: Extraneous maximum residue limits (EMRL) [23] and the Thai Agricultural Standard (TAS 9002-2016) on pesticide residues: Maximum residue limits (MRL) [24]. The FDA issued the Notification on Food Containing Pesticide Residues in order to prevent potential hazards from food consumption [25]. This notification sets its own EMRL and MRL standards that are similar to those of TACFS 9003-2004 and TAS 9002-2016. These standards lead to POPs Pesticide monitoring in the environment and in domestic food and feed.

During 2007-2017, several monitoring projects have been conducted by government agencies and the academia in accordance with Thailand's 2007 NIP. Environmental pollution related to SC POPs Pesticides along the main rivers of Thailand have been monitored by DOA since 2009. PCD is responsible for monitoring water resource quality for both surface water and seawater in various regions of the country, while MWA and PWA regularly analyze SC POPs Pesticides in both raw water and tap water. DMS conducted monitoring and risk assessment on SC POPs Pesticides in food based on the MoPH Notification B.E. 2560 [25] and also conducted a human bio-monitoring project in 2011 to identify DDT and metabolites concentration.

1.4.4.1 Environmental media along major Thai rivers

The surveys and monitoring in the environment were carried out during 2009 to 2017 by the DOA to investigate the spread of organochlorine pesticides (OCPs) from agricultural areas into the main rivers of Thailand, namely Chaopraya, Pasak, Tha Chin, Bangpakong, Mae klong and Ping/Nan, as shown in Table 1-4 and Table 1-5 [26]. The sampling areas covered many provinces that the rivers flow through. Each study period lasted 1 year, during which samples of water, sediment, aquatic plants, and fish were taken 4 times. One particular river system was studied during each 1-year cycle. Of the six river systems studied so far,

only Pasak and Tha Chin Rivers have been investigated twice. Overall, a total of 736 water, 560 sediment, 154 aquatic plant, 44 fish, and 8 soil samples were analyzed for OCPs residues. SC POPs Pesticides that the study inspected covered 6 initial SC POPs Pesticides (aldrin, dieldrin, chlordane, DDT, endrin, and heptachlor) and 4 new SC POPs Pesticides (α-HCH, β-HCH, γ-HCH, and endosulfan). As show in Table 1-4, the numbers and percentages of positive samples indicate that OCPs residues were detected during the first 4 years of the study (2009-2012), but not during the latter years (2013-2017).

In summary, during 2009-2012, data show that some SC POPs Pesticides were still detected in Thailand's river ecosystems. However, the residue levels detected in water and fish samples were lower than the MAC of pesticide residues in water and did not exceed the median lethal concentration (LC50) for golden orfe fish [26].

In comparison with the 2009-2012 monitoring results, the more recent river monitoring data of 2013-2017 may appear to indicate a decreasing trend in SC POPs Pesticide contamination. However, because the samples of these 2 study periods were collected from mostly different river systems (except Tha Chin and Pasak), more coherent, long-term studies for each of these individual river systems will be needed in order to confirm such potential trends.

2009-2012 monitoring

Chaopraya River (2009)

Chlordane, dieldrin, endrin, DDT and metabolites, and technical endosulfan and metabolite were detected in about 20% of the water samples, with concentration in the ranges of 0.03-0.05, <0.01, <0.01, <0.01-0.13, and <0.01-0.21 µg/l, respectively. In about 18% of the sediment samples, dieldrin and technical endosulfan and metabolite were found with concentrations <0.01 mg/kg.

Pasak River (2009-2010)

Dieldrin, DDT and metabolites and technical endosulfan and metabolite were detected in about 10% of the water samples, with concentration ranges of <0.01-0.02, <0.01-0.02, and 0.01-0.04 µg/l, respectively. In about 8% of the sediment samples, chlordane and DDT and metabolites were found with concentration ranges of <0.01-0.04 and <0.01 mg/kg, respectively. In about 10% of the aquatic plant samples, dieldrin and DDT and metabolites were found in the ranges of <0.01 and 0.01-0.02 mg/kg, respectively. In about 47% of the aquatic animal samples, DDT and metabolites and technical endosulfan and metabolite were also found with concentrations in the ranges of <0.01and <0.01 mg/kg, respectively.

Tha Chin River (2010-2011)

DDT and metabolites and technical endosulfan and metabolite were detected in about 44% of the water samples with concentration ranges of <0.01-0.02 and <0.01-0.07 µg/l, respectively. In about 8% of the

sediment samples, DDT and metabolites and technical endosulfan and metabolite were found with concentration ranges of <0.01 and <0.01-0.02 mg/kg, respectively. In about 6% of for the aquatic plant samples, dieldrin and technical endosulfan and metabolite were found in the ranges of <0.01 and <0.01-0.02 mg/kg, respectively. In about 90% of the aquatic animal samples, DDT and metabolites, dieldrin and technical endosulfan and metabolite were found in the ranges of <0.01-0.02, <0.01, and <0.01 mg/kg, respectively.

Bangpakong River (2012)

Dieldrin, DDT and metabolites and technical endosulfan and metabolite were detected in about 11% of the water samples with concentration ranges of <0.01, <0.01, and <0.01-0.05 µg/l, respectively. In about 11% of the sediment samples, DDT and metabolites were found in the range of <0.01 mg/kg. SC POPs Pesticides were not detected in the aquatic plant and the aquatic animal samples.

2013-2017 monitoring Mae Klong, Pasak, Tha Chin and Ping/Nan Rivers (2013-2017)

During 2013-2017, samples from Mae Klong, Pasak, Tha Chin and Ping/Nan river were monitored for organochlorine pesticide residues by DOA. The results in Table 1-4 showed that all samples tested yielded negative result.

Table 1-4: Survey data of organochlorine pesticide residues in environmental samples along the main rivers of Thailand during 2009-2017

Survey Year	2009		2010		2011		2012		2013		2014		2015		2017	
River	Chaopraya		Pasak		Tha Chin		Bangpakong		Mae Klong		Pasak		Tha Chin		Ping and Nan	
Media	n	% positive	n	% positive	n	% positive	n	% positive	n	% positive	n	% positive	n	% positive	n	% positive
Surface water	103	20	99	10	93	44	98	11	83	0	104	0	96	0	60	0
Sediment	89	18	99	8	85	8	75	11	51	0	85	0	51	0	25	0
Aquatic plant	-	-	29	10	71	6	8	0	12	0	3	0	31	0	-	-
Fish	-	-	15	47	21	90	5	0	-	-	3	0	-	-	-	-
Soil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	0

Ref: Department of Agriculture, 2009-2017, Remark: - = no sample, n = number of samples

Table 1-5: Levels of organochlorine pesticide residues in environmental samples along the main rivers of Thailand during 2009-2012

Media	Survey year/River	Aldrin	Chlordane	Dieldrin	Endrin	Heptachlor	p,p'-DDT	o,p'-DDT	p,p'-DDE	o,p'-DDE	α-HCH	β-HCH	γ-HCH	Technical endosulfan[1]
Surface	2009/Chaopraya	-	0.03-0.05	<0.01-0.01	<0.01	-	<0.01-0.02	<0.01	<0.01-0.13	-	-	-	-	<0.01-0.21
Water (µg/L)	2010/Pasak	-	-	<0.01-0.02	-	-	<0.01-0.01	0.02	<0.01	-	-	-	-	0.01-0.04
	2011/ThaChin	-	-	-	<0.01	-	-	-	<0.01	0.01-0.02	-	-	-	<0.01-0.07
	2012/Bangpakong	-	-	<0.01	-	-	-	-	-	<0.01	-	-	-	<0.01-0.05
Sediment	2009/Chaopraya	-	-	<0.01	-	-	-	-	-	-		<0.01		<0.01
(mg/kg dry)	2010/Pasak	-	<0.01-0.04	-	-	-	<0.01	<0.01	<0.01	-	-	-	-	-
	2011/ThaChin	-	-	-	-	-	-	-	<0.01	-	-	-	-	<0.01-0.02
	2012/Bangpakong	-	-	-	-	-	-	-	<0.01	-	-	-	-	-
Aquatic plant	2009/Chaopraya*	-	-	-	-	-	-	-	-	-	-	-	-	-
(mg/kg wet)	2010/Pasak	-	-	<0.01	-	-	0.01-0.02	-	-	-	-	-	-	-
	2011/ThaChin	-	-	<0.01	-	-	-	-	-	-	-	-	-	<0.01-0.02
	2012/Bangpakong	-	-	-	-	-	-	-	-	-	-	-	-	-
Fish	2009/Chaopraya*	-	-	-	-	-	-	-	-	-	-	-	-	-
(mg/kg wet)	2010/Pasak	-	-	-	-	-	<0.01	-	<0.01	-	-	-	-	<0.01-0.04
	2011/ThaChin	-	-	<0.01	-	-	<0.01	-	<0.01-0.02	<0.01-0.01	-	-	-	<0.01
	2012/Bangpakong	-	-	-	-	-	-	-	-		-	-	-	-

Ref: Department of Agriculture, 2009-2012.

Remark: - = not detected, * = not sampled, [1] = technical endosulfan and metabolite (endosufan sulfate)

1.4.4.2 Water resources

During 2007-2017, the PCD reported the results of water quality measurements for both surface water and seawater in various regions of the country. Their analysis included 6 initial SC POPs Pesticides (aldrin, dieldrin, chlordane, DDT, endrin, and heptachlor) and 3 new SC POPs Pesticides (α-HCH, lindane, and endosulfan) according to the quality standards for surface water [27] and seawater [28] for Thailand (See Table 1-8 in the Annex). The PCD concluded in its annual Thailand State of Pollution Reports that there were "no concern" associated with organochlorine pesticide residues for both surface water and seawater in each region of the country [6].

MWA regularly analyzes 6 initial SC POPs Pesticides (aldrin, dieldrin, chlordane, DDT and metabolites, endrin, and heptachlor) and 4 new SC POPs Pesticides (α-HCH, β-HCH, lindane, technical endosulfan and metabolite in both raw water (from the Chaopraya and Mae Klong Rivers) and municipal tap water. During 2007-2017, SC POPs Pesticides in raw water and tap water samples were reported as non-detected. (Detection limit of 0.02 µg/l applies for aldrin, dieldrin, heptachlor, HCH, and α-endosulfan, and 0.04 µg/l for endrin, DDT and metabolites and β-endosulfan.)

During 2017-2018, the PWA analyzed 6 initial SC POPs Pesticides (aldrin, dieldrin, chlordane, DDT, heptachlor, and HCB) and 1 new POPs Pesticide (lindane) in raw water and tap water samples covering 25 river basins. Data showed that SC POPs Pesticides in these water samples were below the standard for tap water quality [19] [20].

1.4.4.3 Ambient air

In 2005, Thailand joined the First Global Monitoring Plan (GMP) for POPs [29]. This international collaboration project aims to monitor POPs in environmental media and in humans, using the same methodology among member countries to enable result comparison. The Asian countries that participated in this program were Cambodia, Indonesia, Japan, Republic of Korea, Mongolia, Philippines, Thailand, and Vietnam. During 2006-2007, ambient air in the central and northern regions of Thailand were sampled and analyzed. The sampling, analytical, and QA/QC methods for ambient air are summarized in Table 1-12 in the Annex [29].

As shown in Table 1-13 in the Annex, most of the initial SC POPs Pesticides were detected in the ambient air in both the central and northern regions of Thailand, with concentrations in the central region being higher. The concentrations of chlordane, dieldrin, heptachlor, and

mirex in Thailand's central region in 2006 were higher than those in other Asian countries.

Among participating Asian countries (except Cambodia), the initial POPs Pesticide with the highest concentration was HCB, with concentration ranging from 13 to 330 pg/m^3. Although historically HCB was not intentionally used for agricultural or pest control in Thailand, it was an unintentional by-product from the industrial production of chlorinated compounds and is also formed by incomplete combustion involving chlorine.

The PCD is currently participating in the Third GMP for POPs (2016-2019), in which ambient air and breast milk are sampled and investigated.

1.4.4.4 Environmental media from specific agricultural areas

In addition to the aforementioned environmental monitoring activities by PCA, DOA, MWA, PWA, and GMP, research works by academic institutions have also reported the contamination of organochlorine pesticides (OCPs) in environmental media from specific agricultural areas that are mostly below the applicable standard values (Table 1-6). However, in some specific areas, OCPs were found to exceed standard levels, such as:

- 2004-2007, DDT and metabolites, HCHs, and technical endosulfan and metabolite concentrations in certain aquatic plants sampled from Rangsit agricultural area in Pathum Thani Province exceeded the EMRL and MRL, as follows [38]-[40]:

  DDT and metabolites detected in 6 samples of Neptunia oleracea with average concentration of 19.61±2.38 ng/g (EMRL < 10 ng/g)

  DDT and metabolites detected in 33 samples of Pisita stratiotes with average concentration of 11.12±1.91 ng/g (EMRL < 10 ng/g)

  HCHs detected in 8 groups (273 samples) of aquatic plants with average concentrations of 5.44± 0.32 to 36.49±6.79 ng/g (MRL= zero tolerance)

  Technical endosulfan and metabolite detected in 8 groups (273 samples) of aquatic plants with average concentrations of 7.91±0.49 to14.03±0.29 ng/g (MRL= zero tolerance)

- 2006-2007, OCPs in water samples from southern rivers (Pattani, Tiba, and Saiburi Rivers) exceeded the standard levels for surface agricultural water as follows [30]:

  Aldrin: 2 of 7 samples (28%) from Pattani and Tiba Rivers exceeded MAC, with average concentrations up to 3.30 µg/l (MAC < 0.1 µg/l)

Dieldrin: 1 sample from 10 samples (10%) from Pattani River exceeded MAC, with average concentrations up to 0.28 µg/l (MAC < 0.1 µg/l)

Heptachlor and Heptachlor epoxide detected in 14 samples, with concentrations up to 1.70 µg/l (MAC < 0.2 µg/l)

DDT and metabolites detected in 14 samples, with average concentrations up to 67.18 µg/l (MAC < 1.0 µg/l)

α-HCH detected in 14 samples, with average concentrations up to 2.33 µg/l (MAC < 0.02 µg/l)

- 2007-2010, lindane and β-endosulfan in livers of bird samples from the Boraphet Wetland, Nakonsawan Province exceeded Codex standard levels as follows [31] [32]:

  Lindane detected in 6 samples of little cormorants, 20 samples of carnivores, 3 samples of purple swamphens, and 17 samples of ominivorces, with average concentrations of 18±21, 11.2±2.1, 19±23, and 16.9±2.2 ng/g, respectively (Codex 2007 MRL for meat < 10 ng/g)

  β-endosulfan detected in 1 sample of little cormorant and 8 samples of yellow bitterns, with average concentrations of 119.4 and 178±238 ng/g, respectively (Codex 2007 MRL for livers of cattle, goats, pigs and sheep < 100 ng/g fat)

- 2011-2012, Aldrin and 4,4'DDE in rice samples from certain GAP-certified agricultural areas in northern Thailand exceeded the EMRL as follows [33]:

  Aldrin: all 78 samples exceeded EU MRL (<0.01 mg/kg)

  4,4'DDE: 4 of 78 samples (5%) exceeded EU MRL (<0.05 mg/kg)

1.4.4.5 Food and crops

In 2010, the Bureau of Quality and Safety of Food, the Department of Medical Sciences (DMS) conducted a survey program to investigate 8 SC POPs Pesticides including 6 initial and 2 new SC POPs Pesticides (aldrin, dieldrin, chlordane, DDT, endrin, heptachlor, endosulfan, and lindane) in animal tissues [34]. 73 samples were collected from fresh markets in 8 provinces covering 4 regions of Thailand. DDT and metabolites were found in 3 of freshwater fish samples (about 4.1% of all samples) in the range of 0.008-0.05 mg/kg fat, which did not exceed the EMRL value (1 mg/kg fat). A low level (<0.005 mg/kg fat) of endosulfan sulfate (a metabolite of endosufan) was detected in one sample of freshwater fish

(about 1.4% of all samples). EMRL for endosulfan in food has not yet been defined by the FDA, also the Codex Standard does not indicate any MRL for endosulfan in fish [32].

During 2012-2014, the Bureau of Quality and Safety of Food monitored 8 SC POPs Pesticides (aldrin, dieldrin, chlordane, DDT and metabolites, endrin, heptachlor, technical endosulfan and metabolite, and lindane) in 203 orange samples. Of these samples were 20 domestic samples grown in Thailand (collected from the markets in Bangkok and suburban area) and 183 imported samples, mostly from Myanmar and China. Organochlorine pesticide residues were not detected in any of these orange samples [35].

Since 1989, the DMS started the total diet study project to assess the population's exposure to toxic substances. In 2017, this project was implemented, and GC-MS/MS analysis for residues of 6 initial POPs and 4 new POPs (aldrin, dieldrin, chlordane, DDT and metabolites, endrin, heptachlor, α-HCH, β-HCH, γ-HCH, and technical endosulfan and metabolite) in cooked food was performed. 34 groups of food and 1,048 samples were collected from 8 provinces, covering 4 regionals of the country. The results of this study showed that POPs Pesticide residues in all of the sampled food groups were below the detection limits [36].

During 2015-2017, the DOA monitored pesticide residue in 12,122 GAP-certified agricultural product samples from supermarkets and farms. Technical endosulfan and metabolite residues above MRL standard were detected in 2 samples (about 0.02%). In such cases, DOA has a mechanism to trace back to the GAP-certified farms and issue corrective action request (CAR) for improvement.

1.4.4.6 Human Serum

The Division of Toxicology, the Department of Medical Sciences (DMS) analyzed concentrations of p,p′-DDT and p,p′-DDE in human blood serum samples from 1,137 adult Thai residents collected in 2011, for use as biomarkers to identify health effects in adults. The geometric mean concentration (95% confidence interval) for serum total p,p′-DDE concentration was 1,539 (1,242-1,837) ng/g lipid and 1,547 (1,293-1,806) ng/g lipid in adult males and females, respectively. The study also provided correlations between serum DDT levels and the risk of diseases [37].

Table 1-6: Research data on organochlorine pesticide residues in environmental samples by the academic institutions

Survey year	Monitored SC POPs Pesticides	Environmental media	No. of samples	Sampling site	Results	Ref
2004	5 initial and 4 new SC POPs Pesticides (aldrin, dieldrin, endrin, DDTs, heptachlor, α-HCH, β-HCH, γ-HCH, endosulfan)	Sediment	104	Coastal areas of Chachoengsao, Chonburi and Rayong Provinces	• Concentrations in sediment samples below the maximum pesticide residue limits allowed in soil for agriculture and habitat.	[38]
2004-2007		Planktons	51	Rangsit agricultural areas, n Pathum Thani Province	• Concentrations below the maximum pesticide residue limits allowed in surface water and soil for agriculture and habitat in all surface water and sediment samples. • Concentrations below EMRL standard in all fish samples. • DDT and metabolites, HCHs, technical endosulfan and metabolite above EMRL in certain aquatic plant samples.	[39] [40] [41]
		Surface water	108			
		Sediment	108			
		Aquatic plants	270			
		Fish	130			
		Shrimps and fish	220			
2006-2007		Sediment	27		• Concentrations below the maximum pesticide residue limits allowed in soil for agriculture and habitat in all sediment samples. Concentrations below EMRL in all mussel samples.	[42] [43]
		Fresh water mussels	20			
2007-2008		Surface water	14	Rivers of Southern Thailand (Saiburi, Pattani, Tiba)	• Concentrations above the maximum pesticide residue limits allowed in surface water for agriculture in certain water samples.	[30]
2007-2010		Bird livers	49	Boraphet wetland, Nakonsawan Province	• Initial POPs below EMRL in all meat and poultry offal samples. • Technical endosulfan and metabolite and lindane above Codex 2007 standard in certain bird livers.	[31]
2011-2012		Soil	51	GAP certifiedagricultural areas in Northern Region	• Most SC POPs Pesticides not detected in soil samples, except heptachlor below MRL. • DDT and metabolites and aldrin above MRL in certain rice samples.	[33]
		Rice	78			
2014	6 initial and 4 new SC POPs Pesticides (aldrin, dieldrin, endrin, DDTs, heptachlor, chlordane, α-HCH, β-HCH, γ-HCH, endosulfan)	Sediment	90	Chainat Province	• Initial SC POPs Pesticides not detected. • Concentrations below the maximum pesticide residue limits allowed in soil for agriculture and habitat in all sediment samples.	[44]

1.5 Conclusion

Thailand has regulations as well as designated government agencies in place for controlling the import, export, production, use, and disposal of dangerous chemicals, including most of the SC POPs Pesticides. There are mechanisms in place to control import, export, production, and use of these substances, as well as regulations and standards for their environmental monitoring. There has never been any production of SC POPs Pesticides in the country. Currently, all 9 initial SC POPs Pesticides and 6 of the 7 new SC POPs Pesticides (except PeCB) have been classified as Category 4 substances under the HSA. Based on the information from the responsible agencies, no import or export records of these substances have been registered during 2007-2017.

Thailand's first inventory for SC POPs Pesticides reported obsolete stocks of 0.22 tonnes of initial SC POPs Pesticides (chlordane, DDT, and heptachlor) and 2.9 tonnes of new SC POPs Pesticides (endosulfan). Subsequently, this current inventory found that, as of 2018 all of the previously reported obsolete POPs Pesticide stocks in DOA possession had been collected and disposed of; however, stockpiles of about 31 kg of chlordane and 0.9 tonnes of lindane were still identified, pending discussions among relevant stakeholders.

During the last 10 years, Thai government agencies as well as researchers have been monitoring SC POPs Pesticides in the environment and food. Corresponding guidelines have been issued for the maximum SC POPs Pesticide contamination levels allowed in water, soil, and food. Most monitoring data in the environment, drinking water and food conducted by DOA, PCD, MWA, PWA and DMS, showed that the levels of residues were within the applicable standard limits. However, four academic research works have shown that DDT and metabolites, HCHs, technical endosulfan and metabolite, aldrin, dieldrin, heptachlor, and lindane also exist above the applicable MAC and MRL/EMRL in specific agriculture areas.

Uncertainty

The import/export data presented in this report are given a high level of confidence as they are based on official DOA figures.

Amounts of domestic stocks of SC POPs Pesticides in this report are given a medium level of confidence because the Thai government (DOA) does not require or maintain domestic records of pesticide transactions along the supply chain.

The data quality from environmental monitoring studies by the academic sector is unknown because most of these testing facilities and methods have not yet been formally verified.

Recommendation

Regulations and standards

Currently, environment, food, and drinking water quality guidelines used by the relevant agencies to monitor various environmental media do not cover all SC POPs Pesticide substances including dicofol (2019 listing). These standards should therefore be revised to include a wider range of SC POPs Pesticides, especially ones that have been used or detected in the country. Also, in order to obtain meaningful data for assessment of the current situation, emphasis should be placed on establishing context-relevant and comprehensive monitoring plans in the long run.

Supply chain database

To help track domestic flow and distribution of SC POPs Pesticides, DOA should set up multi-dimensional database (spacial and temporal data of relevant activities, distribution volumes, remaining stocks and types of relevant pesticides, for examples) along the pesticide supply chain, from import/export, formulation, repackaging, to sales. Such multi-dimensional database is important for the government to plan the management and disposal of obsolete pesticide stocks before applying any future restrictions. Moreover, such database will be vital to the country's pesticide management, including stock traceability, hotspot identification/prediction, and monitoring planning.

Monitoring data

Pesticide monitoring data in the environment, food, and humans are a basis for the assessment of risks to humans and the environment. Well laid-out, long-term national monitoring programs by responsible government agencies therefore deserve prudent planning. The resulting monitoring data should be made systematic, coherent, and readily available to the public.

Certain international/regional collaborative POPs monitoring studies, such as the GMP, are useful for the country both in terms of gaining technical expertise and generating necessary monitoring data. Thailand should therefore make efforts to partake in such activities when possible, including a continued participation in the various phases GMP on POPs.

Since SC POPs Pesticides monitoring research by the academic sector helps fill the country's environmental monitoring data gaps, these works deserve continued support in the long run. Contamination reports by the academia and non-governmental organizations should also be independently verified by responsible government agencies.

□□□

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Annex 1. Regulations related to pesticides management in Thailand

As a major agriculture and food producing country, Thailand gains a significant portion of its income from exporting agricultural commodities. In 2017, agricultural and food products were exported at an approximate value of 40,000 million USD, or 17% of the total national export. The export shares among Thai agricultural products are rubber at 16% followed by rice (12%), sugarcane (8%), cassava (5%), maize (0.2%) and others. Thailand covers an area of about 51 million hectares, of which around 24 million hectares (47%) was utilized for agriculture in 2017 [18]. Of this agricultural area, the biggest share of arable land is rice paddies at 46% followed by dryland farming (21%), fruit gardens and perennial plants (25%), vegetable gardens and flowering plants/ornamental plants (1%), and others (8%). Due to the high proportion of agricultural areas, pesticides play a significant role in the national food production.

Utilization of pesticides affects both humans and the environment. Therefore, Thailand has issued various regulations to control and manage the use of pesticides, from the upstream to the downstream, as follows.

Hazardous Substance Act B.E. 2535 (1992) [7]

Registration, production, distribution, and sale of pesticides

The regulatory process for registration, production, distribution, and sale of pesticides used in crop production is currently controlled by the DOA, which has issued two main notifications, namely:

- Notification of Ministry of Agriculture and Cooperatives on Registration, License Issuance and Renewal of Hazardous Substances under the Responsibility of Department of Agriculture B.E. 2551 (2008) [12].
- Notification of Ministry of Agriculture and Cooperatives on Production, Importation, Exportation and Possession of Hazardous Substances under the Responsibility of Department of Agriculture B.E. 2547 (2004) [13] and additional amendment [14].

Agricultural Standards Act B.E. 2551 (2008) [45]

The Agricultural Standards Act aims to control and monitor pesticide contamination in agricultural products, and is enforced by the MoAC. The act controls the standards and the licensing of manufacturers, importers and exporters of all agricultural products in order to ensure that their operations are in line with international standards. There are three standards related to SC POPs Pesticides in agricultural commodities, namely:

- Thai Agricultural Standard: TAS 9001-2013 "Good agricultural practices for food crop (GAP)" [46].
- Thai Agricultural Commodity and Food Standard: TACFS 9003-2004 "Pesticide residues: extraneous maximum residue limits (EMRL)" [23].
- Thai Agricultural Standard: TAS 9002-2016 "Pesticide residues: maximum residue limits (MRL)" [24].

Good agricultural practice for food crops (GAP)

TAS 9001-2013 promotes good practices in every step of food crop production at farm level. The goal is to obtain good quality produce that are safe for consumption by taking the environment as well as the health, safety, and welfare of workers into account. The standard covers various food crops such as vegetables, fruits, field crops, spices, and herbs. The standard contains 8 groups of principle requirements including 1) water source, 2) plantation area, 3) agricultural hazardous substances, 4) quality management in the production process before harvesting, 5) harvesting quality management and post-harvest handling, 6) transport and storage of produce within the plantation 7) personal hygiene, 8) data recording. The third group of principle requirement involves agricultural hazardous substances, such as the ban on the use and possession of Category 4 hazardous substances and the proper disposal of pesticide containers.

TACFS 9003-2004: Pesticide residues: extraneous maximum residue limits (EMRL)

TACFS 9003-2004 establishes the EMRL for pesticides in food and animal feed, to control agricultural commodities upon sale, import and export. The EMRL is the maximum allowable concentration for each specified pesticide residue arising from environmental media contamination (i.e., not intentionally applied). The EMRL includes certain pesticides that have already been banned but, because of their persistent nature, still exist as environmental residues in agricultural commodities. Six initial SC POPs Pesticides are covered by the EMRL, namely aldrin, dieldrin, endrin, chlordane, DDT, and heptachlor.

TAS 9002-2016: Pesticide residues: maximum residue limits (MRL)

TAS 9002-2016 establishes the MRL for pesticides in food and animal feed, which is used as a reference for the control and inspection of agricultural commodities that are produced, imported and exported. MRL is the maximum residue concentrations for specific intentionally used pesticides that are permitted in or on agricultural commodities, as recommended by the Agricultural Standards Committee. In addition to specifying a list pesticides and their associated MRL values, TAS 9002-2016 also stipulates that all Category 4 pesticides (except those already regulated by the EMRL of TACFS 9003-2004) must exhibit undetectable residue values. This 'undetectable residue' requirement therefore applies to the following 9 SC POPs Pesticides: HCB, mirex, and toxaphene (initial SC POPs Pesticides) and α-HCH, β-HCH, γ-HCH (lindane),

chlordecone, endosulfan, and PCP (new SC POPs Pesticides).

The Food Standards Act B.E. 2522 (1979) [47]

This act is the major law aimed at protecting consumers against health hazards from food consumption. According to this act, the MoPH is in charge of promulgating ministerial regulations, appointing the Food Committee and competent officers, and setting up other activities in order to carry out the provisions of the act. There is one related notification, which establishes both EMRL and MRL for SC POPs Pesticides in various foods, namely:

- Notification of the Ministry of Public Health No.387, B.E.2560 (2017) on Food Containing Pesticide Residues [25] and additional amendment [48].

As discussed above, food safety in terms of pesticide residues are regulated by the 2 relevant ministries: MoPH and MoAC. Despite the fact that both ministries issue its own EMRL and MRL for pesticides, the categorization and limit values of these 2 sets of EMRL and MRL are mostly consistent. In additional to the MRL and the EMRL, pesticide residue levels are regulated according to other standard limits, as summarized in Table 1-7

Table 1-7: Summary of pesticide residue limits in food (and feed) according to Thai regulations

Regulations	Ministry	Standard limits		Key requirements
		EMRL	MRL	
TACFS 9003-2004	MoAC	✓		1. Intentionally used pesticides that are specified in the regulations must not exceed the associated specified MRL. 2. Extraneous pesticides that are specified in the regulations must not exceed the associated specified EMRL. 3. All Category 4 pesticides under the HSA (excluding those specified by the EMRL) must exhibit undetectable residue level. 4. Pesticides that are not specified in the above requirements must exhibit residue levels according to Codex [32], if applicable. 5. Residue levels of all other pesticides must not exceed 0.01 mg/kg.
TAS 9002-2016	MoAC		✓	
Notification No.387 on Food Containing Pesticide Residues, 2017	MoPH	✓	✓	

Enhancement and Conservation of National Environmental Quality Act B.E.2535 (1992) [49]

This law aims to control the quality of natural resources and the environment. Under this act, the National Environmental Board was formed to perform functions according to the provisions of this act. There are four standards that specify the maximum allowable concentrations (MAC) for SC POPs Pesticides in environmental media, namely:

- Notification of the National Environmental Board No.8, B.E.2537 (1994) on Surface Water Standard (covering the usage of surface water for consumption, agriculture, fishery, industry, swimming and water sports, and aquatic ecosystem conservation) [27].
- Notification of the National Environmental Board No.20, B.E.2543 (2000) on Groundwater Standard (covering the usage of groundwater for consumption) [50].
- Notification of the National Environmental Board No.27, B.E.2549 (2006) on Seawater Standard (covering the usage of seawater for natural resource and coral conservation, aquaculture, recreation, industry, and community) [28].
- Notification of the National Environmental Board No.25, B.E.2547 (2004) on Soil Quality Standard [51].

The summary of the MAC for SC POPs Pesticides according to the above notifications is shown in Table 1-8 and Table 1-10. In addition to these notifications, there are other quality standards for SC POPs Pesticides MAC, such as the municipal tap water quality criteria by the MWA [19] and the PWA [20], and the water quality criteria for conservation of aquatic animal resources by the Department of Fisheries [22] as shown in Table 1-8 and Table 1-9.

The Factory Act B.E.2535 (1992) [52]

This act, enforced by the Ministry of Industry (M-Industry), aims to control factory operations in terms of waste disposal, pollution emission and contamination with the main objective of minimizing the impact on the environment. There is one related notification, which specifies MAC in soil and groundwater within factory boundaries, namely:

- Notification of the Ministry of Industry, B.E.2559 on Soil and Groundwater Contamination Control in Factory Area, Soil and Groundwater Quality Inspection and Notification, the Preparation of Soil and Groundwater Quality Inspection Reports, Control Measures to Reduce Soil and Groundwater Contamination Report [21].

Table 1-8: Maximum pesticide residues allowed in various water types in Thailand [unit: µg/L]

No	Pesticide	Surface water [27]	Groundwater [50]	Seawater [28]	Fresh water for aquatic animal resources [22]	Groundwater within factories [21]
1	Aldrin	0.1	-	1.3	-	3×10^{-5}
2	Chlordane	-	0.2	0.004	-	40×10^{-5}
3	DDT	1	2	0.001	0.5	100×10^{-5}
4	Dieldrin	0.1	0.03	0.0019	0.2	3×10^{-5}
5	Endrin	Non detectable	-	0.0023	0.01	1000
6	Heptachlor	0.2	0.4	0.0036	0.4	10×10^{-5}
7	HCB	-	-	-	-	30×10^{-5}
8	Mirex	-	-	-	-	-
9	Toxaphene	-	-	-	-	40×10^{-5}
10	α-HCH	0.02	-	-	-	10×10^{-5}
11	β-HCH	-	-	-	-	30×10^{-5}
12	Lindane/γ-HCH	-	0.2	0.16	-	40×10^{-6}
13	Chlordecone	-	-	-	-	-
14	PeCB	-	-	-	-	-
15	Endosulfan	-	-	0.0087	-	14,000
16	PCP	-	1	-	-	200×10^{-6}
17	Total OCPs	50	-	-	-	-

Remark: - : Not applicable

Table 1-9: Maximum pesticide residues allowed in municipal tap water [unit: µg/L]

No	Pesticide	MWA Tap Water [19]	PWA Tap Water [20]
1	Aldrin	0.03	0.03
2	Dieldrin	0.03	0.03
3	Chlordane	0.2	0.2
4	DDT	1	1
5	Endrin	0.6	-
6	Heptachlor	0.03	0.03
7	HCB	1	1
8	Mirex	-	-
9	Toxaphene	-	-
10	α-HCH	-	-
11	β-HCH	-	-
12	Lindane/γ-HCH	2	2
13	Chlordecone	-	-
14	PeCB	-	-
15	Endosulfan	-	-
16	PCP	-	-

Remark: - : Not applicable

Table 1-10: Maximum pesticide residues allowed in each type of soil in Thailand [unit: mg/kg]

No	Pesticide	Soil for agriculture and habitat [51]	Soil for non-agriculture and habitat [51]	Soil within factory [21]
1	Aldrin	-	-	0.1×10^{-5}
2	Chlordane	16	110	110×10^{-5}
3	DDT	17	120	120×10^{-5}
4	Dieldrin	0.3	1.5	1.5×10^{-5}
5	Endrin	-	-	25
6	Heptachlor	1.1	5.5	5.5×10^{-5}
7	HCB	-	-	1×10^{-5}
8	Mirex	-	-	-
9	Toxaphene	-	-	1.5×10^{-5}
10	α-HCH	-	-	0.3×10^{-5}
11	β-HCH	-	-	0.9×10^{-5}
12	Lindane/γ-HCH	4.4	29	29×10^{-6}
13	Chlordecone	-	-	-
14	PeCB	-	-	-
15	Endosulfan	-	-	485
16	PCP	30	110	110×10^{-6}

Remark: - : Not applicable

Thai Customs Department's list of HS codes for prohibited/restricted POPs Pesticide

In 1998, the Thai Customs Department started to develop the National Single Window (NSW) to serve as the import/export and logistics data linkage system between government agencies and the business sectors. In 2011, the online NSW system was officially launched. The import and export of hazardous chemicals under the HSA, including Category 4 and Category 3 SC POPs Pesticides, are identified and controlled via HS codes in this NSW system. The Thai Customs Department has issued the list of HS codes for hazardous chemicals [53]. Most SC POPs Pesticides have been added to this list; their HS codes, as specified in the Thai Custom's control list, are shown in Table 1-11.

In addition to Thailand's regulations related to domestic pesticide management, there are also other international legal mechanisms affecting the control of SC POPs Pesticides in Thailand, including the Stockholm Convention and the Rotterdam Convention on the Prior Information Consent (PIC) Procedure for Certain Hazardous Chemicals and Pesticides in International Trade.

Rotterdam Convention

Thailand acceded to the Rotterdam Convention in 2002 with obligations coming into force for Thailand in 2004. The objective of the Rotterdam Convention is to promote international cooperation and share responsibility among parties in the international trade of certain hazardous chemicals in order to protect human health and the environment from harmful chemicals. The PIC procedure is a mechanism

to formally obtain and disseminate the decisions of importing parties as to whether they wish to receive future shipments of the chemicals listed in annex of the convention. The SC POPs Pesticides listed under this convention include aldrin, chlordane, DDT, dieldrin, heptachlor, HCB, toxaphene, α-HCH, β-HCH, lindane, endosulfan, and PCP [54].

Annex 2. HS Codes for SC POPs Pesticides

Table 1-11: Identification HS codes of SC POPs Pesticides for the restriction and prohibition of import/export by the Thai Customs Department

No	Pesticide	CAS No.	Category	HS code
1	Aldrin	309-00-2	4	2903.82.00-001
				3808.59.10-XXX*
				3808.59.21-001
				3808.59.29-001
				3824.84.00-000
2	Chlordane	57-74-9	4	2903.82.00-002
				3808.59.10-003
				3824.84.00-000
3	DDT	8017-34-3	4	2903.92.00-002
				3808.52.10-004
				3808.52.90-004
				3808.59.10-004
				3824.84.00-000
4	Dieldrin	60-57-1	4	2910.40.00-000
				3808.59.10-005
				3824.84.00-000
5	Endrin	72-20-8	4	2910.50.00-000
				3824.84.00-000
6	Heptachlor	76-44-8	4	2903.82.00-003
				3808.59.10-006
				3824.84.00-000
7	Hexachlorobenzene	118-74-1	4	2903.92.00-001
				3808.59.21-101
				3808.59.29-102
				3824.86.00-000
8	Mirex	2385-85-5	4	2903.83.00-000
				3824.84.00-000
9	Toxaphene	8001-35-2	4	2903.89.00-008
				3808.59.10-008
				3824.84.00-000
10	Chlordecone	143-50-0	4	2914.71.00-000
				3824.84.00-000
11	Endosulfan	115-29-7	4	2920.30.00- XXX*
				3808.59.10-207
				3824.84.00-000
	Alpha-endosulfan	959-98-8	3	2920.30.00-002
				3808.91.30- 090
				3808.91.90-208
	Beta-endosulfan	33213-65-9	3	2920.30.00-003
				3808.91.30- 090
				3808.91.90- XXX*
12	BHC(benzene hexachloride) or HCH(hexachlorocyclohexane)	608-73-1	4	2903.81.00-001

No	Pesticide	CAS No.	Category	HS code
				3808.59.10-012
				3808.59.99-012
				3824.85.00-000
13	Beta-HCH or 1,3,5/2,4,6-hexachlorocyclohexane	319-85-7	4	2903.81.00-001
				3808.91.30- 090
				3808.91.90- XXX*
14	Lindane or gamma-HCH	58-89-9	4	2903.81.00-002
				3808.59.10-016
				3808.59.99-016
				3824.85.00-000
15	Pentachlorophenol	87-86-5	4	2908.11.00-000
				3808.59.10-007
				3808.59.91-007
				3808.59.99-107

Ref: Data obtained from Thai Customs Department

Remark: * = Thai Customs Department is in the process of adding new HS codes

Annex 3. Data from the First Regional Monitoring Report (Asia Pacific Region 2008), the Global Monitoring Plan for POPs

Table 1-12: Details of sampling, analytical, and QA/QC methods for ambient air investigation

Sampling	Analytical procedures	QA/QC
• Quartz fiber filter and PUF • High Volume sampler: 700 L/min, 24 hr, total 1,000 m^3 • Middle Volume sampler: 100 L/min, 7 days, total 1,000 m^3 • Low Volume sampler: 3 L/min, 24 hr, total 4 m^3	For Toxaphene: • Cleanup in a Florisil column • GC/NCI-HRMS-SIM For other POPs: • Cleanup in a Florisil column • GC/HRMS-SIM or GC/NCI-HRMS-SIM with the addition of 13C-labeled substances as surrogate standard substances	• Recovery test • Blank test • Standard samples containing known concentrations of analytes • Duplicate measurement • Travel blank test • Participation in proficiency testing

Ref: [29]

Annex 4. SC POPs Pesticides in ambient air of participating Asian countries (1st GMP)

Table 1-13: 2006-2007 SC POPs Pesticides in ambient air of participating Asian countries (1st GMP)

Substance	Amount (pg/m^3)										
	2006								2007		
	Thailand Central region	Cambodia	Indonesia	Philippines	Vietnam	Korea	Mongolia	Japan	Thailand Northern region	Korea	Japan
Aldrin	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	<0.17	n.d.	n.a.	n.a.	n.a.
cis-Chlordane	27	n.a.	1.7	2.3	2.3	-	(0.66)	n.d.-1.9	(0.55)	1.1-1.3	1.4-4.4
trans-Chlordane	45	n.a.	2.4	3.5	2.8	*1.4-2.3*	*<0.58*	n.d.-1.3	<0.58	1.0-1.4	0.77-2.7
cis-Nonachlor	3.2	<0.56	0.21	0.36	0.06	-	<0.56	n.d.-(0.17)	<0.56	<0.1-1.4	n.d.-(0.15)
trans-Nonachlor	19	n.a.	1.2	1.7	0.84	<0.02	(0.66)	n.d.-1.3	<0.65	<0.05-1.2	0.77-2.7
Oxychlordane	1.7	<1.8	0.26	0.26	0.22	<0.08	<1.8	n.d.-(0.51)	<1.8	<0.1	n.d.-(0.52)
Dieldrin	23	1.5	19	*1.5*	1.1	<0.06	(0.68)	n.d.-3.5	(0.51)	<0.1	3.2-6.7
o,p'-DDD	1	1.0	1.3	(0.06)	1.9	<0.04	<0.43	n.d.	<0.43	<0.05	n.d.-0.38
p,p'-DDD	2.2	2.1	2.8	<0.07	2.8	<0.07	<0.45	n.d.-2.9	<0.45	<0.1	n.d.
o,p'-DDE	2.7	2.0	2.5	0.22	8.8	<0.01	<0.19	(0.15)-0.88	(0.35)	<0.05-1.3	(0.05)-1.2
p,p'-DDE	14	25	95	0.88	14	<0.02	0.59	n.d.-2.2	1.5	1.8-4.8	0.6-2.3
o,p'-DDT	6.9	8	24	0.7	21	<0.03	<0.46	(0.55)-2.3	1.8	<0.05-1.6	(0.17)-4.8
p,p'-DDT	22	28	41	1.0	15	<0.10	1.7	n.d.-1.1	3.4	<0.01-1.5	n.d.-2.1
Endrin	0.94	<0.38	11	<0.1	<0.1	<0.1	<0.38	n.d.-0.33	<0.38	<0.1	0.22-0.67
Heptachlor	23	0.85	1.4	*1.5*	1.1	<0.03	<0.52	n.d.-2.9	<0.52	0.4-0.5	n.d.-3.8
cis-Hepachlorepoxide	2.5	(0.32)	0.45	0.34	0.29	-	<0.19	n.d.-0.72	<0.19	-	0.36-1.1
trans-Hepachlorepoxide	<0.05	<0.19	<0.05	<0.05	<0.05	-	0.64	n.d.-0.77	<0.19	-	n.d.
HCB	*330*	n.a.	110	110	330	*70-75*	*94*	13-94	87	81.5-103.3	64-125
Mirex	1.8	<0.41	0.29	0.10	0.47	<0.005	*<0.17*	n.d.-0.15	<0.41	<0.05	0.13-0.32
Toxaphene (Parlar-26)	<1	<0.86	17	<1	<1	-	<0.86	n.d.	<0.86	<1	n.d.
Toxaphene (Parlar-50)	<1	<2.6	18	<1	<1	-	<2.6	n.d.	<2.6	<1	n.d.
Toxaphene (Parlar-62)	<14	<6.8	<16	<14	<14	-	<6.8	n.d.	<6.8	<10	n.d.

Ref: [29], Values in parenthesis show that it was within instrumental detection limit to instrumental quantification limit

n.d = not detected; - = no information; Italic letter = reference value because surrogate recovery was out of 40 to 120 percent;

n.a.= not available because surrogate recovery was out of 25 to 150 percent