# Updated Inventory of POPs Pesticides in Sri Lanka - 2015

**Project on Enabling Activities to Review and Update the National Implementation Plan (NIP) of the Stockholm Convention on Persistent Organic Pollutants (POPs) in Sri Lanka (GEF/UNIDO)**

**Ministry of Mahaweli Development & Environment, Sri Lanka**

**October 2017**

# Updated Inventory of POPs Pesticides in Sri Lanka - 2015



ISBN978-955-8395-16-5

Published by : Project on Enabling Activities to Review and Update the National Implementation Plan for the Stockholm Convention on Persistent Organic Pollutants, Ministry of Mahaweli Development and Environment

Funded by : Global Environment Facility (GEF)
United Nations Industrial Development Organization (UNIDO)

Year of Publication : 2017

Printed by : K.S.U. Graphic (Pvt) Ltd.
510, Rajagiriya Road, Rajagiriya.
Tel: 011 2884701 Fax: 011 2882323
E-mail: ksugraphic@yahoo.com

# Project on Enabling Activities to Review and Update the National Implementation Plan (NIP) of the Stockholm Convention on Persistent Organic Pollutants (POPs) in Sri Lanka (GEF/UNIDO)

## PROJECT COORDINATING UNIT

**Project Director**

Mr. Anura Jayatilake

**Project Office**

Mr. S M Werahera, Assistant Director
Ms. Vindya Hewawasam, Research Assistant
Ms. U Dilhani Maheshika, Trainee
Ms. K G Chathuni Malsha, Trainee

**Expert**

Dr. J A Sumith Pesticides Expert/ Research Officer
Office of the Registrar of Pesticides
Department of Agriculture, Sri Lanka

**Disclaimer**

The content of this publication are the sole responsibility of Ministry of Mahaweli Development & Environment.

## Members of the POPs pesticides inventory Task Team

1. Dr. J A Sumith, (Team Leader)
   Research Officer/ Pesticide Expert, Department of Agriculture Office of Registrar of Pesticides

2. Dr. Inoka Suraweera,
   Consultant Community Physician/ Environment & Occupational Health, Ministry of Health Nutrition & Indigenous Medicine

3. Ms. P. L. J. Gunarathna,
   Assistant Controller, Import & Export Control Department.

4. Mr. Nihal Alahapperuma,
   Supdt: of Customs, Sri Lanka Customs, Department of Customs

5. Ms. Dushanthi Ranpatige,
   Senior Research Engineer/ Environmental Technology, Industrial Technology Institute Industrial Technology Institute

6. Mrs. N M Samaranayake,
   Senior Deputy Director (Env) Board of Investment

# Executive Summary

The Stockholm Convention on Persistent Organic Pollutants (POPs) includes the list of compounds complying with the Annex D objectives, such as persistence, bio–accumulation, toxic (PBT) and potential for long range transport. As a Party to the Stockholm Convention since 05.09.2001 (being a signatory) and by its ratification on 22.12.2005, Sri Lanka is obliged to take part in exercising to review and update of the National Implementation Plan (NIP) in connection with rest of the objectives described in Articles 3 through 16 of the Convention as a result of the amendments brought to the Convention in 2009 and 2011. The first NIP was published in 2006 and since then several key administrative actions have been taken to upgrade the entire situation. Apart from clearly establishing historical POPs pesticide use in Sri Lanka, the current compendium highlights some areas of concern in other aspects of pesticides.

Sri Lanka has been prodigious in making decisions well advance of the announcement of international actions on POPs pesticides under the Stockholm Convention; the current status is spectacular as that almost all POPs pesticides have been de–registered and/or banned from major uses at least earlier than 15 years; the only exception is lindane, which had been used until 2012. Consequently, the levels of biotic and abiotic contamination by POPs pesticides previously determined and reported in the NIP–1 are lower than those data published from some of the regional countries in South Asia where there have been reports of current use. In this context, a further reduction of environmental residue levels would be expected in this country. There is no strong science-base to link environmental contamination with any of the biological and/or epidemiological effect on human and biota under local conditions.

On top of the POPs pesticides (represented by 0.17% of entire stock), there are other obsolete pesticides that require proper disposal, including, over 41 tonnes that includes about 26 tonnes in government farms and research institutions of the Department of Agriculture. Some of the substances are being stored under inappropriate conditions and are deteriorated from being segregated and/or being identified. There are significant barriers preventing providing efficient services of approved disposal facilities (e.g. incineration by co–processing at cement plants) for the management of obsolete pesticides such as financial and technical deficiencies including feeding (of solids), segregation and odour management. Secure storage of obsolete pesticides would be one of the highest priorities until there is an amenable solution for safe disposal.

# Acknowledgements

I have my great appreciation for the Secretary/Ministry of Mahaweli Development and Environment (MMD&E) for accepting me as a consultant on POPs pesticides to prepare the National Implementation Plan update in Sri Lanka. I wish to express my sincere gratitude to all staff in the Air Resources Management and International Relations Division of the MMD&E, especially Mr. Anura Jayathilake, Mr. S.M. Werahera & Ms. Vindya Hewawasam for their invaluable motivation during this compilation. Special thanks are given to my all relevant stakeholders, stakeholder groups for valuable contribution in various capacities and technical inputs throughout the report writing exercise. Last but not least, the financial support given by the United Nations Industrial Development Organization/ Global Environmental Facility (UNIDO/GEF) to accomplish this endeavour is greatly appreciated.

**J A Sumith**
**Pesticides Expert**
**NIP project**

# Table of Contents

# List of Tables

# Table of Figures & Pictures

# List of Abbreviations

| | | |
|---|---|---|
| a.s. | – | active substance |
| ATSDR | – | Agency for Toxic Substance and Disease Registry |
| BHC | – | Benzenehexachloride |
| CARI | – | Central Agricultural Research Institute |
| CAS | – | Chemical Abstract Service |
| CCA | – | Copper Chrome Arsenic |
| CCB | – | Copper Chrome Borate |
| CIC | – | Chemical Industries Ceylon |
| CRI | – | Coconut Research Institute |
| DDD | – | Dichlorodiphenyldichloroethane |
| DDE | – | Dichlorodiphenyldichloroethylene |
| DDT | – | Dichlorodiphenyltrichloroethane |
| DOA | – | Department of Agriculture |
| DRE | – | Destruction and Removal Efficiency |
| EC | – | Emulsifiable Concentrate |
| EDC | – | Endocrine Disrupting Chemicals |
| EPA | – | Environment Protection Agency |
| FAO | – | Food and Agriculture Organization |
| HCB | – | Hexachlorobenzene |
| HCH | – | Hexachlorocyclohexane |
| HS | – | Harmonized System |
| ICI | – | Imperial Chemical Industries |
| ISO | – | International Standardization Organization |
| ITI | – | Industrial Technology Institute |
| IPCS | – | International Program on Chemical Safety |
| LD | – | Lethal Dose |
| MMDE | – | Ministry of Mahaweli Development and Environment |

| | | |
|---|---|---|
| NIP | – | National Implementation Plan |
| OPs | - | Organophosphates |
| PCBs | – | Polychlorinated biphenyls |
| PCT | – | Polychlorinated triphenyls |
| PCDD | – | Polychlorinated dibenzo–p–dioxin |
| PCDF | – | Polychlorinated dibenzo furans |
| PCNB | – | Pentachloronitrobenzene |
| PCP | – | Pentachlorophenol |
| PeCB | – | Pentachlorobenzene |
| PFAS | – | Perflouroalkylated substances |
| PFOA | – | Perfluorooctanoic acid |
| PFOS | – | Perfluorooctane sulfonate |
| POPs | – | Persistent Organic Pollutants |
| ROP | – | Registrar of Pesticides |
| SLAB | – | Sri Lanka Accreditation Board |
| UK | – | United Kingdom |
| UNEP | – | United Nations Environment Program |
| UNIDO | - | United Nations Industrial Development Organisation |
| USEPA | - | United States Environment Protection Agency |
| USP | – | United States Pharmacopeia |
| WHO | – | World Health Organization |

# Units of Measurement

| | |
|---|---|
| pg | Pictogram |
| ng | Nanogram |
| µg | Microgram |
| mg | Milligram |
| kg | Kilogram |
| $g\ mol^{-1}$ | gams per mole |
| $\mu g\ kg^{-1}$ | microgram per kilogram (corresponds to parts per billion) |
| $mg\ kg^{-1}$ | milligram per kilogram (corresponds to parts per million) |
| $ng\ m^{-3}$ | nanogram per cubic meter |
| $ng\ l^{-1}$ | nanogram per liter |
| $ng\ g^{-1}$ | nanogram per gram (corresponds to parts per billion) |
| ppb | parts per billion |
| ppm | parts per million |

# Inventory on the Status of POPs Pesticides in Sri Lanka

## 1. Introduction

The Stockholm Convention on Persistent Organic Pollutants (POPs) includes a list of compounds complying with the Annex D objectives, such as persistence, bio–accumulation, toxic (PBT) and potential for long range transport. The initial list of compounds was declared in Annex A & Annex B of the Stockholm Convention in May 2001[1]. Since then there were couple of new compounds that have been negotiated and subsequently added to the Annex A of the Stockholm Convention in May 2009[2] and May 2011[3].

### 1.1. The Critical Obligations under the Stockholm Convention

The control measures that must be taken by countries of Parties are classified by the Annex in which chemical substances are listed:

> **Annex A**: Parties must take measures to eliminate the production and use, import and export of the chemicals listed under Annex A. Specific exemptions for use or production are listed in the Annex and apply only to Parties that register for them.
>
> **Annex B**: Parties must take measures to restrict the production and use, import and export of the chemicals listed under Annex B in light of any applicable acceptable purposes and/or specific exemptions listed in the Annex.
>
> **Annex C**: Parties must take measures to reduce the unintentional release of chemicals listed under Annex C with the goal of continuous minimization and, where feasible, ultimate elimination.

When chemicals are listed, Parties need to:

---

[1] UNEP, 2001
[2] UNEP/POPS/COP.4/38. 8 May 2009
[3] UNEP/POPS/COP.5/INF/27 May 2011

- Implement control measures for each chemical (Article 3);
- Develop and implement action plans for unintentionally produced chemicals (Article 5);
- Develop inventories of the chemicals' stockpiles (Article 6);
- Review and update the National Implementation Plan (Article 7);
- Report on the implementation status (Article 15);
- Effectiveness evaluation of the Convention implementation (Article 16).

The Ministry of Mahaweli Development and Environment is the national focal point and responsible agency for reporting the status of POPs chemicals and pesticides in Sri Lanka. The initial inventory on POPs pesticides has been published in June 2006[4].

This report describes the current knowledge on POPs pesticides in Sri Lanka, which considered and updated the outcome of the first National Implementation Plan (NIP–1) conducted in 2003 and considered new listed POPs pesticides (chlordecone, endosulfan, lindane and waste HCH isomers, sulfluramide (a PFOS precursor) and to some extent pentachlorophenol (PCP listed in 2015)). In order to achieve a meaningful inventory on POPs pesticides, the following themes including production, use and wastes are discussed. The subsequent sections will discuss existing management aspects including environmental contamination as per the current understanding with reference to POPs pesticides.

## 1.2. The Methodology Used on Data Collection

The present inventory was started with a desk study, aimed at gathering available information on POPs pesticides used in Sri Lanka along with the data collected during the first inventory preparation in 2003. Specific data on use and stocks available with private/government/semi-government organizations were collected by written requests with specific questionnaires and guidelines (**Annexure 1**). The environmental analysis data on POPs pesticides were referred from scientific literature published during recent times and collated with background data on NIP–1 report. A limited survey was conducted for the availability of POPs pesticides in the

[4] Ministry of Environment, 2006

market place. This was accompanied with a questionnaire survey on lindane–based pharmaceuticals in the country (**Annexure 2**).

## 1.3. History of POPs Pesticide Use in Sri Lanka

The use of POPs pesticides in Sri Lanka had been embarked with the use of DDT in 1946 during the World War II. The history of malaria in Sri Lanka is a success story on near eradication of the main vector, a member of the *Anopheles culicifacies* complex, by residual spraying of DDT in households. After a history of severe epidemics in the 1930s (2–3 million cases and 80,000 deaths in 1934–35), DDT in Sri Lanka had dramatic effects in reducing malaria mortality in the 1950s. It was successful in achieving eradication – only 17 recorded cases in 1963.

Then its use spread to the agricultural sector. The other organochlorine pesticides entered the crop production sector during the next decade. The benefits accruing to crop production is well documented in small scale field studies but was not as spectacular as the phenomenal success DDT had in combating malaria as depicted in **Figure 1**. With the build up of vector resistance DDT had to be replaced by malathion in 1976.

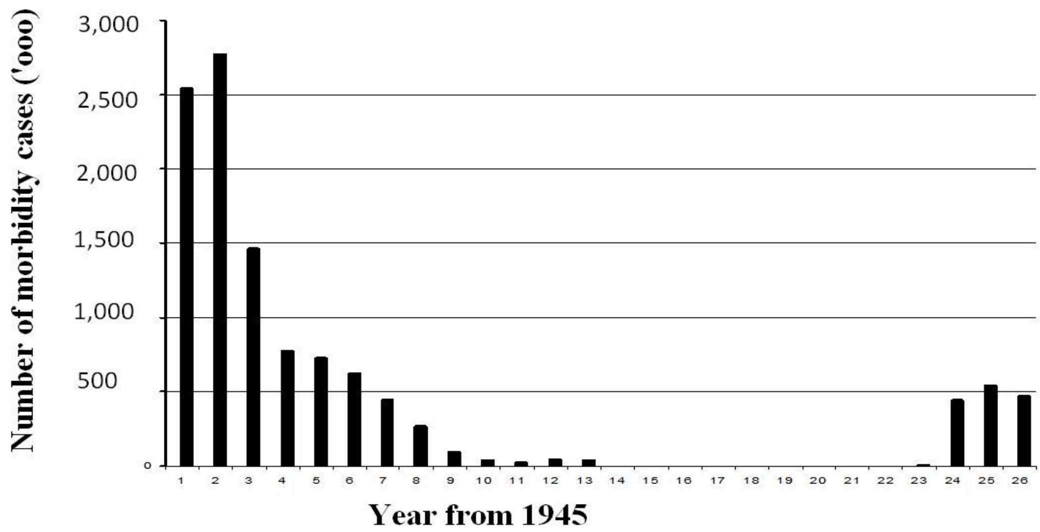


**Figure 1:** Incidence of malaria morbidity in Sri Lanka during 1945–1970 (modified from Wickramasinghe, 1981)

Mounting scientific evidence from the international community on the ubiquitous nature of the POPs pesticides and the concomitant adverse environmental and health impacts alerted the attention of the entomologists at the Central Agricultural Research Institute (CARI) of the

Department of Agriculture (DOA) in the 1970's was focussed on the need to replace them especially in the rice ecosystem and for vegetables and subsidiary crop production.

In the absence of regulatory control prior to 1984[5] and the constraints in monitoring health impacts on farmers and on trends in environmental pollution, the only pragmatic approach was to reduce the market demand for these products. The entomologists tested alternatives with different mode–of–action and revised the official DOA recommendations for the control of various pests. With effective extension campaigns by the DOA to promote the recommended alternatives the demand for the former was appreciably reduced. By 1980, imports of DDT, dieldrin, and aldrin had dwindled so that the total volume of POPs pesticides (organochlorines) and synthetic pyrethroids imported for agriculture was represented by 4.2%.

The agricultural use of POPs pesticides was only eminent before 1998; during which the last member of organochlorine pesticide–endosulfan (listed under Annex A of the Stockholm Convention in May 2009) had been recommended for general crop use. Endosulfan 35% EC was not a key insecticide during late 1980s although it had been recommended for several key pests of paddy, *viz*. brown plant hopper (*Nilaparvata lugens*), rice gall midge (*Orseolia oryzae*), paddy bug (*Leptocorisa varicornis*) and rice leaf folders (*Tryporiza incertulas* and *Cnaphalocrocis medinalis*). It became apparent that rice farmers were relied upon more toxic compounds such as monocrotophos, methamidophos and *gamma*–HCH for rice pest control. Consequently, Jackson (1991) reported that 114, 150 and 540 tonnes (a.s.) of methamidophos, monocrotophos and *gamma*–HCH had been dispersed annually (during 1987–1989) over a cumulative area of 270, 600 and 36 ('000) hectares, respectively. Impending severe restrictions imposed upon highly hazardous pesticides, had dramatic escalation for alternative substances in WHO Hazard Class II organophosphates (e.g. dimethoate, fenthion, trichlorfon) and endosulfan in early 1990s. A similar shifting was apparent in selection of lethal tools for deliberate poisonings (e.g. suicides) as shown in **Figure 2**.

Alternatively, tea had been one of the major sectors of POPs pesticide use in the past but it was limited to few members, such as aldrin, DDT, dicofol (a candidate POPs pesticide[6]),

[5] The Control of Pesticides Act No. 33 of 1980 was institutionalized after 1984.
[6] www.pop.int

dieldrin, heptachlor, and pentachlorophenol. The past records of pesticide usage confirms that 1998 was the last year of using POPs pesticides in tea (**Table 1**).

The current status of POPs pesticides in Sri Lanka as stated below which reveals a 15–30 year history of non–use of individual POPs pesticides. The following analysis in **Table 2** is taken from import statistics available with the Registrar of Pesticides (ROP) and by other pertinent sources, highlighting the magnitude and diversity of POPs pesticides at their most diminishing years of use in Sri Lanka.

Manuweera et al. (2008) reported that targeted banning of pesticides did not significantly impacted on the overall agricultural production during 1990s in the country.

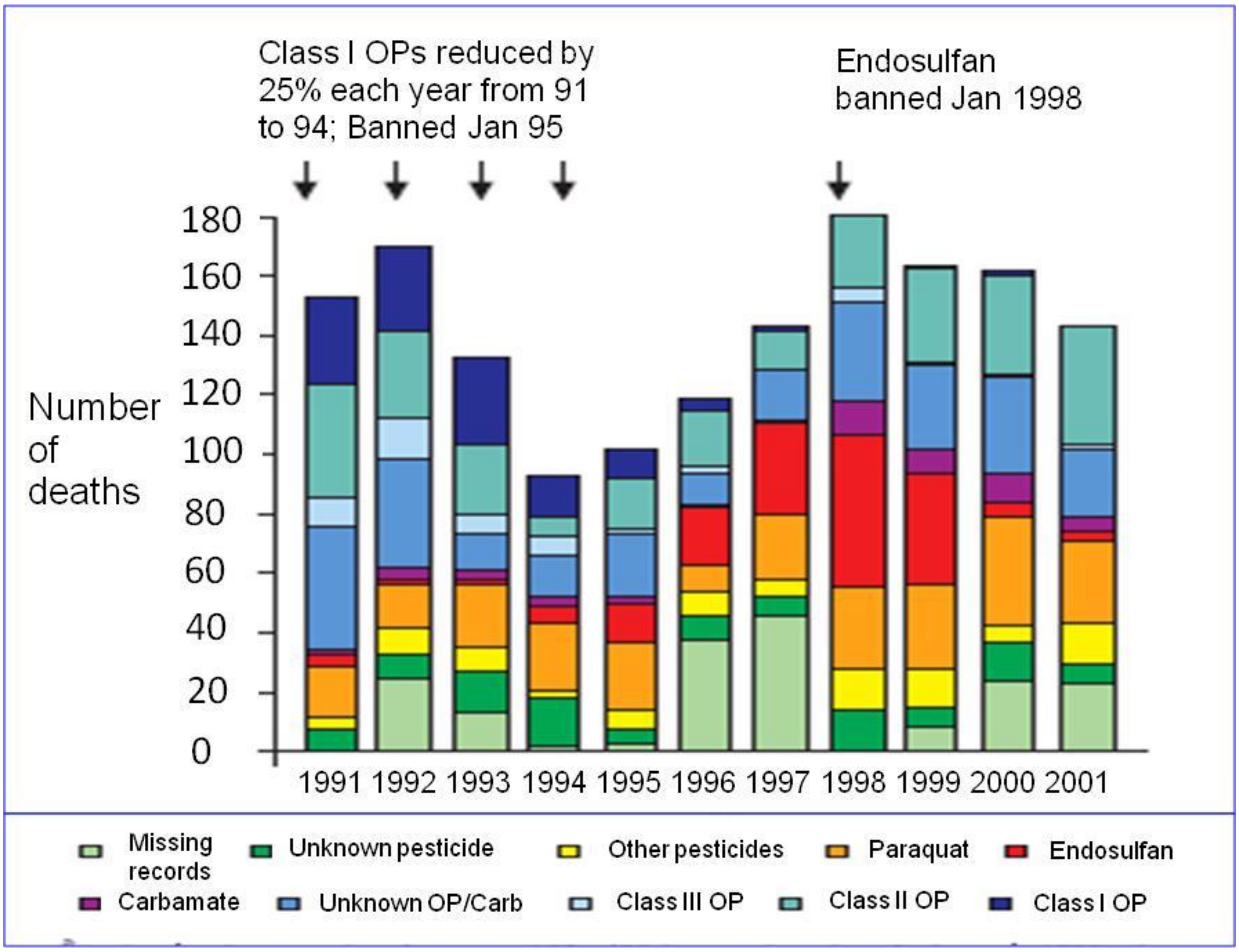


**Figure 2**: Shifting of lethal tools for deliberate poisonings (e.g. suicides) in Sri Lanka. The above chart shows that endosulfan 35% EC had been prominent as a lethal tool in consequent to gradual banning of WHO Hazard Class I Organophosphates (OPs) compounds (Modified from Roberts et al. 2013).

**Table 1**: The past status of POPs pesticides recommended by Tea Research Institute of Sri Lanka[7]

| Chemical/CAS Number | Possible Trade/Commercial Names | Past use | Stocks available |
|---|---|---|---|
| Aldrin 309–00–2 | Aldrin 20 EC, Aldrex® 25% EC | Withdrawn in 1966 | None |
| *Alpha*–hexachlorocyclohexane 319–84-6 | None | None | None |
| Hexachlorocyclohexane (BHC mixed isomers) 608–73–1 | Hexidole® 10% Dust, Hexidole® 10% Granule, Sevidol® 4% (+4% Carbaryl) Granule | None | None |
| *Beta*–hexachlorocyclohexane 319–85–7 | None | None | None |
| Chlordane 57–74–9 | Intox®–8, Chlordane 40 EC | None | None |
| Chlordecone 143–50–0 | None | None | None |
| DDT (1,1,1–trichloro–2,2–bis(4–chlorophenyl)ethane) 50–29–3 | Arkotine® D18, Didimac® 25 EC, Deenol® 25% EC, Sillortox® and DDT 50% WP | Replaced with trichlorphon and methomyl in 1972 | None |
| Dicofol 115–32–2* | Dicofol 42% EC (Kelthane®) | Replaced with propargite in 1994 | None |
| Dieldrin 60–57–1 | Dieldrex®, Dieldrin 20 EC, Dieldrin 30 EC, Wood Preservative–A (+PCP), Dieldrin Termite Soil Concentrate 0.25% AL | Withdrawn in 1966 | None |
| Endrin 72–20–8 | Endrex® 20% EC | None | None |
| Heptachlor 76–44–8 | Heptachlor 2E, Heptox® EC | Withdrawn in 1985 | None |

[7] Information submitted by Dr. Sarath B. Abeysinghe of the Tea Research Institute of Sri Lanka, 27.10.2014

| | | | |
|---|---|---|---|
| Hexachlorobenzene 118–74–1 | None | None | None |
| Lindane (*Gamma*–hexachlorocyclohexane) 58–89–9 | Gammaxene® D 120, Gammalin® | None | None |
| Mirex 2385–85–5 | None | None | None |
| Pentachlorophenol (PCP) 87–86–5* | Santobrite®, Rencit® VII, Popton® 44, Corium®, MMA, MMB, Candarsan® P, Mason's® Collar Protectant | Market availability ceased in 1998 | None |
| Pentachlorobenzene (PeCB) 608–93–5 | None | None | None |
| Endosulfan, Technical endosulfan and its related isomers | Endomack®, Endosan®, Anglosulfan®, Harcosan®, Endosulfan 35% EC, Agrosan® EC 35%, Thiokil® 35 EC, Morison's® Endosulfan, Thiodan® 35 EC, Unisulfan® 35 EC, Thiodrin® 35 EC, Thionex® 350 | None | None |
| Toxaphene 8001–35–2 | Shell® Toxaphene 50% EC | None | None |
| Sulfluramid 4151–50–2 | None | None | None |

**Table 2**: The magnitude and diversity of POPs pesticides used in Sri Lanka (last noted use import and/or use).

| **POPs pesticide (CAS No.)** | **Last imports**[#] | |
|---|---|---|
| | ***Amount (kg a.s.)***[§] | ***Year*** |
| Aldrin (309–00–2) | 1,408 | 1986 |
| | 327.4 | 1988 |
| *Alpha*–hexachlorocyclohexane (319–84–6) | 37,800 (in *gamma*–BHC 10%) [*] | 1987–1989 |
| *Beta*– hexachlorocyclohexane (319–85–7) | 6,480 (in *gamma*–BHC 10%) [*] | 1987–1989 |
| *Gamma*–hexachlorocyclohexane (58–89–9) = Lindane | 800 (in technical HCH 99%) | 1989 |
| | 8,100 (in *gamma*–BHC 10%) [*] | 1987–1989 |
| | 14 (*gamma*–HCH 1%)[**] | 2012 |
| Chlordane (57–74–9) | 3,400 | 1986–1993 |
| | 1,840 | 1994 |
| Chlordecone (143–50–0) | No history of use | Not applicable |
| DDT (50–29–3) | 4,342,000[##] | 1954–1975 |
| | 158,000[##] | 1976 |
| Dicofol (115–32–2) | 420 | 1988 |
| | 455.3 | 1989–1992 |
| Dieldrin (60–57–1) | 3,209 | 1983–1990 |
| | 338 | 1988 |
| | 1,100 | 1991 |
| Endrin (72–20–8) | Not available | Not available |
| Heptachlor (76–44–8) | Not available | Not available |
| Endosulfan (115–29–7) | 49,210 | 1997 |

| | | |
|---|---|---|
| Hexachlorobenzene (118–74–1) | No history of use | Not applicable |
| Mirex (2385–85–5) | No history of use | Not applicable |
| Pentachlorobenzene (608–93–5) | ? (in 125.4 kg PCNB 75%) | 1989 |
| Pentachlorophenol (87–86–5) | Not available | Not available |
| Sulfluramid (4151–50–2) | No history of use | Not applicable |
| Toxaphene (8001–35–2) | Not available | Not available |

# Unless specifically mentioned, the imported/use amounts are based on import statistics available with the Registrar of Pesticides.

§ Conversion factors used for estimation of the amount of active substance, i.e. aldrin 20%, *alpha*–HCH 70% , *beta*–HCH 12%, *gamma*–HCH 15%, chlordane 40%, DDT 50%, dicofol 42%, dieldrin 40%, endosulfan 35%

* Jackson , 1991

** Drug Control Authority, Ministry of Health

## Anti-Malaria Campaign, Ministry of Health

Legal provisions are provided by the Control of Pesticides Act No. 33 of 1980, which contains 27 Sections covering instructional, procedural and risk reduction aspects. The licensing authority is the Registrar of Pesticides (ROP) for the enforcement of regulatory provisions for the control of pesticides in Sri Lanka.

Getting rid of most problematic pesticides under the local conditions was one of the earliest measures adopted by the country even prior to enactment of the regulatory mechanism, i.e. Control of Pesticides Act No. 33 of 1980 (**Table 3**). Here, it is important to stress that the pesticides were carefully chosen according to the local scenario based on international and local experience.

**Table 3**: List of banned and or severely restricted pesticides in Sri Lanka with the year of implementation and the year of legal declaration

| Year (regulatory) banned | Year (legally) banned | Name of Pesticide (a.s.) |
|---|---|---|
| 1970 | 2001 [a] | Endrin* |
| 1976 | 2001 [a] | DDT* |
| 1980 | 2001 [a] | Chlordimeform |
| 1980 | 2001 [a] | Dieldrin* |
| 1980 | 2001 [a] | Phosphamidon |
| 1980 | 2001 [a] | Thalium sulphate |
| 1984 | 2001 [a] | 2,4,5–T |
| 1984 | 2001 [a] | Ethyl–parathion |
| 1984 | 2001 [a] | Methyl–parathion |
| 1986 | 2001 [a] | Aldrin* |
| 1986 | 2001 [a] | Lindane* |
| 1987 | 2001 [a] | HCH (mixed isomers)* |
| 1987 | 2001 [a] | Mercury compounds |
| 1988 | 2001 [a] | Arsenic (arsenites & arsenates) |
| 1988 | 2001 [a] | Heptachlor* |
| 1988 | 2001 [a] | Leptophos |
| 1989 | 2001 [a] | Captafol |
| 1990 | 2001 [a] | 1,3–dichloropropane |
| 1990 | 2001 [a] | Aldicarb |
| 1990 | 2001 [a] | Quintozene (PCNB) |
| 1994 | 2001 [a] | Pentachlorophenol* |
| 1994 | 2001 [a] | Chlordane* |
| 1995 | 2001 [a] | Methamidophos |
| 1995 | - | Monocrotophos (60% SL restricted to use on red weevil in coconut) |

| | | |
|---|---|---|
| 1998 | 2001 [a] | Endosulfan (35% EC)* |
| 2008 | 2014 ¶ | Paraquat (20% SL) |
| 2011 | 2014 ¶ | Paraquat (6.5% SL) |
| 2011 | 2014 ¶ | Dimethoate (40% EC) |
| 2011 | 2014 ¶ | Fenthion (50% EC) |
| 2011 | 2014 ¶ | Cyromazine (75% WP) |
| 2012 | 2014 ¶ | Alachlor (36% EC) |
| 2013 | 2014† | Propanil (36% EC) |
| 2013 | 2014† | Carbofuran (3% GR) |
| 2013 | 2014† | Carbaryl (85% WP) |
| 2013 | 2014† | Chlorpyrifos (20% EC & 40% EC) |
| 2014 | 2014† | Glyphosate (36% SL) |
| 2015 | 2015 §¤ | Glyphosate (36% SL) |

*Classic organochlorine pesticides (POPs pesticide) listed under the Stockholm Convention

[a]Ban of registration by the government extraordinary gazette No. 1190/24 of 29.06.2001 under the Control of Pesticides Act No. 33 of 1980.

¶Ban of registration by the government extraordinary gazette No. 1854/47 dated 21.03.2014 under the Control of Pesticides Act No. 33 of 1980.

†Regional restriction for sale, offer for sale and use as per the government extraordinary gazette No. 1894/4 of 22.12.2014 under the Control of Pesticides Act No. 33 of 1980.

§Ban of importation by the government extraordinary gazette No. 1813/14 of 05.06.2013 under the Import and Export (Control) Act No. 01 of 1969.

¤Ban of registration by the Government Extraordinary Gazette No. 1937/35 dated 23.10.2015 under the Control of Pesticides Act No. 33 of 1980.

# 2. Description, Production, Use and Wastes

## 2.1. Aldrin

a. Description

Aldrin (CAS No. 309–00–2) takes the form of white, odourless crystals when it is pure. Technical grades are tan to dark brown with a mild chemical odour (Ritter et al. 1995). Aldrin contains no less than 95% 1,2,3,4,10,10–hexachloro1,4,4a,5,8,8a–hexahydro–endo–1,4–exo–5,8–dimethanonaphthalene (HHDN). HHDN is a white, crystalline, odourless solid with a melting point of 104–104.5°C. Technical aldrin is a tan to dark brown solid with a melting range from 49 to 60°C. It is almost insoluble in water, moderately soluble in petroleum oil and stable to heat, alkalis and mild acids (ATSDR, 2002). Pure aldrin is stable at <200°C and within a pH range from pH 4 to pH 8; however, oxidizing agents and concentrated acids attack the unchlorinated ring under any conditions. Aldrin is non–corrosive or slightly corrosive to metals because of the slow formation of hydrogen chloride during storage. Aldrin and dieldrin (1,2,3,4,10,10–hexachloro–6,7–epoxy–1,4,4a,5,6,7,8,8a–octahydro–endo–1,4–exo–5,8–dimethanonaphthalene, CAS No. 60–57–1) are the common names of two insecticides which are chemically closely related. Aldrin is readily converted to dieldrin in the environment.

b. Production

There is no history of production or formulation of aldrin in Sri Lanka.

c. Import and Use

Aldrin had been imported as formulated materials by the names of Aldrin 20 EC (containing 200 g/l aldrin) and Aldrex® 25% EC [containing 250 g/l aldrin active substance (a.s.)]. Major uses reported were for the control of soil dwelling pests in agricultural lands (e.g. cockchafer grub, root–eating ants and banana weevil), pests of rice (e.g. leaf folders, leaf hoppers), pests of tea (e.g. shot hole borer) and as a termiticide (1% v/v solution dip) for nursery plants in reforestation schemes (Herath and Joshi, 1986; Midgley and Weerawardena, 1986). Dantanarayana and Fernando (1971) tested Aldrin (Aldrex® 20% EC; *ex* Shell, England–Lankem) for the control of live wood termites (*Postelectrotermes militaris* (Desneux) in tea but had no effect because of the secretive habits of the termites. The use of Aldrin as a termiticide was popular among other applications as well as in nurseries of coconut and tobacco. Reportedly, Aldrex® 25% EC was the commercial formulation recommended for coconut nurseries (CRI, 1992) prior to its ban for use in agriculture in 1986[8]. Apparently, there had been quantity and use restrictions before its complete phase out from import in 1986. Previous assessment for NIP–1[9] reported that an amount of 7,040 liters of Aldrin was imported to Sri Lanka in 1986. However, summary statistics[10] show that there had been a restrictive import of 1,637 liters of Aldrex® 20% EC by M/s Lankem Ceylon Ltd., in 1988.

d. Stockpiles and Wastes

There are no reported major obsolete stockpiles or wastes of aldrin in Sri Lanka.

## 2.2. Alpha–hexachlorocyclohexane

a. Description

*Alpha*–hexachlorocyclohexane (α–HCH) (CAS No. 319–84–6) is an organochloride which is one of the isomers of technical grade hexachlorocyclohexane (HCH). *Alpha*–HCH is one of the five stable isomers of technical HCH, an organochlorine pesticide formerly used in agriculture. Technical grade HCH is a mixture of different isomers: α–HCH (60–70%), β–HCH (5–12%), γ –HCH (10–15%), δ –HCH (6–10%), and ε –HCH (3–4%) (Kutz et al. 1991). It is a by–product of the production of the insecticide lindane (γ–HCH) and therefore, it typically constitutes 60–70% of technical grade HCH. At ambient temperatures it is a stable, white, powdery solid substance.

b. Production

There is no history of production of *alpha*–hexachlorocyclohexane-containing compounds in Sri Lanka.

c. Use

There is no specific use of *alpha*–hexachlorocyclohexane in Sri Lanka. However, this compound had been constituted in some of the products containing technical HCH (BHC

[8] Directive of the Pesticides Formulary Committee No. 23 of July 31, 1986
[9] Ministry of Environment, 2006
[10] Source: the Office of the Registrar of Pesticides, Sri Lanka

mixed isomers; CAS No. 608–73–1) that were used prior to 1989. The reported formulations were Hexidole® 10% Dust and Sevidol® 4% Granule (+ carbaryl) for the control of rice bugs (*Leptocorisa varicornis*) and swarming and leaf–eating caterpillars. Jackson (1991) reported that 540 tonnes of *gamma*–HCH (a.s. in main formulation Hexidole® 10% Dust) had been used over 36,000 hectares of paddy during 1987–1989. The dust formulation, Hexidole® 10% Dust was also used for the control of leaf hoppers in cashew. In late 1960s Dantanarayana and Fernando (1970) tested BHC (Lin–Dol® 6% granular; *ex* Mackwoods & BHC smoke generator®; *ex* ICI, UK–CIC) in the form of fumigant for the control of live wood termites (*Postelectrotermes militaris* (Desneux) in tea but had no effect because of the secretive habits of the termites. All agricultural uses were prohibited in 1987.[11]

d. Stockpiles and Waste

There are no reported major obsolete stockpiles or wastes of *alpha*–hexachlorocyclohexane in Sri Lanka. However, only two instances were reported of possessing obsolete BHC (an *alpha*–HCH–containing compound) by two government farms but the total quantity is about 28 kg (including approx.21 kg alpha-HCH).

## 2.3. Beta–hexachlorocyclohexane

a. Description

β–hexachlorocyclohexane (β–HCH) (CAS No. 319–85–7) is an organochloride which is one of the isomers of technical grade HCH. *Beta*–HCH is one of the five stable isomers of technical HCH, an organochlorine pesticide formerly used in agriculture. Technical grade HCH is a mixture of different isomers: α–HCH (60–70%), β–HCH (5–12%), γ –HCH (10–15%), δ –HCH (6–10%), and ε –HCH (3–4%) (Kutz et al. 1991). It is a by-product of the production of the insecticide lindane (γ–HCH). Therefore, it typically constitutes 5–12% of technical grade HCH. The modes of action of the HCH isomers differ quantitatively and qualitatively with regard to their biological activity in the central nervous system as the main target organ. *Beta*–HCH is mainly a depressant and the final effect of the mixed isomers depends on the composition. Animal studies show that organochlorine pesticides, including *beta*–HCH, are neurotoxic, cause oxidative stress, and damage the brain's dopaminergic

[11] Directive of the Pesticide Formulary Committee No. 29 of 09 October 1987

system. The biological activity of mixed-isomers is further exemplified by *delta*–HCH's potent cytotoxicity, mainly through the induction of thymocyte necrosis (Sweet et al. 1998). According to IARC all HCH isomers are classified as Group 2B carcinogens. The evidence for their carcinogenicity to animals is sufficient for technical–grade and for the *alpha* isomer, but limited for the *beta*– and for the *gamma*– (lindane) isomers. EU classifies *alpha*– and *beta*–HCH as carcinogens (Category 2) but not lindane. The EPA has additionally classified technical HCH and *alpha*–HCH as probable human carcinogens, *beta*– and *gamma*– (lindane) isomers as possibly human carcinogens.

b. Production

There is no history of production of *beta*–hexachlorocyclohexane-containing products in Sri Lanka.

c. Use

There is no specific use of *beta*–hexachlorocyclohexane in Sri Lanka. However, this compound had been constituted in some of the products containing technical HCH (BHC mixed isomers; CAS No. 608–73–1) that were used prior to 1989. The reported formulations were Hexidole® 10% Dust and Sevidol® 4% Granule (+carbaryl) for the control of rice bugs (*Leptocorisa varicornis*) and swarming and leaf–eating caterpillars. Jackson (1991) reported that 540 tonnes of *gamma*–HCH (a.s. in main formulation Hexidole® 10% Dust) had been used over 36,000 hectares of paddy during 1987–1989. The dust formulation, Hexidole® 10% Dust was also used for the control of leaf hoppers in cashew. In late 1960s Dantanarayana and Fernando (1970) tested BHC (Lin–Dol® 6% granular; *ex* Mackwoods & BHC smoke generator®; *ex* ICI, UK–CIC) in the form of fumigant for the control of live wood termites (*Postelectrotermes militaris* (Desneux) in tea but had no effect because of the secretive habits of the termites. All agricultural uses were prohibited in 1987.[12]

d. Stockpiles and Waste

There are no reported major obsolete stockpiles or wastes of *beta*-hexachlorocyclohexane in Sri Lanka. However, only two instances were reported of possessing store obsolete BHC (a

[12] Directive of the Pesticide Formulary Committee No. 29 of 09 October 1987

*beta*–HCH–containing compound) by two government farms but the total quantity is about 28 kg including approx. 3 kg beta-HCH.

## 2.4. Chlordane

a. Description

Technical chlordane (CAS No. 57–74–9) is a viscous mixture of at least 23 different compounds, including chlordane isomers, other chlorinated hydrocarbons and by–products. The principal constituents of technical chlordane are *trans*–chlordane (*gamma*–chlordane) (about 25%), *cis*–chlordane (*alpha*–chlordane) (70%), heptachlor, *trans*–nonachlor and *cis*–nonachlor (<1%). Heptachlor is one of the most active components of technical chlordane, which is a viscous, colourless or amber–coloured liquid with a chlorine–like odour. Pure *cis*–chlordane has a melting point of 106°C and pure *trans*–chlordane 104°C. They are not soluble in water and are stable in most organic solvents, including petroleum oils. They are unstable in the presence of weak alkalis (ATSDR, 1994; Holoubek et al., 2004; Ritter et al., 1995; UNEP, 2002). The USEPA considers as technical chlordane another mixture identified by the CAS No. 12789–03–6 and composed of 60% octachloro–4,7–methanotetrahydroindane (the *cis*– and *trans*– isomers) and 40% related compounds.

b. Production

There is no history of production or formulation of chlordane in Sri Lanka.

c. Import and Use

Chlordane had been used as a formulated material containing 10% chlordane in Intox–8 which was replaced by Chlordane 40 EC (containing 400 g/l chlordane a.s.) since October 1986. Major uses of chlordane in agriculture were on pests of floricultural crops (e.g. cockchafer grubs), coconut (e.g. termites) and forestry (1% v/v solution as a plant dip) (Hagen and Ekanayake, 1977; Midgley and Weerawardena, 1986; CRI, 1992). Dantanarayana and Fernando (1970) tested chlordane (Intox–8®; *ex* Sandoz, Switzerland–Baurs) for the control of live wood termites (*Postelectrotermes militaris* (Desneux) in tea but had no effect because of the secretive habits of the termites. Reportedly, there had been use and quantity restrictions imposed over chlordane after 1985 with strict prohibition on agricultural applications while permitting on non–agricultural applications as a popular termiticide until its phase out from import in 1996[13]. The strict control over its use on structural and non-structural termite control had been assured through approved pest control institutions by prior approval procedure by the Registrar of Pesticides. In early 1995[14], the use of chlordane was restricted to a maximum of 2,000 liters per year. However, due to self–restrictions imposed by the manufacturer of Chlordane 40 EC over minimum export quantity of 5,000 liters per consignment, the import of chlordane was automatically stopped in 1995 with no apparent negotiation. The volume of Chlordane 40 EC imported to Sri Lanka since 1986 through 1994 was 13,100 liters (= 5,240 kg of a.s.). The last quantity of import of Chlordane 40 EC was 4,600 liters in 1994 and continued its use until ex-stocks were depleted in 1997.

d. Stockpiles and Wastes

There are no reported obsolete stockpiles or wastes of chlordane in Sri Lanka.

## 2.5. Chlordecone

a. Description

Chlordecone (CAS No. 143–50–0) is a synthetic chlorinated organic compound. Chlordecone was also known as Kepone®. Chlordecone is a highly stable odourless white or tan coloured solid. Its solubility is low in water, but readily dissolves in some organic (carbon–containing) solvents (e.g. soluble in acetone, ketone, and acetic acid and slightly soluble in benzene and hexane). Chlordecone is also a contaminant in mirex formulations and is a degradation product of mirex (Bus and Leber, 2001). Chlordecone is resistant to degradation in the environment. It is not expected to react with hydroxyl radicals in the atmosphere or to hydrolyse or photolyze. Chlordecone in the air is likely to be removed by deposition of particles. Studies have shown that microorganisms degrade chlordecone slowly. Chlordecone is expected to adsorb to soil and to stick to suspended solids and sediments in water. Small amounts of chlordecone will evaporate from soil or water surfaces. Chlordecone has a high potential for bioaccumulation in fish and other aquatic organisms (ATSDR, 1995).

---

[13] Directive of the Pesticide Technical and Advisory Committee No. …of January 01, 1996

[14] Directive of the Pesticide Technical and Advisory Committee No. 04 of 1995

b. Production

There is no history of production or formulation of chlordecone in Sri Lanka.

c. Use

There is no history of use of chlordecone in Sri Lanka.

d. Stockpiles and Waste

There are no reported obsolete stockpiles or wastes of chlordecone in Sri Lanka.

## 2.6. DDT

a. Description

Technical DDT (*p,p*'–DDT–the main component– and *o,p*'–DDT) (CAS No. 50–29–3) was used extensively all over the world as a domestic and agriculture pesticide (Ecobichon, 1995). Water solubility of *p,p*'–DDT, *p,p*'–DDD, and *p,p*'–DDE are 0.0055, 0.02, and 0.1 mg/L at 20–25°C. Values of log Kow are 5.7 for *p,p*'–DDT, 6.1 for *p,p*'–DDD and 6.0 for *p,p*'–DDE. Also, the sorption coefficients (log Koc) are 6.3 for *p,p*'–DDT, 5.0 for *p,p*'–DDD, 4.7 for *p,p*'–DDE at 20–25°C. The large ratio of DDD/DDE likely indicates reductive dechlorination of DDT to DDD, which has been observed in sediments under flooded, anaerobic conditions. Under anaerobic conditions, sediment DDT is mainly metabolized to DDD by reductive dechlorination either by microbial degradation or by chemical reaction. Under aerobic conditions, DDT is metabolized to DDE by dehydrochlorination. Environmental exposure to *p,p*'–DDT and its main metabolite *p,p*'–DDE or dietary sources exposure (especially, food of animal origin, but also through water, outdoor and indoor air, dust and soil) result in the bioaccumulation of these chemicals in the human body (especially, adipose tissue, serum, and breast milk). DDT and its metabolites are endocrine disrupting chemicals (EDCs); DDT has a very long average–life. In addition, it is metabolized to DDE, which tends to persist much longer in the body, and this metabolite is of greater concern as regards bioaccumulation, since it is a marker of chronic exposure (Jaga and Dharmani, 2003). DDT is estrogenic and DDE is an anti-androgen (Damstra et al. 2004). Recently, the International Program on Chemical Safety (IPCS) issued a comprehensive report entitled Global Assessment of the State of the Science of Endocrine Disruptors. This report evaluates the science surrounding endocrine disruption in humans and other animals and makes conclusions, (when possible), based on broad bodies of scientific evidence. Parental compounds (*p,p*'–DDT and *o,p*'–DDT) present in technical formulations of DDT are the most estrogenic among all DDT derivatives (Robinson et al. 1985).

b. Production

There is no history of production or formulation of DDT in Sri Lanka.

c. Import and Use

The use of DDT in Sri Lanka is dated far back to 1946 when it was introduced to control malaria vector mosquitoes. Some of the reported DDT formulations were Arkotine® D18, Didimac® 25 EC, Deenol® 25% EC, Sillortox® and DDT 50% WP in public health and agricultural use. The noticeable agricultural uses were on tea (e.g. tea tortrix), floriculture (e.g. cockchafer grub, caterpillars and stem borers) and rice (Hagen and Ekanayake, 1977; Cranham and Danthanarayana, 1971). The long term use of DDT during 1950 through 1970 on tea lands had purportedly brought up severe (secondary) pest outbreaks of red spider mites in major tea estates led to its discontinuation (ban) in 1970 (Cranham and Danthanarayana, 1971). Dantanarayana and Fernando (1970) tested DDT (DDT (Deenol® 25% EC; *ex* Baurs) for the control of live wood termites (*Postelectrotermes militaris* (Desneux) in tea but had no effect because of the secretive habits of the termites. In 1971, the use of DDT on tea was banned. The insecticide, DDT played a significant role in malaria eradication program in Sri Lanka since 1958 through 1977. The strategy adopted during this period was blanket or carpet spraying of households throughout the dry zone of Sri Lanka including some parts of the western province. There are reports of rampant cases of developing resistance in mosquito populations (e.g. *Anopheles nigerrimus*) since 1969 (Clarke et al. 1974) through 1982 (Herath and Joshi, 1986), covering the entire country. The use of DDT was discontinued in Sri Lanka in 1976 with gradual replacement by Malathion in 1977 in mosquito vector control programs (Wickramasinghe, 1981).

Dicofol (CAS No. 115–32–2) and DDT are chemically closely related. Dicofol is manufactured from DDT. During some manufacturing processes, technical dicofol can be contaminated with 10–34% of DDT like compounds (Qiu et al. 2005). However, under controlled manufacturing processes can produce technical grade dicofol which contains up to 0.5% DDT (Li et al. 2014). Dicofol 42% EC (Kelthane®), an effective miticide, had been recommended for the control of tea mites (*Oligonychus coffeae*) since 1965 through 1994 until its concerns on DDT residues in tea products were recognized. The contaminants of DDT isomers, which may have originated from the manufacturing of dicofol, were proliferating in tea products due to repeated use of dicofol on severe mite infestations occurred during dry weather conditions in major tea estates. Dicofol was de–registered in 1994 hitherto recommended exclusively for use on tea.

The volume of DDT imported to Sri Lanka in 1971 was about 120 tonnes according to Ramasundaram et al. (1978). However, official statistics of the Ministry of Health, Sri Lanka reported that a quantity of 2,080 tonnes of DDT had been used during 1971–1972, while the total consumption during 1954–1976 was 9,000 tonnes (50% DDT). The last recorded use of DDT by the Ministry of Health was about 316 tonnes (50% DDT) in 1976.

The total consumption of Dicofol 42% EC in tea was 2,084 liters during 1988–1992. In the year 1988 alone, 1,000 liters of Kelthane® had been imported to Sri Lanka by M/s Chemical Industries (Colombo) Ltd.

d. Stockpiles and Wastes

There are no reported obsolete major stockpiles or wastes of either DDT or dicofol in Sri Lanka. However, only one instance is reported to possess obsolete DDT by a government farm but the total quantity is about 10 liters.

## 2.7. Dieldrin

a. Description

Dieldrin (CAS No. 60–57–1) is a technical product containing 85% 1,2,3,4,10,10–hexachloro–6,7–epoxy–1,4,4a,5,6,7,8,8a–octahydro–endo–1,4–exo–5,8,–dimethanonaphthalene (HEOD). Dieldrin is closely related to its precursor aldrin. The pure major ingredient, HEOD, is a white crystalline solid with a melting point of 176–177°C. Technical dieldrin is a light tan, flaky solid with a melting point of 150°C. It is almost completely insoluble in water and slightly soluble in alcohol. Pure HEOD is stable in alkalis and dilute acids but reacts with strong acids (ATSDR, 2002).

b. Production

There is no history of production or formulation of dieldrin in Sri Lanka.

c. Import and Use

Dieldrin had been imported to Sri Lanka in the form of Emulsifiable Concentrate formulations (i.e. Dieldrex® 20% EC, Dieldrin 20 EC) containing 200 g/l dieldrin (a.s.) for agricultural and non–agricultural uses. One of the major agricultural use of dieldrin was on tea for the control of shot hole borer since 1961 (Seneviratne, 1995) but purportedly brought up severe (secondary) pest outbreaks of looper and twig caterpillars in major tea estates during 1962–1963 (Danthanarayana and Kadirawetpillai, 1969). Dantanarayana and Fernando (1970) tested Dieldrin (Dieldrex® 20% EC; *ex* Shell, England–Lankem) for the control of live wood termites (*Postelectrotermes militaris* (Desneux) in tea but had no effect because of the secretive habits of the termites. In 1976, all uses of Dieldrin on tea were banned. To some appreciable extent, non-agricultural uses were limited to structural and pre- and post-construction termite control in buildings since 1980, the era that all agricultural uses were prohibited. The strict control over its use on structural and non-structural termite control had been assured through approved pest control institutions by prior approval procedure by the Registrar of Pesticides. An alternate ready–to–use mixture formulation containing 2.5 g/l dieldrin (a.s.) and 1.2 g/l pentachlorophenol (a.s.) was used as a wood preservative. The historical data indicates that some alternate Dieldrin formulations containing 300 g/l dieldrin (a.s.) had also been imported to Sri Lanka during 1986–1987 due to the discontinuation of Dieldrin 20 EC by the manufacturer. The total volume of Dieldrin imported to Sri Lanka from 1983 through 1991 was 21,545 liters (= 4,309 kg of a.s.). Among the last consignments, 1,690 and 5,500 liters of Dieldrin 20 EC were reported to be imported in 1988 and 1991, respectively and continued its use until ex-stocks were depleted in 1993.

d. Stockpiles and Wastes

There are no reported obsolete stockpiles or wastes of dieldrin in Sri Lanka.

## 2.8. Endrin

a. Description

Endrin (CAS No. 72–20–8), when pure, is a white crystalline solid and has a melting point of 200°C. It decomposes at temperatures above 245°C (boiling point). The technical product is a light tan powder with a characteristic odour. It is nearly insoluble in water and slightly soluble in alcohol. It is stable in alkalis and acids, but it rearranges to less insecticidally active substances in the presence of strong acids, on exposure to sunlight or on heating above 200°C (ATSDR, 1996).

b. Production

There is no history of production or formulation of endrin in Sri Lanka.

c. Use

There are no credible reports of past use of endrin in Sri Lanka. However, Dantanarayana and Fernando (1970) tested endrin (Endrex® 20% EC; *ex* Shell, England–Lankem) for the control of live wood termites (*Postelectrotermes militaris* (Desneux) in tea but had no effect because of the secretive habits of the termites; they did not come in contact with the outer surface of the tea bush where the insecticide deposit was found. It had been discontinued prior to 1970.

d. Stockpiles and Wastes

There are no reported obsolete stockpiles or wastes of endrin in Sri Lanka.

## 2.9. Heptachlor

a. Description

Pure heptachlor (CAS No. 76–44–8) is a white crystalline solid with a melting point of 95–96°C. Technical heptachlor is a soft, waxy solid with a melting range between 46 and 74°C. It is nearly insoluble in water and slightly soluble in alcohol. It is stable up to temperatures between 150 and 160°C and also to light, air moisture, alkalis and acids. It is not readily dechlorinated but is susceptible to epoxidation (ATSDR, 1993). Heptachlor is a persistent dermal insecticide with some fumigant action. It is non–phytotoxic at insecticidal concentrations.

b. Production

There is no history of production or formulation of heptachlor in Sri Lanka.

c. Use

There are very limited reports available on the status of past use of heptachlor in Sri Lanka. It had been used prior to 1986 on agricultural applications in banana (e.g. weevil), cardamom (e.g. rhizome borer) and other soil pests. Dantanarayana and Fernando (1970) tested heptachlor (Heptachlor 2E; *ex* Velsicol, USA–Baurs) for the control of live wood termites (*Postelectrotermes militaris* (Desneux) in tea but had no effect because of the secretive habits of the termites. Due to prevailing concerns on human health and environmental issues, the use of Heptachlor had been restricted for pre– and post–construction subsurface application for termite control in buildings in 1986[15] and the same became obsolete by the decision to deregister heptachlor in 1988[16]. The commercial products used in the past include Heptachlor 2E and Heptox® EC containing 200–300 g/l of heptachlor (a.s.). Heptachlor can be present as an impurity in chlordane containing products (UNEP, 2001).

d. Stockpiles and Wastes

There are no reported obsolete stockpiles or wastes of heptachlor in Sri Lanka.

## 2.10. Hexachlorobenzene

a. Description

Hexachlorobenzene (HCB) (CAS No. 118–74–1) is a chlorinated monocyclic aromatic compound in which the benzene ring is fully substituted by chlorine. HCB is a white crystalline solid (melting point 231°C) which is nearly insoluble in water but is soluble in ether, benzene and chloroform. It has a high octanol–water partition coefficient, low vapour pressure, moderate Henry's Law constant and low flammability. HCB is found almost exclusively in the solid phase (as is predicted by its vapour pressure), with under 5% associated with particles in all seasons except winter, where levels are still below 10% particle–bound (Cortes et al. 1998).

b. Production

There is no history of production or formulation of hexachlorobenzene in Sri Lanka.

[15] Directive of the Pesticides Formulary Committee No. 23 of July 31, 1986
[16] Directive of the Pesticides Formulary Committee No. 30 of January 27, 1988

c. Use

Historically, the major use of HCB as a pesticide was as a fungicide. However, there is no history of use of Hexachlorobenzene in Sri Lanka. HCB might have infiltrated to the country as a by–product and/or minor impurity in some of the chlorinated pesticides (e.g. pentachlorophenol, chlorothalonil). HCB impurity levels in pesticide formulations are regulated in some countries, for example the maximum allowable impurity levels of HCB in chlorothalonil formulations would be at or below 40 ppm (USEPA, 1999).

d. Stockpiles and Wastes

There are no reported obsolete stockpiles or wastes of hexachlorobenzene in Sri Lanka.

## 2.11. Lindane

a. Description

Lindane, (CAS No. 58–89–9) also known as *gamma*–hexachlorocyclohexane, (γ–HCH), is an organochlorine chemical variant of hexachlorocyclohexane. Lindane is the *gamma* isomer of hexachlorocyclohexane (γ–HCH) which is >99% pure. Hexachlorocyclohexane (HCH), formally known as benzene hexachloride (BHC), is a synthetic chemical that exists in five major chemical forms called isomers. The different isomers are named according to the position of the hydrogen atoms in the structure of the chemical. Technical grade HCH is a mixture of different isomers: α–HCH (60–70%), β–HCH (5–12%), γ –HCH (10-15%), δ –HCH (6–10%), and ε –HCH (3–4%) (Kutz et al. 1991). In addition to the issue of lindane pollution, there are concerns related to the other isomers of HCH, namely *alpha*–HCH and *beta*–HCH, (refer above) which are notably more toxic than lindane, lack its insecticidal properties, and are by–products of lindane production. It is a white poisonous crystalline powder with a slight musty odour; 1,2,3,4,5,6–hexachlorocyclohexane. It is a white solid whose vapour may evaporate into the air. The vapour is colourless and has a slight musty odour when it is present at 12 or more parts HCH per million parts air (ppm).

b. Production

There is no history of production and/or formulation of lindane in Sri Lanka. In the year 1989, 800 kg of technical–HCH (99% purity which corresponds to lindane) had been imported by M/s CIC. The production statistics are not available.

c. Import and Use

There are very limited reports available on the status of past use of lindane in Sri Lanka. It had been used prior to 1986 on agricultural applications in coconut (e.g. termites in nurseries), rice, mango and cashew (e.g. on plant hoppers and leaf hoppers), rice (e.g. on paddy bugs), and for spotted locust control[17]. However, the use had been restricted in 1986 to some limited applications for the treatment of coconut nurseries and emergency use for spotted locust control. The commercial products used in the past in agriculture include Gammalin® 20 (20% EC) and Gammaxene® D120 (10% Dust). Due to prevailing concerns on human health and environmental issues, the remaining use of lindane had been discontinued in early 90s.

Lindane was continued to be used as anti-lice, anti-scabies hair shampoo under the approval by the Medical Technology & Supplies (Drug Regulatory Authority), Sri Lanka as per the prescriptions of United States Pharmacopeia (USP) until 2012. As per the decision taken by the Drug Regulatory Authority of Sri Lanka, three registered lindane containing products were banned with effect from 1st March, 2012[18]. Therefore, previously registered commercial products containing 1% lindane (Lindane Lotion USP 1% w/v, Scaboma®; Lindane 1% + Benzocaine 2% Cream, Scaboma®; Lindane Lotion USP 1% w/v, Scabcur®) were discontinued by February 2012.

The last recorded import of lindane 1% (Scabcur®) to Sri Lanka was 14,000 bottles of 100 ml to the government State Pharmaceutical Corporation, Sri Lanka in January 2012. The author had conducted a limited market survey during October 2014–December 2014 in randomly selected pharmacies/drug stores in several districts (namely, Colombo, Gampaha, Anuradhapura, Killinochchi, Jaffna, Puttlam, Matara and Kurunegala) in Sri Lanka and found no remaining lindane–based products.

d) Alternatives to lindane as human health pharmaceuticals for control of head lice and scabies

[17] Directive of the Pesticides Formulary Committee No. 23 of July 31, 1986
[18] Directive of the Technical Advisory Committee of MTS/CP/PS/TAC 11/2012 of February 16, 2012

A list of non–lindane anti–lice, anti–scabies products available in the market are shown in Table 4.

**Table 4:** List of non–lindane anti–lice, anti–scabies products available in the market (Sri Lanka)

| Brand name | Chemical name and strength (%) | Remarks/Manufacturer |
|---|---|---|
| Lysine® | Permethrin 0.5% | M/s W.M. De Silva Industries, Sri Lanka |
| Ascabs® Liquid | Permethrin 5% | M/s HOE Pharmaceutical Sdn. Bhd., Malaysia |
| Perlice® Cream | Permethrin 1% | M/s Encube Ethicals (Pvt.) Ltd., India |
| Permite® Cream | Permethrin 5% | M/s Encube Ethicals (Pvt.) Ltd., India |
| Pathima® | Herbal mixture; no description | M/s |
| Mediker® Anti–lice Shampoo | Herbal mixture containing coconut oil, neem and camphor & Formaldehyde 45% | M/s Marico Limited, Mumbai, India |
| Kadahapola Ukunu Behetha® | Herbal mixture; No description | M/s Kadahapola Aushadalaya, Narammala, Sri Lanka |

e) Stockpiles and Wastes

There are no reported major obsolete stockpiles or wastes of lindane in Sri Lanka. However, only two instances are reported to possess obsolete BHC (a lindane–containing compound) by two government farms but the total quantity is about 28 kg.

## 2.12. Mirex

a. Description

Mirex (CAS No. 2385–85–5) is a white, odourless crystalline substance with a melting point of 485°C and as such is fire–resistant. It is soluble in several organic solvents including tetrahydrofuran (30%), carbon disulphide (18%), chloroform (17%) and benzene (12%), but is nearly insoluble in water. Mirex is considered to be extremely stable. It does not react with sulphuric, nitric, hydrochloric or other common acids and is un–reactive with bases, chlorine and ozone. In the environment, it degrades to photomirex when exposed to sunlight (ATSDR, 1995; IPCS, 1997).

b. Production

There is no history of production or formulation of mirex in Sri Lanka.

c. Use

There is no history of use of mirex in Sri Lanka.

d. Stockpiles and Wastes

There are no reported obsolete stockpiles or wastes of mirex in Sri Lanka.

## 2.13. Pentachlorobenzene

a. Description

Pentachlorobenzene (PeCB) (CAS No. 608–93–5) belongs to the group of chlorobenzenes. This substance has been used in the past as a pesticide. It is not clear whether it is still used as a pesticide on its own; however, it can be found as an impurity and degradation product of pentachloronitrobenzene (PCNB; quintozene) and other pesticides such as clopyralid, atrazine, chlorothalonil, dacthal, lindane, pentachlorophenol, picloram and simazine. PeCB was used as an intermediate (raw material) product to manufacture pentachloronitrobenzene (PCNB or quintozene), a pesticide used as a fungicide. Pentachlorobenzene can be present as an impurity in some organochlorine solvents and pesticides.

b. Production

There is no history of production or formulation of PeCB in Sri Lanka.

c. Import and Use

There is no history of use of PeCB in Sri Lanka. PeCB might have infiltrated in to the country as a by–product and/or minor impurity with Quintozene (PCNB) itself and in some of the commercial chlorinated pesticides (e.g. pentachlorophenol, lindane and simazine in the past. The last quantity of import of PCNB (Terrachlor® 75% WP) recorded was 125.4 kg in 1989 by M/s Anglo Chem Limited.

d. Stockpiles and Wastes

There are no reported obsolete stockpiles or wastes of PeCB in Sri Lanka. There is no information available on PeCB present in contemporary pesticides as an impurity.

### 2.14. Sulfluramid (PFOS related substance)

a. Description

Perfluorooctane sulfonate (PFOS) is a fully fluorinated anion used as a surface active agent in a wide range of applications. PFOS can be formed by degradation from a large group of related substances, referred to as PFOS related substances, and is a member of a larger family of perflouroalkyl sulfonate (PFAS). N–ethyl perfluorooctane sulfonamide (EtFOSA; sulfluramid; CAS No. 4151–50–2), is both a surfactant and a pesticide.

In addition to their function as pesticides, fluorosurfactants may be used as “inert” surfactants (enhancers) in pesticide products. The two PFOS–related substances, potassium N–ethyl–N–[(heptadecafluorooctyl) sulfonyl] glycinate (CAS No. 2991–51–7) and 3–[[(heptadecafluorooctyl)sulfonyl]amino] –N,N,N–trimethyl 1– propanaminium iodide (CAS No. 1652–63–7), have been approved in pesticide formulations in the United States of America.

b. Production

There is no history of production or formulation of PFOS and related sulfluramid in Sri Lanka.

c. Use

There is no history of use of sulfluramid in Sri Lanka.

d. Stockpiles and Wastes

There are no reported obsolete stockpiles or wastes of sulfluramid in Sri Lanka.

## 2.15. Toxaphene (Camphechlor)

a. Description

Toxaphene (CAS No. 8001–35–2) is an insecticide containing over 670 polychlorinated bicyclic terpenes consisting predominantly of chlorinated camphenes. Toxaphene formulations included wettable powders, emulsifiable concentrates, dusts, granules, baits, oils, and emulsions (IARC, 1979; ATSDR, 1996). In its original form, it is a yellow to amber waxy solid which smells like turpentine. Its melting range is from 65 to 90°C. Its boiling point in water is above 120°C, which is the temperature at which it starts to decompose. Toxaphene tends to evaporate when in solid form or when mixed with liquids and does not burn. Toxaphene is also known as camphechlor, chlorocamphene, polychlorocamphene and chlorinated camphene (ATSDR, 1996; Fiedler et al., 2000).

b. Production

There is no history of production or formulation of toxaphene in Sri Lanka.

c. Use

There are very limited reports available on the status of past use of toxaphene in Sri Lanka. It had been used in early 1960s by a regional recommendation (Circular No. PP/T1/62 of Dry Zone Research Institute, Maha–illuppallama, Sri Lanka dated 01.05.1962), but withdrawn due to prevailing concerns on human health and environmental issues. The only commercial product reported in the past was Shell® Toxaphene 50% EC which contained 500 g/l of toxaphene (a.s.).

d. Stockpiles and Wastes

There are no reported obsolete stockpiles or wastes of toxaphene in Sri Lanka.

## 2.16. Technical endosulfan and its related isomers

a. Description

Endosulfan (CAS No. 115–29–7) is a chlorinated cyclodiene pesticide. Endosulfan is a derivative of hexachlorocyclopentadiene, and is chemically similar to aldrin, chlordane, and heptachlor. Specifically, it is produced by the Diels–Alder reaction of hexachlorocyclopentadiene with cis–butene–1, 4–diol and subsequent reaction of the adduct with thionyl chloride. The two isomers, endo– and exo–, are known popularly as I and II. Endosulfan sulfate is a product of oxidation containing one extra O atom attached to the S atom. Technical endosulfan is a 7:3 mixture of stereoisomers; designated α and β. α– and β–endosulfan are conformational isomers arising from the pyramidal stereochemistry of sulfur. α–Endosulfan is the more thermodynamically stable of the two, thus β–endosulfan irreversibly converts to the α form, although the conversion is slow. Endosulfan is volatile, persistent, and has the potential to bio–accumulate in aquatic and terrestrial organisms. Due to its unique mode of action, it is useful in resistance management; however, as it is not specific, it can negatively impact populations of beneficial insects. It is, however, considered to be moderately toxic to honey bees, and it is less toxic to bees than organophosphate insecticides.

A large body of scientific literature documents endosulfan's medium– and long–range transport on a global scale and subsequent accumulation in nearly all environmental media. Through the process of global distillation, endosulfan is present in air, water, sediment, and biota thousands of miles from use areas.

b. Production

There is no history of production or formulation of endosulfan in Sri Lanka.

c. Import and Use

The only formulation used in Sri Lanka is Emulsifiable Concentrates (EC) containing 35% endosulfan (a.s.). The past uses were basically limited to control of leaf hoppers in pulses, Aulacophora beetle in cucurbits, shoot and fruit borer in okra, leaf–eating beetle in mustard and stem borer in maize/sorghum. However, Endosulfan 35% EC had been widely used for variety of other crops such as chilli pepper by local farmers because of its relatively low price, which unavoidably caused excess residue levels of *alpha*– and *beta*–endosulfan and endosulfan sulphate in export consignments of dry chilli powder in early 1997.

Apart from popular mis–use in agriculture, Endosulfan 35% EC formulations were implicated with increased intentional mis–use for suicides in Sri Lanka by 2–5% during 1992 through 1995 in consequent to the phase out of highly hazardous WHO Hazard Class Ib pesticides in early 1990s. Subsequent evaluation of mammalian toxicity potential of Endosulfan 35% EC formulations using real assay reports, in contrast to the mathematical extrapolation from technical product of WHO Hazard Class II, revealed that the formulations are more toxic than that of the technical product, which is falling in to Hazard Class Ib. In fact, a range of liquid formulations of Endosulfan 35% EC have been shown to be highly toxic to experimental animals (e.g. rats), with a wide variation in the $LD_{50}$ of 15–147.35 mg/kg body weight (b.w.), depending on the formulation composition, chemical dosing vehicle and the sex. In a series of reviews, it revealed that the lowest strength of 8.5% Endosulfan EC and the highest strength of 50% Endosulfan EC were often more toxic to female rats by 2–5–fold compared to male rats (Hoechst Schering AgrEvo GmbH, Germany, July 1998). Similar observations were made by independent tests requested by the Office of the ROP, Sri Lanka for acute toxicity of Endosulfan 35% EC for registration purposes, where the reported $LD_{50}$ values had been established at 15 mg/kg b.w. for female rats, that is falling under WHO Hazard Class Ia. For the reason of toxicity verifications, the phase out decision on Endosulfan 35% EC had been delayed and later effected in December 1997[19], arising from the former decision to prohibit importation of WHO Hazard Class Ia/Ib pesticide formulations for agriculture in 1995[20].

There were several commercial products available before its complete phase out from import in December, 1997. They were Endomack®, Anglosulfan®, Harcosan®, Endosulfan 35% EC, Agrosan® EC 35%, Thiokil® 35 EC, Morison's® Endosulfan, Thiodan® 35 EC, Unisulfan® 35 EC, Thiodrin® 35 EC and Thionex® 350. The last quantity of import of Endosulfan 35% EC formulations was 49.21 tonnes of a.s. in 1997 and continued its use until ex–stocks were depleted in 1999. During the diminishing phase of use, 45.85, 37.16 and 12.44 tonnes of endosulfan (a.s.) had been used in 1997, 1998 and 1999, respectively.

[19] Directive of the Pesticides Technical and Advisory Committee No. 16 of 1997
[20] Directive of the Pesticides Technical and Advisory Committee No. 3 of 1995

d. Stockpiles and Wastes

By January 2003, there were a stock of 465.4 liters of Endosulfan 35% EC that had remained obsolete in several stores belong to the pesticide industry. Recent motives to incinerate obsolete/outdated stocks of pesticides available with the pesticide industry by co–processing in the cement kilns at M/s Holcim Lanka, Sri Lanka have caused to deplete a considerable amount of pesticide wastes in the country including Endosulfan 35% EC. Therefore, there are no obsolete stocks of Endosulfan 35% EC available in any pesticide store belongs to the pesticide industry. However, few instances are reported to possess obsolete Endosulfan 35% EC insecticide by government farms but the total quantity is as less as 9 liters.

## 2.17. Pentachlorophenol and its salts and esters

Pentachlorophenol (PCP) has been recently listed as a POP at COP7 in 2015.

a. Description

Pentachlorophenol (CAS No. 87–86–5) exists as colorless or white crystals (when pure) with a sharp, phenolic odor when hot, but very little odor at room temperature. The odor threshold for pentachlorophenol is approximately 12 parts per million (ppm). Impure pentachlorophenol is dark gray to brown and exists as dust, beads, or flakes. The chemical formula for pentachlorophenol is $C_6HCl_5O$, and its molecular weight is 266.35 g $mol^{-1}$. The vapor pressure for pentachlorophenol is 0.00011 mm Hg at 25°C, and it has a log octanol/water partition coefficient (log $K_{ow}$) of 5.01 (ATSDR, 1999). Pentachlorophenol was once one of the most widely used biocides in the United States, but it is now a restricted use pesticide and is no longer available to the general public. The principal use for pentachlorophenol is as a wood preservative; it is also used for the formulation of fungicidal and insecticidal solutions and for incorporation into other pesticide products. Pentachlorophenol has been detected at low levels in drinking water and food. Exposure may also occur through dermal contact with pentachlorophenol or with wood products treated with pentachlorophenol. The USEPA has classified pentachlorophenol as a Group B2, probable human carcinogen (USEPA, 1999). Pentachlorophenol and its breakdown products (e.g. pentachloroanisole)

b. Production

There is no history of production or formulation of pentachlorophenol and its salts and esters in Sri Lanka.

c. Import and Use

Pentachlorophenol had been imported and used for paint, varnish and adhesive preservation in the past. Control actions were imposed on pentachlorophenol and its salts and esters as a pesticide under the pesticide regulations in Sri Lanka– Control of Pesticide Act No. 33 of 1980– since 1987. Collar and/or root treatment for *Rigidophorus lignosus* control with pentachlorophenol not exceeding 3% (w/w) in a bituminous base as a water proof wound dressing for rubber trees was allowed in 1991[21]. Pentachlorophenol and its salts and esters for timber preservation were approved since 1993[22]. However, in response to effective participation at the Rotterdam Convention, all uses of pentachlorophenol were withdrawn since 1994 and official declaration in a form of a government notification to ban all POPs pesticides including pentachlorophenol was published on 29.06.2001[23].

During 1960's the necessity of water immiscible chemicals was emphasized in rubber plantations and as a result the first collar protestant dressing, 20% Pentachloronitrobenzene (PCNB) in a bituminous–/grease–base was recommended in Sri Lanka (Liyanage, 1984) and it was widely used with success in Sri Lanka till it was suspended in 1989. The results of the study for alternatives clearly showed that 2% PCP could be used in place of 20% PCNB in the management of white root disease in young rubber plants of Sri Lanka (Jayasinghe et al. 1995). Meanwhile, biological control of white root disease (*R. microporus*) by *Trichoderma harzianum* isolates has been successful in place of chemical control in rubber plantations (Jayasuriya and Thennakoon, 2007).

d) Alternatives

The commercial and current availability of alternatives for pentachlorophenol as a wood preservative is limited–Celcure CB90® containing sodium dichromate dehydrate (36% w/w) + copper sulphate pentahydrate (32.4% w/w) + boric acid (21.6% w/w) is registered in Sri

[21] Directive of the Pesticides Technical and Advisory Committee No. 46 of 1991
[22] Directive of the Pesticides Technical and Advisory Committee No. 55 of 1993
[23] The Gazette of the Democratic Socialist Republic of Sri Lanka Extraordinary No. 1190/24 of 29.06.2001

Lanka. Boric acid and borax (disodium tetraborate) mixtures are used for diffusion treatment of rubber wood. In Sri Lanka State Timer Corporation (STC) use Creosote to treat railway sleepers and transmission poles. A useful comparison of Creosote and two other commonly used wood preservatives in Sri Lanka – PCP and inorganic arsenicals– is shown in the **Table 5**.

Some of the earlier formulations containing pentachlorophenol in Sri Lanka were Santobrite®, Rencit® VII, Popton® 44, Corium®, MMA® Tar, MMB® Tar Emulsifiable Concentrates (EC) formulation containing 36% w/v, Candarsan® (Paste)–0.035% w/w, Mason's® Collar Protectant (Paste)–2.0% w/w.

**Table 5**: Summary of advantages, disadvantages and properties of the restricted–use pesticides creosote, pentachlorophenol and inorganic arsenicals (Source: Mihilaka Forestry Service[24]**)**.

| Wood Preservative/ Pesticide | Advantages | Disadvantages |
|---|---|---|
| Creosote | • Excellent protection against fungi, insects and most marine borers<br>• Insoluble in water<br>• Excellent stability, suitable for thermal and Boultonizing processes<br>• Provides excellent water repellency and mechanical stability | • Poor protection against certain marine borers<br>• Leaves dark, oily, un–paintable surface<br>• Tendency to bleed or exude from wood surface<br>• Strong odor–cannot be used in homes or other living areas because of toxic fumes. Harmful to plants<br>• Contact with treated wood may cause skin irritation or burns<br>• Heating is required to reduce viscosity<br>• Can ignite, so it must be heated cautiously.<br>• Treated wood remains considerably heavier: 25–50% weight increases are |

[24] Mihilaka Forestry Service, http://www.timber.lk/PRASERVATION/Woodpreservatives/index.html. accessed on 20.04.2015.

| | | |
|---|---|---|
| | | common. |
| Pentachlorophenol | • Excellent protection against fungi and insects<br>• Can be dissolved in oils having a wide range of viscosity, vapor pressure and color<br>• Can be glued or painted depending on carrier<br>• Water repellents can be added to improve weatherability<br>• Good heat stability–but heating PCP is not common<br>• Low weight increase (1–2%) if an evaporating carrier is used | • Poor protection from marine borers<br>• Can leave oily, un–paintable surface, depending on carrier used<br>• Irritating smell, toxic to plants, animals and people<br>• Not suitable for use in homes or other living areas<br>• Contact with treated wood may cause skin burns or irritation<br>• All oil carriers are flammable<br>• Permanent weight increases of 20–50% if heavy oils are used<br>• Tendency to "bloom" |
| Inorganic arsenicals# | • Excellent protection against fungi insects and most marine borers<br>• Produces no smell or vapors<br>• Suitable for use indoors<br>• Non–toxic to nearby growing plants<br>• Treated surfaces can be painted<br>• Permanent weight increases of only 1–2% after wood has re–seasoned | • Only moderate protection from pholad marine borers<br>• Will not prevent mildew<br>• Does not protect wood from excessive weathering<br>• Not heat stable above 140° F; therefore cannot be used in thermal or Boultonizing process<br>• Temporary weight increases of 20–90% immediately after treatment. Swells wood when treated, so some seasoning defects may occur when re–dried. |

#Copper–Chrome–Arsenic (CCA) is by far the most widely–used wood preservative in the Sri Lanka till it was banned in 2001. A large portion of wood products treated with waterborne preservatives were treated with CCA. The widely used CCA formulations (type C) were based on copper oxide 18.5% + chromium trioxide 47.5% + arsenic pentoxide 34%.


**Figure 3:** Once popular brand of pentachlorophenol containing product (0.035% w/w) Candarsan® is now formulated without pentachlorophenol and marketed in Kalutara, Sri Lanka. Date inspected 12.10.2014 (Photo by J.A. Sumith).

e) Stockpiles and Wastes

There are no reported obsolete stockpiles or wastes of pentachlorophenol in Sri Lanka. However there is wood treated with PCP which need to be managed. In particular consider biomass combustion where PCP treated wood can form dioxins. It should be highlighted that also wood treated with copper containing salts have a high dioxin formation potential and that both type of treated wood should not be used in biomass power plants where ash might be used on agriculture but that PCP and copper salt containing treated wood need to be incinerated in waste incinerators with waste management of ashes or co–incinerated e.g. cement kiln.

It is believed that State Timber Corporation (STC), Timber Treatment Depot, Kaldemulla, Sri Lanka had been one of the major users of PCP for timber preservation (i.e. railway sleepers and utility transmission poles) before to its ban in 1994; now has shifted to use Creosote. M/s Finlay Rentokill owns a commercial timer treatment plant in Wattala, Sri Lanka. They have begun its treatments with CCA as early as 1992 and subsequently shifted to use CCB (copper–chrome–borate). In the light of the above, STC, Kaldemulla would be one of the "hot spots" of PCP contamination by treatment wastes, which needs to be further investigated (by environmental sampling and analysis for PCP and its major degradation compounds). For example, two test water samples were taken from the site in 2004 and analysed by the laboratory of the ROP for NIP–1 synthesis (Ministry of Environment, 2006); the sampling locations were –one sample from a well at the site and second sample from a well adjacent to the site belongs to a Buddhist temple. The analysis was limited to the original POPs compounds and not focussed on PCP and/or its degradation products. Out of the originally declared POPs pesticides, only dieldrin was detected at $5.26 \times 10^{-4}$ µg $l^{-1}$ (minimum detection limit = $0.14 \times 10^{-4}$ µg $l^{-1}$) from the well water at the treatment site.

## 2.18. Dicofol

a. Description

Dicofol (CAS No. 115–32–2) and DDT are chemically closely related. Dicofol is manufactured from DDT. During some manufacturing processes, technical dicofol can be contaminated with 10–34% of DDT like compounds (Qiu et al. 2005).

b. Production

There is no history of production or formulation of dicofol in Sri Lanka.

c. Import and Use

Dicofol 42% EC (Kelthane®), an effective miticide, had been recommended for the control of tea mites (*Oligonychus coffeae*) since 1965 through 1994 until its concerns on DDT residues in tea products were recognized. The contaminants of DDT isomers, which may have originated from the manufacturing of dicofol, were proliferating in tea products due to repeated use of dicofol on severe mite infestations occurred during dry weather conditions in major tea estates. Dicofol was de–registered in 1994 hitherto recommended exclusively for use on tea.

The total consumption of Dicofol 42% EC in tea was 2,084 liters during 1988–1992. In the year 1988 alone, 1,000 kg of Kelthane® had been imported to Sri Lanka by M/s Chemical Industries (Colombo) Ltd.

d. Stockpiles and Wastes

There are no reported obsolete stockpiles or wastes of dicofol in Sri Lanka.

## 3. Obsolete Pestici7des & Stockpiles

The inventory taken for the first NIP (NIP–1) development in 2006[25] was the first ever estimation of the status of obsolete pesticides in Sri Lanka, where a total of 166 tonnes of pesticides comprising of various chemical groups had been reported. The following analysis shown in Table 6 has been conducted from the stock figures taken in 2003 for the NIP–1 (Ministry of Environment, 2006), which highlights the relative contribution of major chemical groups of obsolete pesticides, including organochlorines. The inventory revealed the magnitude of obsolete stocks of organochlorine pesticides stored above ground is almost negligible (0.42%) compared to other classes of pesticides such as carbamates (52.1%), dithiocarbamates (16.3%), inorganics (12.7%), and organophosphates (11.6%). It is indeed 689.4 kg of formulated POPs pesticides, reported to be stored in several locations belongs to the pesticide industry and government farms (<6) scattered in the country in 2003.

**Table 6**: Relative contribution of major chemical groups of obsolete pesticides in Sri Lanka as reported in 2003 (deduced from data on NIP–1, Ministry of Environment, 2006)

| Pesticide group | Quantity (kg or l) | Percent (%) of total |
|---|---|---|
| Organochlorines | 689.4 | 0.42 |
| Organophosphates | 19230.5 | 11.61 |
| Carbamates | 86285.1 | 52.11 |
| Pyrethroids | 227.0 | 0.14 |
| Inorganics | 21022.0 | 12.70 |
| Pthalimides | 3837.2 | 2.32 |
| Anilides | 972.5 | 0.59 |
| Dithiocarbamates | 27010.2 | 16.31 |
| Oximes | 1507.4 | 0.91 |
| Acetamides | 139.1 | 0.08 |
| Chloroacetamides | 252.5 | 0.15 |
| Phenoxy | 3438.1 | 2.08 |
| Bridged diphenyls | 2.0 | 0.00 |
| Benzimidazoles | 18.1 | 0.01 |
| Thiadiazines | 507.0 | 0.31 |
| Trifluoromethyls | 58.0 | 0.04 |
| Urea derivatives | 104.0 | 0.06 |
| Amides | 110.0 | 0.07 |
| Bipiridils | 13.6 | 0.01 |
| Pyrazoles | 30.0 | 0.02 |
| Other | 126.2 | 0.08 |
| **Total** | **165579.8** | **100.0** |

[25] Ministry of Environment, 2006

The current inventory carried out for obsolete pesticides from significant users (e.g. government departments of agriculture and botanical gardens) and the pesticide industry revealed even fewer stocks are available, which accounts for 41.451 tonnes. The inventory also revealed insignificant amounts of POPs pesticides (e.g. aldrin, DDT, BHC & endosulfan) waiting for disposal, which is estimated to be 71.53 kg (0.17%), available from few locations in government farms of the DOA. Thus, the use of the term “POPs pesticide stockpile” would not be meaningful for Sri Lanka due to two reasons:

(i). there are insignificant stocks of obsolete POPs pesticides in Sri Lanka; and

(ii). there are no records of production and/or formulation of POPs pesticides in Sri Lanka and hence production discards are almost non–existent.

The most commonly referred meaning on POPs pesticide stockpiles in the context of Stockholm Convention would account for the last portion of the pesticide lifecycle. The key actions taken during last few years in the management of obsolete pesticides in Sri Lanka were almost straight forward in the form of "pack and treat" in local and foreign disposal facilities. However, ground burial is the method earlier adopted by the Department of Agriculture (DOA) at institution level (e.g. farms, research divisions etc.) in the management of obsolete pesticides in the absence of dedicated facility/facilities for safe/complete destruction with in the country.

Disposal by burial was conducted in a burial pit filled with simple absorbent/adsorbent materials (e.g. saw dust, charcoal) and reactants (e.g. lime powder) in a composited manner (Figure 3). The selection of the land locale for disposal had always been done by careful consideration of ground and environmental factors in order to minimize environmental and ground water contamination. However, due to recent advent of chemical waste disposal at Holcim Geocycle, Sri Lanka, the DOA has been inclined to explore opportunities of disposal by incineration of obsolete pesticides accumulated over the time.

M/s Holcim Sri Lanka is the only production plant that produces cement clinker. This has been validated to perform waste destruction by co–processing with an overall efficiency (Destruction and Removal Efficiency, DRE) of >99.9999% and the overall environmental performance as high as international regulations in relation to emission standards of PCDD/PCDFs or HCB (Karstensen et al., 2010). From 2009 through 2014, M/s Holcim Geocycle has undertaken destruction (by co–processing[26]) of 273.68 tonnes of obsolete pesticides, pesticide contaminated packaging wastes and plant washings possessed by the pesticide industry (Table 7).

The segregation of compounds according to hazard characteristics such as acute toxicity, environmental persistence etc. has always been the primary management operation in dealing with obsolete pesticides in the DOA. As a result, pesticides/pesticide formulations identified to be highly toxic (e.g. WHO Hazard Class Ia/Ib) and/or radioactive and/or inorganic (including heavy metals) and/or POPs pesticides were recorded separately. During this inventory exercise, two bottles of 500 ml each of uranium acetate (a laboratory chemical) was identified from Field Crop Research and Development Institute, Maha–illuppallama, having radioactive properties. The substance was taken to the Atomic Energy Authority, Sri Lanka, for safe disposal.

In preparation for incineration by co–processing at M/s Holcim, Puttlam, the DOA has identified a regional stock of pesticides from several research stations in the north–western province (Makandura, Tabbowa and Kalpitiya). The trial stock of obsolete pesticides was represented by 13 liters of liquid pesticides and 104 kg of solid pesticides. A part of the stock was heavily deteriorated thus preventing true identity of pesticides remains an issue for further processing at M/s Holcim Goecycle, Puttlam. The response from M/s Holcim Geocycle for the inquiries was still standstill.

The total tonnage of obsolete pesticides accumulated in government farms and research institutions represent 2,037.47 liters of liquids and 24,347.89 kg of solids for almost last 2–3 decades. Mean while, a stock of laboratory chemicals has also been accumulated over the past, which account for 303.55 liters of liquids and 1,290.753 kg of solids.

Alternatively, a multi–stakeholder project sponsored by M/s Bayer Crop Science has undertaken safe destruction of a total of 7.2 tonnes of pesticide wastes in a special waste incinerator at Bürrig, Germany in April, 2011[27]. The entire waste tonnage was consisted of 241 drums which had been accumulated over a period of 30 years in a former premise of

[26] Information submitted by Mr. Sanjeewa Chulakumara of Goecycle, M/s Holcim (Lanka) Ltd., 16.10.2014
[27] Information submitted by Mr. A.L.B. Purijjala, Country Representative, M/s Bayer Crop Science, Republic of Germany.

Bayer Crop Science, M/s Hayleys Agro, Colombo, Sri Lanka. The waste consisted of very old product mixtures owned by M/s Bayer Crop Science (e.g. Tamaron® (methamidophos), Folidol® (ethyl–parathion), Metacide® (methyl–parathion), Endosan® (endosulfan), Judo® (chlorpyrifos), Bayrusil® (quinalphos) and market returns (e.g. Antracol® (propineb), Fruvit® (propineb+metalaxyl), Unden® Dust (propoxur), Bathion® Dust (phoxim), Morestan® (oxythioquinox), Lecspro® (fentrazamide+propanil), most of them were highly toxic. The project demonstrated M/s Bayer Crop Science's cradle–to–grave responsibility for the safe use and handling of their products.


Figure 4**: The practice of ground burial of obsolete non-POPs pesticides at farm level approved by the Pesticide Authority, Sri Lanka; Date of treatment 20.10.2014 at Wanathawilluwa. (A) Lining of the burial pit with polyethylene; (B) Filling charcoal layer; (C) Filling lime powder layer; (D) Filling saw dust layer; (E) Obsolete pesticides and waste materials; (F) Filling covering materials. (Photos by W. Gunawardena).**

**Table 7**: Recent stocks of pesticide wastes incinerated by co–processing at M/s Holcim Cement Plant, Puttlam, Sri Lanka during 2009–2014 (Values are in tonnes).

| No. | Customer | Waste Type | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | Total |
|---|---|---|---|---|---|---|---|---|---|
| 01 | M/s Harcros | Mixed solid/packaging/ expired pesticides | 23.57 | 7.49 | – | 16.10 | 5.71 | 6.83 | 59.70 |
| 02 | M/s Baurs | Expired pesticides/solid | – | 8.04 | – | 2.73 | 6.54 | 2.80 | 20.11 |
| 03 | M/s Opex | Mixed solid/packaging | – | 3.60 | – | – | 0.96 | – | 4.56 |
| 04 | M/s Hayleys | Expired pesticides/solid & liquids | 6.21 | 26.27 | 2.13 | 17.13 | 27.39 | 11.83 | 90.96 |
| 05 | M/s CIC | Expired pesticides/solid & liquids/packaging/ washings | 13.91 | 24.04 | 4.65 | 0.91 | 12.46 | 6.22 | 62.19 |
| 06 | M/s Ceypetco | Expired pesticides/solid & liquids | – | – | 1.50 | – | – | 12.73 | 14.23 |
| 07 | M/s BASF | Expired pesticides/solid & liquids | – | 1.41 | – | 1.77 | 3.28 | – | 6.46 |
| 08 | M/s Lankem | Expired pesticides/solid & liquids | – | – | – | 4.51 | 2.57 | 2.22 | 9.30 |
| 09 | M/s Mackwoods | Expired pesticides/solid & liquids | 3.30 | 2.87 | – | – | – | – | 6.17 |
| **Total** | | | 46.99 | 73.72 | 8.28 | 43.15 | 58.91 | 42.63 | 273.68 |

There were few isolated instances of accumulating obsolete pesticides of non–organochlorine (non–POPs) origin in the recent past (**Figure 5**–**7**). The motive to safe destruction of obsolete technical malathion at M/s Holcim Geocycle has been held back due to offensive odor of the substance.

# 4. Sri Lanka's Obligation for POPs Pesticide Management

## 4.1. Legal and Policy Framework

➢ ***Control of Pesticides Act No. 33 of 1980***

The policy framework for the regulation of POPs pesticides is provided by the Acts of Control of Pesticides Act No. 33 of 1980 and Imports and Exports (Control) Act No. 01 of 1969 and their respective implementing rules and regulations issued in pursuance of these Acts.

The Government Extraordinary Gazette No. 1190/24 of 29.06.2001 under the Control of Pesticides Act No. 33 of 1980 banned the importation and use of 10 POPs pesticides outright (i.e. aldrin, *alpha*–hexachlorocyclohexane, *beta*–hexachlorocyclohexane, *gamma*–hexachlorocyclohexane (lindane), chlordane, DDT, dieldrin, endrin, endosulfan and heptachlor). The rest of which not banned under the pesticide jurisdiction may have either no records of registration or no history of past use in Sri Lanka. However, they are regulated (i.e. listed compounds as licensed control) under the Imports and Exports (Control) Act No. 01 of 1969, which include chlordecone, hexachlorobenzene, mirex, pentachlorobenzene and toxaphene.

➢ ***Imports and Exports (Control) Act No. 01 of 1969***

The Import & Export Regulations No.1813/14 dated 05 June 2013 published under the Imports and Exports (Control) Act No. 01 of 1969 listed chemicals and pesticides under specific HS Codes for clear identification and efficient control at the point of entry. It included a list of 15 compounds designated under the Stockholm Convention as POPs pesticides (**Annexure 3**). The objective of the listing is to control import of chemicals under stringent scrutiny at the point of entry.

Concerning obligations on Basel Convention, also the regulations as an amendment to the National Environmental (Protection and Quality) Regulation No. 01 of 1990 (Gazette Extraordinary No. 595/16 dated 16$^{th}$ February 1990) by publishing Part II in the Gazette Extraordinary No. 924/13 dated 23$^{rd}$ May 1996 on the management of hazardous wastes is of relevance to Sri Lanka. In February 2008 the above regulations were rescinded by the National Environmental (Protection & Quality) regulation No. 01 of 2008 by the Gazette Extraordinary No. 1534/18 with a prescribed list of waste which refers as scheduled waste. The updated regulations prescribed off–specification and outdated products and contaminated containers from pesticide formulations and repacking plants and trade of pesticides (Waste Code S176), and used containers and bags contaminated with residues of raw materials and products of pesticide formulation plants (Waste Code S251), into the waste of which requiring the holder of waste to dispose of or obliged to dispose of in pursuant of the above regulations. In this respect, obsolete pesticides are considered as wastes.

There are specific provisions to identify polychlorinated waste streams such as polychlorinated biphenyls (PCBs) and polychlorinated triphenyls (PCTs) in the scheduled waste regulations (Waste Codes N021– N024).

Importation of hazardous waste in the Basel Convention lists A and B are regulated by the Regulation No.1813/14 of 05.06.2013 under Imports and Exports (Control) Act No. 01 of 1969. However, all Basel list A wastes are not banned under the Import & Export Regulations No.1813/14 dated 05 June 2013.

- ***Need for Strict Observance of the Custom Codes***

Sri Lanka still faces severe hindrance for efficient regulating of chemicals except otherwise controlled under specific jurisdictions in the country, e.g. Control of Pesticides Act No. 33 of 1980 (CSIR-NEERI & MoERE, 2014). Even in case that there is a proper regulatory mechanism is being implemented on pesticides, A recent review of a practical guide on regulatory and/or responsible authorities on import of chemicals by HS codes revealed significant mismatches in the listing where some of the POPs pesticides (e.g. PCP) were either listed under improper authority (e.g. State Trading Corporation (STC), Secretariat of the Chemical Weapons Convention, CWC) or not listed under the proper authority. For example, following POPs and non-POPs pesticides were erroneously listed under certain authorities;

- HS Codes 2908.11 (pentachlorophenol), 2908.19.10 (pentachlorophenol salts), 2908.91 (dinoseb and its salts) & 2908.92 (4,6–dinitro–*o*–cresol and its salts)

- HS Code 2924.29.10 (metalaxyl)
- HS Code 2925.21 (chlordimeform)
- HS Code 2930.90.80 (aldicarb)

Following listings were either inconclusive or improper in the chemical management point of view;

- HS Code 2933.21 (hydantoin and its derivatives) is being listed under the STC authority, however there are members of pesticides in this group (e.g. the hydantoin derivative, imiprothrin is a pyrethroid insecticide. Iprodione is a popular fungicide belongs to the hydantoin group) which should be referred to the ROP.
- HS Code 2825.10 (hydrazine and hydroxylamine and their inorganic salts) is being listed under the STC authority, however there are members of pesticides in this group (e.g. maleic hydrazide is an anti-sprouting agent in potato) which should be referred to the ROP.

Following listing was erroneous in terms of effective management of pesticides;

- HS Code 2903.39.10 (bromomethane; methyl bromide) has been allotted in the listing of bromoform (tribromomethane): methyl bromide is a highly restricted pesticide regulated in terms of objectives under the Montreal Protocol whereas tribromomethane is an organic solvent (non-pesticide).

## 4.2. Management Challenges in the Past

Sri Lanka had been neutral in the past in reaching specific regulatory decisions on import and use of POPs pesticides, as many of the banning decisions of POPs pesticides came into effect long time before the Stockholm Convention came into ratification in 22.12.2005. However, Sri Lanka's commitment to the Stockholm Convention was shown by developing and implementing the NIP–1 on the management of POPs pesticides in the past.

In some situations, Sri Lanka has been opted out in listing pesticide compounds for international conventions, such as; for example, Sri Lanka persistently abstained in submitting pesticide review notifications under the Rotterdam Convention due to lack of data and/or documentation on impacts and/or risks on environmental and health counterparts from pesticides prevailing in the country. However, Sri Lanka attempted to report notifications on its banned compounds such as endosulfan (1998) and paraquat (2011), but in either case the notification objectives had not been fulfilled (criteria b (iii) of Annex II of the Rotterdam Convention) due to lack of a monitoring system of poisonings other than intentional misuse (i.e. suicides).

Only Endosulfan 35% EC formulations were officially banned in Sri Lanka in the context of its severely hazardous nature. If Sri Lanka were to comply with the Rotterdam Convention's Annex-III objectives, the current legislative control decision should be upgraded to declare endosulfan as a banned compound by its active substance (a.s.) rather than that of the Endosulfan 35% EC formulation.

- ***Illegal Importation & Non–compliance***

There are no pervasive evidence to import and/or illegal smuggling of POPs pesticides banned in Sri Lanka.

However, the Office of the ROP recently (18.09.2014) detected a case of illegal trade of extremely toxic pesticides containing 2% methyl parathion (a non–POPs insecticide) in the name of Dethyl® 2% DP in Jaffna (Northern Sri Lanka). This extremely toxic illegal pesticide is manufactured by Decan Agro Chemicals, Plot No 411, 11th Cross, 4th Phase, Peenya Industrial Area, Bangalore–58, India (**Figure 5**). Evidence presented that this highly powerful insecticide had been sold in retail quantities after opening the original container. Then the product is without any label preventing its identity, which is extremely dangerous for anyone using of the product and/or exposing to the product, especially the children and uninformed persons. Even though the illegal trade is very limited, the cases like this would tarnish safe initiatives in the past by banning almost all extremely toxic pesticides of WHO Hazard Class I category from general purpose pest control including POPs pesticides.

Before 1985, the use of this pesticide in Sri Lanka was limited to few commercial products (i.e. Metacide®, Folidol® M) containing 500 g/l or 46.7% methyl parathion. All pesticides containing methyl parathion have been banned from import to Sri Lanka since 1985 and the official declaration of prohibition has been published in the Government Extraordinary Gazette No. 1190/24 of 29.06.2001 under the Control of Pesticides Act No. 33 of 1980.

Annex III of the Rotterdam Convention declares that all pesticide products containing methyl-parathion (CAS No. 298–00–0) in the form of Emulsifiable Concentrates (EC) at or above 19.5% active ingredient and dusts (DP) at or above 1.5% active ingredient are extremely toxic which warrants international action.


**Figure 5**: Illegal trade of extremely toxic pesticides containing 2% methyl parathion in the name of Dethyl® 2% DP in Jaffna (Northern Sri Lanka). The pesticide product Dethyl® 2% DP claims versatile use in the form of pictograms. Date inspected 18.09.2014 (Photo by J.A. Sumith).

It is advocated the fact that there have been few other illegal pesticides– illegally produced locally and/or smuggled by unscrupulous traders for household use– were also found in the market recently (**Figure 6–8**). There were number of problems with the products offered to the consumer such as hindrance of true identity of active ingredient, mislabelling and/or misleading labels. There are no data on analytical verifications that has been conducted to elucidate true identity of active ingredients central to these investigations; expert judgement on many of the situations excludes the possibility of trading POPs pesticides. However, possibilities exist that smuggled products may be containing or contaminating with POPs pesticides since some of the regional countries are still reported to be producing, and/or being in trade and/or possessed usable stocks of such pesticides such as DDT, endosulfan and lindane (Ali et al. 2014 and references there in; NIP Mongolia, 2014). In a study conducted in Nicaraguva, Gladstone (2001) reported that there are possibilities to exist that the chemical nature of the substances may or may not be labelled on the packages and the labels may or may not actually reflect the actual substance and its concentration on illegal pesticides. The above study showed the salient nature of intrusion of POPs pesticides in the way of mislabelling and in some situations verbal claims of POPs pesticides were not really true as to the fact that consumer preference in the past for long–acting POPs pesticides has been exploited by ambulatory salesmen and re-packers (e.g. mirex). A similar situation had been existed in Sri Lanka in the past (e.g. DDT) (NIP–1; Ministry of Environment, 2006).

Alternatively, some of these illegal products can be admixed with agricultural pesticides by the way of either mimicking of active ingredients used or withdrawn from products in household pest control (e.g. phoxim, dichlorvos, chlorpyrifos) or can contain severely restricted pesticides smuggled from India (e.g. malathion). Currently, almost over 90% of Sri Lanka's total mosquito coil requirement is manufactured within the country; of 262 million mosquito coils used in the country during the year 2014, only 9.2% of coils (equals to 22 million mosquito coils) have been imported into Sri Lanka (Office of the Registrar of Pesticides, 2015). In contrast, the total mosquito coil consumption– 110 million coils, had been imported in 2003 (NIP–1) Therefore, one of the earlier measures adopted by the Registrar of Pesticides for regular monitoring of illegal admixtures of DDT from new sources of imports of mosquito coils have almost been invalidated due to insignificant degree of imports.


**Figure 6**: Illegal pesticides found in the city of Colombo smuggled from India. (A) Termite Killer Powder– identity of active substance is obscured; (B) Bed Bug Killer– identity of active substance is obscured; (C) Any Killer Powder– chemical identity is given as chlorpyrifos 1% w/w; (D) One Shot Ant Killer– chemical identity is given as zinc phosphide 0.25% w/w. Date inspected 18.09.2013 (Photos by J.A. Sumith).

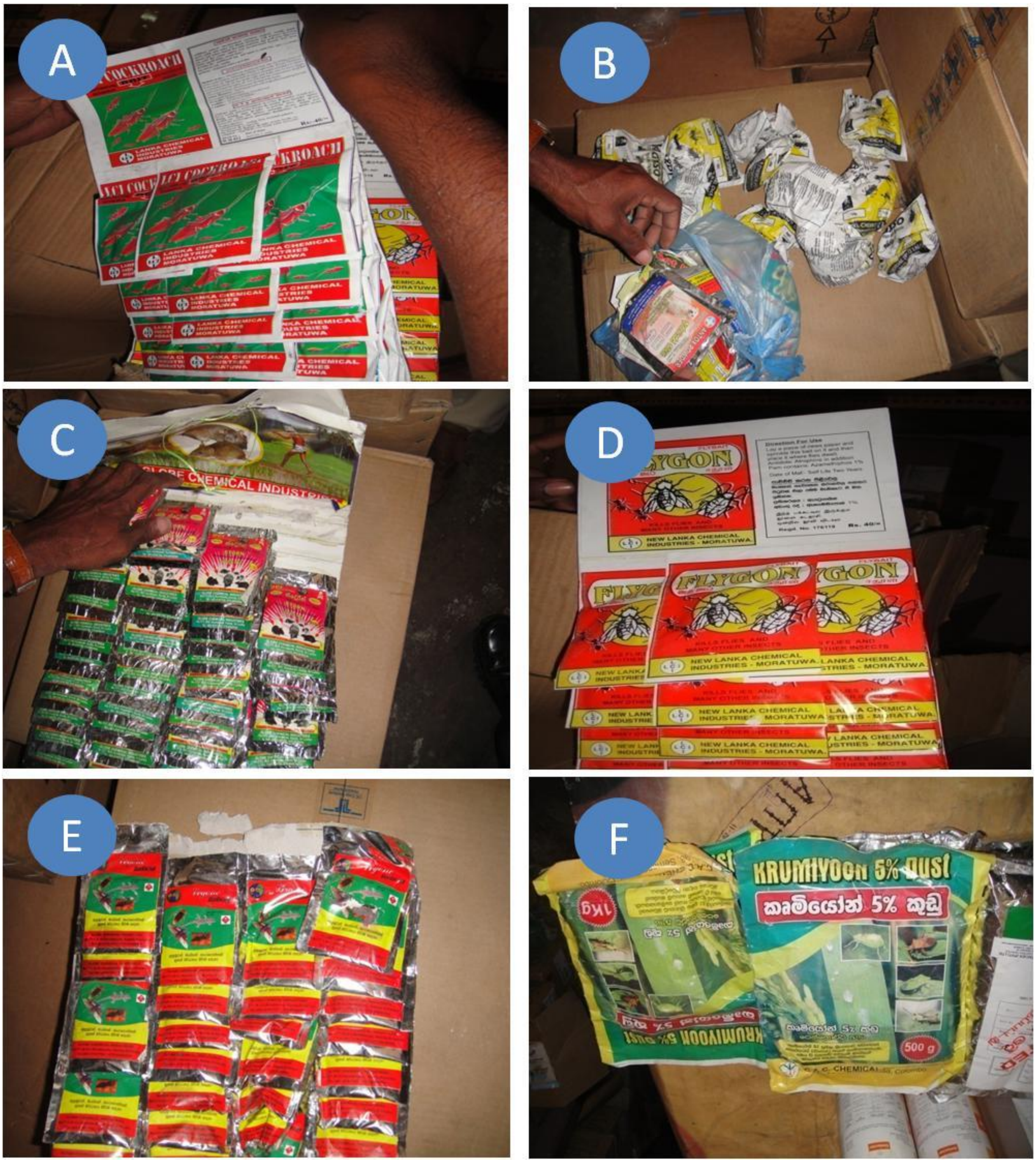


**Figure 7**: Illegal pesticides manufactured locally and found to be sold in Colombo and suburbs. (A) Cockroach Bait– chemical identity is given as chlorpyrifos 2% w/w; (B) Mackso– identity of active substance is obscured; (C) Storn– chemical identity is given as brodifacoum 0.005% w/w; (D) Flygon Fly Bait– chemical identity is given as azamethiphos 1% w/w; (E) Veygone– chemical identity is given as chlorpyrifos 1% w/w; (F) Krumiyoon 5% Dust– chemical identity is given as phenthoate 5% w/w. Date inspected 18.09.2013 (Photos by J.A. Sumith).


**Figure 8**: Illegal pesticides manufactured locally and found to be sold in rural agricultural areas in Sri Lanka. The active substances used in these formulations are suspected to be organophosphates– either malathion (from illegal trade from India) or phenthoate (from agricultural formulations used in Sri Lanka). (A) Bistar 10% WP– mimicry to an insecticide containing bifenthrin 10% w/w; (B) Bethiyon– mimicry to an insecticide containing phoxim 1% w/w; (C) Ant and White Ant Powder– chemical identity is obscured; (D) Clearant Ant Killer– chemical identity is given as phoxim. Date inspected 18.09.2013 (Photos by J.A. Sumith).

**Figure 9**: Some stocks of heavily deteriorated obsolete pesticides owned by pesticide companies stored at regional centers were managed to disposed of by incineration with intervention of the Pesticide Authority, Sri Lanka. Location: Anguruwathota, Kegalle, Date inspected: .....(Photos by J.A. Sumith).


**Figure 10:** The nature of non-POPs pesticides waste for disposal: (A) A stock of obsolete pesticide formulations; (B) A stock of pesticide contaminated waste including bulk containers. Location: Ceylon Petroleum Corporation (Agrochemical Function), Kollonnawa, Date inspected: 17.02.2012 (Photos by J.A. Sumith).

### ➢ *Quality Control of Pesticides*

The analytical laboratory of the Registrar of Pesticides has been functioning for the compliance monitoring activities in pesticide management in Sri Lanka. It is one of the laboratories authorized by the Control of Pesticides Act No. 33 of 1980 (*vide* Government Extraordinary Gazette No. 1293/21 of 19.06.2003) for legal purposes.

The strengthening of laboratory management towards accreditation is an ongoing approach in laboratory management and quality management systems. It is with the goal to produce measurable improvement and prepare the laboratory for accreditation based on international laboratory standards. In October, 2013, an application was submitted for the Sri Lanka Accreditation Board in order to obtain International Standardization Organization (ISO) 17025: 2005 Laboratory Accreditations.

The required procedures have been developed with the following scope:

i.) Testing method development and validation for key pesticide formulations by Gas Chromatography (GC) and High–Performance Liquid Chromatography (HPLC)
ii.) Testing for pesticide residues in water for chlorpyrifos, diazinon and profenophos by GC and Gas Chromatography in tandem with Mass Spectrophotometer (GC–MS)
iii.) Testing of pesticide residue levels in fruits and vegetables by QuChERS method by GC and HPLC
iv.) Testing of heavy metal contamination in pesticide formulations and environmental samples by Inductively–Coupled Plasma–Mass Spectrophotometer (ICP–MS)

Quality control of pesticides is one of the major undertakings at the laboratory of the Office of the ROP. It has been functioning for compliance monitoring purposes with the existing capacity, which is being ungraded for service–oriented activities upon receiving the status of laboratory accreditation; ISO 17025: 2005. Currently, there is no POPs–focussed analytical schedule is being implemented by the laboratory, but it is being given focus on few non–POPs pesticides in development of in–house method development and validation (e.g. diazinon, glyphosate, chlorpyrifos, profenophos, etc) as of above.

During the year 2014, 282 pesticide formulations (i.e. production batches) were analyzed for quality and performance parameters (Admin. Report, Department of Agriculture, 2013) and 279 production batches were confirmed valid on quality grounds & approved for marketing. Meanwhile, three (3) pesticide consignment imported were re–shipped to the manufacturer on the failure of quality standards.

- ***Measurement of Quality Standards Using ICP–MS Instrument***

During the last quarter of 2013, the laboratory acquired an ICP–MS, which is one of the most sophisticated analytical instruments for heavy metal analysis in any media (pesticide formulations and environment samples). The instrument has been initially calibrated to analyze 17 trace metals including arsenic, cadmium, mercury, lead and chromium. At the very inception, the service provider has been given, two hands–on training on instrumentation and analytical techniques.

Currently, several trial analysis have been performed in random with quality compliance on pesticide formulations, including trace metal contamination in 59 glyphosate formulations (which is one of the leading weedicides in Sri Lanka and its use has been challenged on human health grounds), and confirmed negligible in contaminants like arsenic, cadmium and mercury. More analytical works are being carried out on water and rice samples from the field.

- ***Accreditation Road–show***

The laboratory is being upgraded with a newly–renovated space for pesticide residue analysis in order to meet the ISO 17025: 2005 laboratory standards. Already acquired new ancillary equipments and accessories have been installed for efficient conductance of analytical work. Some critical components in this process were calibration and documentation of each piece of equipment. A team of assessors from the Sri Lanka Accreditation Board (SLAB) visited the laboratory for the initial assessment in August 2014. The system requires an inter–laboratory comparison for major complements, which has been the thrust in the course of time. The scope of accreditation will initially be restricted to physical parameters of pesticide formulations and heavy metal analysis in pesticides and environmental samples.

## 4.3. Unintentionally Produced POPs from Pesticides

Information on contemporary pesticide sources capable of accumulating unintentionally produced POPs such as PCDD/F are sparse and generally not included in most emission inventories submitted to the Stockholm Convention (Holt et al. 2010). The countries that have successfully evaded from classical POPs pesticides may still have potential to contaminate with unintentionally produced POPs. Depending on the volume of use the application of pesticides may represent an important POPs source to the environment. The USEPA lists 161 pesticides that have the potential to contain PCDD/F impurities when manufactured under conditions that favor dioxin formation (USEPA, 2005). Several of them have been listed in the UNEP toolkit (UNEP, 2013). Furthermore, the PCDD/F release from pesticide application have resulted in contamination of agricultural area (Weber and Masunaga, 2005; UNEP, 2013).

Contamination of pesticides with unintentionally produced POPs is further exemplified by the fact that-

a). in China, triclosan production has been described as one of the nation's largest PCDD/F sources (Zheng et al. 2008).

b). in Australia, agricultural application of a single pesticide, pentachloronitrobenzene (PCNB), was reported as possibly that nation's largest single PCDD/F source (Holt et al. 2010).

**Table 8:** List of pesticides with (historical) unintentional POPs contamination[28]

| Pesticide | Use History | Date of Ban |
|---|---|---|
| Quintozene (82–68–8) | Morut® 70% PCNB (+10% fenaminosulf) EC<br>Terrachlor® 75% WP<br>As a soil fungicide used in vegetable nurseries<br>Shell® Colar Protectant | De–registered in 01 June, 1990[29] |
| 2,4–D | Hedonal® D 55%[#], Bi–Hedonal® SL 70%[##] | Withdrawn in 2006 |
| 2,4,5–T | – | De–registered in 1984 |
| Pentachlorophenol (PCP) (87–86–5) | Santobrite®, Rencit® VII, Popton® 44, Corium®, MMA® Tar, MMB® Tar Emulsifiable Concentrate (EC) formulation containing 36% w/v, Candarsan® (Paste) – 0.035% w/w, Mason's® Collar Protectant (Paste) – 2.0% w/w. | De–registered in 1994 |
| Triclosan [(5chloro2(2,4dichlorophenoxy)phenol] | – | No data available |

[#] withdrawn in 2001

[##] the last quantity of 1,600 kg Technical 2,4–D was imported before 2005 for the formulation of Bi–Hedonal® SL 70%

[28] Pesticides listed in UNEP Toolkit Table III 2.2, UNEP (2013)

[29] Directive of the Pesticides Technical and Advisory Committee No. 35 of 1989


**Figure 11**: A stock of obsolete technical malathion in Department of Health Stores at Nochchiyagama, Sri Lanka (Photo by J.A. Sumith)

**Figure 12:** Safe decanting and storage of the stock of obsolete technical malathion in Department of Health stores at Nochchiyagama, Sri Lanka (Photo by J.A. Sumith)


**Figure 13:** An obsolete stock of Methyl Bromide 98% at Food Commissioner's Department Stores, Orugodawatta, Sri Lanka, Date inspected 04.10.2012 (Photos by J.A. Sumith).

# 5. Environmental and Health Impact of POPs Pesticides in Sri Lanka

As required under the Stockholm Convention, the national scenario of the status of POPs pesticides in the environment and the biota would be highly warranted. However, some of the POPs pesticides have not been used over 1½ decades (at least), and most of the candidates were discontinued from use over several decades, their persistent properties, semi-volatility, multimedia mobility and ability to bio-concentrate in the food chain, necessitated a closer look at contamination levels in the regional perspective, which would reveal a measure of the threat of damage to Sri Lankan nations' health and the ecosystem as contamination could result during storms via atmospheric and/or ocean pathways.

Data on POPs pesticides in various environmental compartments have been reported from the developed world ever since "Silent Spring" by Rachel Carson in 1962. The UNEP–GEF Global report (2003) makes reference to the volume of scientific literature over the period 1990–2002 for different environmental compartments but stress that "data are often patchy, and typically the result of one–off studies rather than systematic, comparable and long–term monitoring"[30]. Many more studies relate to water and biota followed by studies on soils and sediments, human and food with the least information being available for air.

However, some monitoring on PFOS and perfluorooctanoic acid (PFOA; currently evaluated by POPRC) has been conducted in Sri Lanka very recently but recent data on POPs pesticides is non–existent. A recent study (Guruge et al. 2005) explored to quantify several fluorinated organic compounds (FOCs) in human sera and seminal plasma in rural (Thalawakele) and urban (Colombo) populations in Sri Lanka and revealed following concentrations (mean):

- Seminal plasma in urban populations PFOA = 241 pg $ml^{-1}$ PFOS = 125 pg $ml^{-1}$
- Sera in urban population PFOA = 9.54 ng $ml^{-1}$ (max. 23 ng $ml^{-1}$) PFOS = 7.8 ng $ml^{-1}$ (max. 18 ng $ml^{-1}$)
- Seminal plasma in rural populations PFOA = 621 pg $ml^{-1}$ (max. 2.13 ng $ml^{-1}$), PFOS = 190 pg $ml^{-1}$ (max. 529 pg $ml^{-1}$)
- Sera in rural population PFOA =9.06 ng $ml^{-1}$ (max. 23.5 ng $ml^{-1}$), PFOS 6.23 ng $ml^{-1}$ (max. 17.5 ng $ml^{-1}$)

[30] UNEP-GEF Global report 2003 pg. 54

Accordingly, the accumulation of PFOS/A was not significantly different in sera from Colombo (urban population) and Talawakele (rural conventional tea workers), which signifies the ubiquity of pollutants.

However, the Haldummulla population (rural organic tea workers) had relatively lower exposure to PFOS compared to the other two groups, urban and rural conventional tea workers (Guruge et al. 2005), which signifies the levels of exposure (data not shown).

Even data for the Indian Ocean Region (UNEP Region VI) on POPs pesticides is comparatively sparse. Available information mainly comprise data on aldrin, DDT and HCB with the other organochlorine pesticides – chlordane, dieldrin, endrin, heptachlor and endosulfan also receiving mention. In general, much of the pollution data are cases of spills or due to adoption of inappropriate disposal procedures.

Currently several countries in UNEP Region VI – India, Pakistan, Sri Lanka, Nepal, Bhutan and Bangladesh have either banned or not registered POPs pesticides for agricultural use and their presence in the environment may be a result of excessive use in agriculture in the past and run off leading to contamination of various river basins. In the meantime, some recent inputs of POPs pesticides has been reported from South Asian countries, such as India and Pakistan (Ali et al. 2014 and references therein).

## 5.1. Levels of Residues of POPs Pesticides in the Environment

Wind, rain and irrigation carry pesticides applied for public health requirements and agricultural activities, finally ending up in surface waters of lakes, rivers, and oceans and in different layers of the soil and even in the ground water. Information on recent residue loadings in various abiotic (air, water, soil and sediments) and in biotic (marine organisms and humans samples) compartments in South Asia (Ali et al. 2014 and references therein) has been summarized in **Table 9**.

**Table 9:** Some recent records of POPs pesticides contamination levels in South Asia

| Location | ΣHCH | ΣDDT | Aldrin | Dieldrin | Endrin | HCB | Heptachlor | α–Endosulfan |
|---|---|---|---|---|---|---|---|---|
| **Air (pg $m^{-3}$)** | | | | | | | | |
| Mumbai (urban) | 637 | 1,637 | – | – | – | – | – | 498 |
| Chennai (urban) | 1,691 | 2,901 | – | – | – | – | – | 680 |
| **Water (μg $l^{-1}$)** | | | | | | | | |
| Rawal lake | – | 1.76–5.26 | – | – | – | – | – | 0.66–0.72 |
| Solu-Khumbu | – | – | – | – | – | <0.00002 | – | – |
| Unnao | – | <0.3 | <2.03 | – | <0.01 | – | – | <0.13 |
| **Sediments/soils (ng $g^{-1}$)** | | | | | | | | |
| Pesticide dumping ground Hyderabad city, Pakistan | 13.5–4,090 | 21–21,200 | – | – | – | 0.04–100 | 0.03–28 | – |
| River Yamuna Delhi | 0.11–30.27 | – | 1.05–29.1 | 5.49–81.8 | 12.1–67.6 | – | 0.79–25.23 | – |
| Punjab Province, Pakistan | 7.8 | 40 | – | – | – | 0.21–10 | – | – |
| **Human and biota samples (ng g−1)** | | | | | | | | |
| River Chenab Fish samples | 2.5–8.6 | 9.17–405 | – | – | – | 0.41–4.11 | – | – |
| Gujarat and Islamabad Rural | 50 | 832.5 | – | – | – | 6.5 | – | – |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| children | | | | | | | | |
| Gujarat and Islamabad Urban mothers | 55 | 264.2 | – | – | – | 14 | – | – |

The following text explains the historical contamination levels of POPs pesticides recorded in various environmental compartments with limited information from Sri Lanka and in particular in South Asia.

## 5.2. Abiotic Compartments

(i) Air

The UNEP–GEF Global report (2003) notes that tropical temperate regions of the world particularly Asia (India) and Africa have recorded the highest levels of toxic substances in the air, the loading being in the range of 0.076–62.8 ng $m^{-3}$ for DDT.

(ii) Soils

In Indian soils range of 0.005–0.049 mg $kg^{-1}$ of total DDT residues have been found (ICAR, 2002) while in Sri Lanka 0.012–0.203 mg $kg^{-1}$ DDT and 0.004–0.032 mg $kg^{-1}$ of dieldrin have been reported from Jaffna soils (Ramasundaram et al. 1978).

(iii) Sediments

Sarkar et al. (1997) studied sediments along the west coast of India and the wider studies of sediments by Iwata et al. (1994) revealed that offshore sediments (10–15 km from river mouths) had organochlorine residues of comparative lower levels than sediments at the mouth of estuaries. Further, that sediments of east coast estuaries were much more heavily loaded than that along the west coast of India with levels of DDT ranging from 63–260 µg $kg^{-1}$, aldrin 0.1–0.26 µg $kg^{-1}$, dieldrin 0.7–3.33 µg $kg^{-1}$ and endrin 0.42–0.95 µg $kg^{-1}$ (Sarkar and Everaats, 1998), while in Sri Lanka in studies undertaken on sediments by Guruge and Tanabe (2001) in the west coastal region in Sri Lanka and in lagoon by Industrial Technology Institute; total DDT residues of 0.00009–0.0096 µg $kg^{-1}$ and chlordane at 0.000063–0.00012 µg $kg^{-1}$ were detected.

(iv) Water

DDT residues ranging from 100–440 ng $l^{-1}$ in the coastal waters of the west coast of India have been reported by Shailaja and Singhal (1994). While the wider study by Iwata et al. (1994) of organochlorine pollutants in air, water and sediments in Asia and Oceania established that the highest levels of DDT were found in coastal waters of the Indian Ocean.

No residues of POPs pesticides were detected in studies undertaken on surface and ground water, lagoons and sea water in Sri Lanka, though DDT and chlordane residues were detected in bottom sediments in lagoons (Guruge and Tanabe, 2001).

## 5.3. Biotic Compartments

(i) Marine organisms

In general, fish and marines invertebrates such as clams and mussels are regarded as good bio-indicators of the extent of pollution in the habitats they occupy.

Concentrations of DDT and aldrin in 4 species of bottom feeding fish in the Bay of Bengal ranged from 1.31–115.9 µg $kg^{-1}$ and aldrin residues of 0.3–4.2 µg $kg^{-1}$ while in Sri Lanka levels detected in fish were DDT 0.05–0.12 µg $kg^{-1}$ with chlordane detected in bivalves (mussels) of 0.0017 µg $kg^{-1}$ and fish 0.0017–0.0088 µg $kg^{-1}$ (Guruge and Tanabe, 2001). These results are in keeping with DDT and chlordane contaminants found in bottom sediments.

(ii) Terrestrial organisms

In comparison to the in depth long term monitoring studies on the indirect sub–lethal effects such as eggshell thinning, abnormal gonadal development and skewed sex ratios that have impacted species at the population level studies in the Indian Ocean region document only contaminant levels in body tissues.

Residue studies by Tanabe et al. (1998) on resident and migratory birds in South India revealed varying levels of organochlorine pesticide residues depending on the migratory behaviour. Short distant migrants from central China and Middle East countries had DDT levels of 17–1,800 ng $g^{-1}$ while long distance migrants from the Himalaya range revealed DDT at 67–1,300 ng $g^{-1}$, but DDT levels in resident birds ranged from 0.3–3,600 ng $g^{-1}$, chlordane levels too were lower in residents (0.1–4.3 ng $g^{-1}$) compared to 0.3–10 ng $g^{-1}$ in migrants. In the absence of ecological studies to determine the impact of those pollutants in species decline, there is no scientific evidence that pollutants at recorded levels have caused lasting environmental damage.

(iii) Humans

Exposure of humans to toxic chemicals is of 3 types:

a). High dose acute exposure due to accidents

b). Middle level chronic impact due to occupational exposure or proximity to contaminated sites (as from outdoor and indoor residual sprays in public health vector control programs) or from dietary sources where there is high consumption of contaminated sea food.

c). Low level chronic exposure of general population due to residues in diet which would be more relevant in the long term.

The likelihood of high acute exposure or middle level chronic health impacts of POPs pesticides in a non–industrial country like Sri Lanka due to spillage or poor disposal respectively, are low, as current un–disposed stocks documented were 71.53 kg (0.17% of all classes of pesticides). In like manner dietary exposure too would have scaled down over the years due to non–use. Recent assessment of human urine samples in a population of rural agricultural workers in a dry–zone district of Sri Lanka showed contamination below the reference limit of <2 µg $l^{-1}$ of pentachlorophenol and its first degradation product 2,4,5–trichlorophenol (Jayathilake et al. 2013). Thus, the current low levels of PCP and 2,4,5–TCP in the general population from Sri Lanka further confirm that PCP has not been used in the country for a number of years.

**Table 9** records information on POPs organochlorine residues found in human milk, blood serum, and adipose tissue, whereas the data for Sri Lanka is over the period 1978–1981. In India, a nationwide study in 1988 recorded DDT levels in communities from 0.2 µg $kg^{-1}$ in Central India to higher value of 17.2 µg $kg^{-1}$ in West India (Jani et al. 1988). Based on this a national DDT level of 11.1 µg $kg^{-1}$ has been established. The wide variation of DDT and its metabolites in the population from various parts of India has been attributed to the differences in use and consumption levels of DDT (for public health and agriculture) and the food habits in the various regions. In Sri Lanka, the levels of DDT in human milk (0.19–0.221 µg $kg^{-1}$) and adipose tissue (10.69–102.02 µg $kg^{-1}$) is comparatively low and with its history of non-use since 1976 levels would have decreased significantly with the withdrawal of indoor and outdoor sprays of DDT for vector control.

(iv) Food

Human food derived from aquatic and terrestrial biota can be considered as a biotic compartment. Many studies have covered the residue levels as this is the most common pathway into the human body and source for health impacts.

A coordinated research project to determine pesticide residues in food items in India in recent years revealed levels of DDT contaminants in vegetables and fruits up to 8.6 µg $g^{-1}$ while aldrin residues were at 0.03 µg $kg^{-1}$. The presence of DDT residues from 0.02–1.47 µg $g^{-1}$ in several brands of baby milk powder raised concerns on the increasing residue loads that could affect children in their crucial formative years. In studies undertaken in Sri Lanka 3½ decades ago, when organochlorine levels would have been optimal as their use would have spanned over 2 decades, residues ranging as follows: DDT 0.002–2.387 µg $kg^{-1}$, dieldrin 0.001–0.233 µg $kg^{-1}$, endrin 0.001–0.413 µg $kg^{-1}$ and heptachlor 0.001–0.199 µg $kg^{-1}$ were detected in fruits and vegetables while these contaminants were also found in hulled rice, tea, processed foods and some exported products such as tobacco, coffee beans, tea and cardamom (NIP–1).

In the absence of market basket surveys of principle food items used by Sri Lankans, **Table 10** presents the permissible levels of POPs pesticides as established by WHO and FAO (Codex Alimentarious 1993), in relation to intake levels which could be regarded as devoid of health effects for a 10 year old (20 kg b.w.) and an adult (60 kg b.w.) served to underline the fact that most of the residues detected are low. This statement is subjected to findings in more recent studies undertaken on imported food items and fish in local inhabitants data for which are yet to be presented.

Further in the light of organochlorine residues detected by Silva and Thieman (1992) in export grade tea and lack of analytical facilities with the pesticide registration authority (e.g. for compliance monitoring) during the pertinent time period for monitoring of DDT impurities in generic dicofol imports (which was specifically used in tea plantations), the Pesticides Technical and Advisory Committee (PeTAC) deregistered dicofol in 1994 to prevent all likelihood of undesirable DDT residues occurring in the globally acclaimed Ceylon Tea we export.

Potential adverse health effects due to POPs pesticides have been documented as:

(i) probable carcinogens such as DDT, chlordane an heptachlor in Group II while aldrin, dieldrin and endrin in Group III are considered as unclassifiable as to carcinogenicity (NIP–1).
(ii) neurotoxicants affecting peripheral nervous system, e.g. aldrin, dieldrin and affecting central nervous system e.g. heptachlor.
(iii) affecting reproductive and foetal development e.g. aldrin, dieldrin, DDT, endrin.
(iv) immunological effects e.g. all POPs pesticides
(v) endocrine disruptors e.g. all POPs pesticides.

The contemporary concerns regarding pesticide residues have centrally based on compliance assessment in export agricultural products, on which a number of initiatives are being implemented including the supervision of export production at farm levels and promotion & awareness on Good Agricultural Practices (GAPs). Farmers do not abide by instruction of pre–harvest intervals in vegetable production, in general. In contrast, imported agricultural products for local consumption are not monitored for pesticide residues owing to lack of a properly enforced regulatory system (the key provisions are held with the Food Act No. 26 of 1980; executing agency is the Ministry of Health).

Biotic and abiotic contamination levels of POPs pesticides previously determined and reported in the NIP–1 (2006), are lower than those data published by Ali et al. (2014) from some of the regional countries in south Asia where there have been reports of current use. In this context, a further reduction of environmental residue levels could be expected in this Island nation because a considerable time period has been elapsed since its ban of last POPs pesticide listed under the Stockholm Convention.
In conclusion, in Sri Lanka as well as in the rest of the Indian Ocean Region, the concentration of POPs pesticide residues in various environmental compartments have been quantified, but there are no science based that link pollutant levels to specific biological effects that would have lead to ecologically significant population decline. Hence, it is not

possible to predict or associate adverse environmental impacts that have resulted from the use of POPs pesticides in the past.

However, in the absence of epidemiological knowledge in Sri Lanka linking cause–effect relationship to low level dietary exposure, it is doubtful that health surveys at this late stage of contamination would serve any purpose, as the risks due to POPs pesticide use in the past are low in comparison to many of life's daily risks which are accepted by most people.

**Table 10**: Dietary permissible levels of POPs pesticides.

| POPs Pesticide | Acceptable Daily Intake (ADI) mg $kg^{-1}$ b.w.* | Acceptable Dietary Level | | Maximum residue Limits (MRI) mg $kg^{-1}$† |
|---|---|---|---|---|
| | | 20 kg b.w. | 60 kg b.w. | |
| Aldrin & Dieldrin | 0.0001 | 0.002 | 0.006 | Milk 0.006<br>Cereals 0.02<br>Fruits 0.05<br>Vegetables 0.1 |
| Chlordane | 0.0005 | 0.01 | 0.03 | Milk 0.002<br>Rice 0.02<br>Fruits 0.02<br>Vegetables 0.02 |
| DDT | 0.02 | 0.4 | 1.2 | Milk 0.05<br>Cereals 0.1 |
| Endrin | 0.0002 | 0.004 | 0.12 | Milk 0.0008<br>Cereals 0.02 |
| Heptachlor | 0.0001 | | | Milk 0.006<br>Vegetables 0.05<br>Pineapple 0.01 |

* b.w. body weight † Codex Alimentarious, 1993

# 6. Implementation Strategy

The use of POPs pesticides in Sri Lanka was initially prohibited during the early seventies and the last of the POPs pesticide (*viz.* lindane or *gamma*–HCH) used for head–lice control in shampoo and other dermal preparations was banned in 2012. None of the agricultural applications is authorized to use POPs pesticides almost limited to the listing of Annex 3 of the Stockholm Convention and Sri Lanka banned the last of POPs pesticides, endosulfan in 1998. The contemporary regulatory actions have been taken under the Control of Pesticides Act No. 33 of 1980 and its amendment Act No. 06 of 1994. Hence, we can safely assume that no legal importation of any POPs pesticide is taking place in Sri Lanka. However, there are possibilities for illegal importation of pesticides – though not necessarily POPs pesticides – with some evidence available. Therefore, the contemporary concerns regarding POPs pesticides have centrally based on compliance assessment in order to ascertain whether Sri Lanka's past intervention on POPs pesticide management has been fulfilled or not.

The following priority issues were identified by taking the limited threat of POPs pesticides under Sri Lankan context.

## 6.1. Priority Objectives and Recommendations

***Objective 1***: to encourage effective and efficient pesticide use practices, in order to minimize waste to reduce accumulation of obsolete pesticides at the source.

***Objective 2***: to enhance regulatory monitoring of illegal/counterfeit pesticides accompanied with analytical confirmations in order to spot possible infiltration of banned pesticides including POPs pesticides.

***Objective 3***: to sample and analyse for POPs pesticides and their major degradation products at major use and/or storage "hot spots" in order to delineate potential environmental contamination.

***Objective 4***: to encourage local analytical laboratories to effectively engage in environmental sampling for POPs pesticides in tandem with establishing possible correlations between their presence and biological effects.

***Objective 5***: to facilitate establishing a temporary storage facility to avoid any mis–use of obsolete pesticides and to facilitate establishing an empty-containers/packaging management system for pesticides used existent on the market.

***Objective 6***: to assess currently used (highly) hazardous pesticides and substitute them by less hazardous pesticides and integrated vector control. Promote the use of alternative pest management strategies and, in case they are not available, promote research for development of alternative strategies;

***Objective 7***: to facilitate organic farming to reduce the overall use of (hazardous) pesticides and to improve biodiversity and healthy soils.

***Objective 8***: to raise awareness on hazardous pesticides and alternatives including organic farming/food and related activities on awareness raising on national, regional and local levels for stakeholder groups (decision makers, farmers, public, NGOs, industry etc.).

***Objective 9***: to raise awareness on special chemicals groups and pesticides for stakeholder groups including customs.

***Objective 10***: to identify, assess the risk, to manage and remediate the POPs pesticides contaminated sites in an environment sound manner.

***Recommendations***

1. Implement awareness and control mechanisms to encourage effective and efficient pesticide use practices in order to minimize waste in order to reduce accumulation of obsolete pesticides at the source.
2. Strengthen pesticide regulatory system with improved manpower and laboratory facilities to enhance regulatory monitoring of illegal/counter fight pesticides accompanied with analytical confirmations in order to spot possible infiltration of banned pesticides including POPs pesticides.

3. Designing an analytical monitoring system to sample and analyse for potential POPs and their major degradation products at major use "hot spots" in order to delineate potential environmental contamination (leading to declare Sri Lanka as a "POPs Pesticide Free" country).
4. Implement coordinated research network to encourage local analytical laboratories to effectively engage in environmental sampling for POPs pesticides in tandem with establishing possible correlations between their presence and biological effects.
5. Establishment of a secured temporary storage facility for obsolete pesticides to avoid any mis–use of such pesticides at field level and of an empty-containers/packaging management system for pesticides used existent on the market.
6. Implement effective regulatory mechanism and control programs to assess currently used (highly) hazardous pesticides and substitution by less hazardous pesticides and integrated vector control. Promote the use of alternative pest management strategies and, in case they are not available, promote research for development of alternative strategies;
7. Policy development and implement strategies and programs to facilitate organic farming to reduce the overall use of (hazardous) pesticides and to improve biodiversity and healthy soils.
8. Awareness raising of stakeholder groups on hazardous pesticides and alternatives including organic farming/food and related activities on awareness raising on national, regional and local levels for stakeholder groups (decision makers, farmers, public, NGOs, industry etc.)
9. Training for custom officials on identification and management of special chemical groups including POPs pesticides and encourage inter-agency coordination among relevant stakeholders.
10. Identification, assessment of the risk, management and remediation of the POPs pesticides contaminated sites in an environment sound manner.

## 7. References

**Ali, U, H.S. Jabir, N.M. Riffat, K. Athanasios, L. Jun, Z. Gan and C.J. Kevin**, 2014. Organochlorine pesticides (OCPs) in South Asian region: A review. Science of the Total Environment 476–477: 705–717.

**ATSDR**, 1999. Toxicological Profile for Pentachlorophenol (Update) (Draft). Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

**ATSDR,** 1994. Toxicological Profile Information Sheet for chlordane, update May 1994. Available at www.atsdr.cdc.gov/toxprofiles/.

**ATSDR**, 1995. Toxicological Profile Information Sheet for mirex and chlordecone, update August 1995. Available at www.atsdr.cdc.gov/toxprofiles/.

**ATSDR**, 1996. Toxicological Profile Information Sheet for endrin, update August 1996. Available at www.atsdr.cdc.gov/toxprofiles/.

**ATSDR**, 2002. Toxicological Profile Information Sheet for aldrin and dieldrin, update September 2002. Available at www.atsdr.cdc.gov/toxprofiles/.

**ATSDR**, 2002. Toxicological Profile Information Sheet for hexachlorobenzene, update September 2002. Available at www.atsdr.cdc.gov/toxprofiles/.

**Bus, J.S. and A.P. Leber**, 2001. Miscellaneous chlorinated hydrocarbon pesticides. In: Bingham, E., Cohrssen, B. Powell, C.H. eds. Patty's toxicology. Electronic version available through subscription to Wiley Interscience. Available online at http://www.mrw.interscience.wiley.com/pattys/pattys_search_fs.html (accessed March 24, 2004).

**Clarke, J.L., P.R.J. Herath and M.B. Wickramasinghe**, 1974. Studies on DDT resistance in *Anopheles culicifacies* in Sri Lanka. WHO/MAL/74.826 and WHO/VBC 74.478, pp. 1– 11.

**Coconut Research Institute**, 1992. Advisory Circular No. A1, Planting of Coconut Seedlings, Coconut Research Institute, Lunuwila, May 1992.

CSIR-National Environmental Engineering Research Institute and Ministry of Environment and Renewable Energy, 2014. Capacity Buiding for Promoting Synergistic Implementation of Basel, Rotterdam and Stockholm Conventions in Sri Lanka, Final Report, December 2014, p. 137.

**CODEX**, 1993. Codex Alimentarius Commission: Codex Committee on Food Hygiene. Guideline for the application of hazard analysis critical control point (HACCP) system

(Alinorm 19/13A, Appendex B), Food and Agriculture Organization/ WHO, Rome http://www.codexalimentarius.net.

**Cortes, D.R., I. Basu, C.W. Sweet, K.A. Brice, R.M. Hoff, and R.A. Hites**, 1998. Temporal trends in gas–phase concentrations of chlorinated pesticides measured at the shores of the Great Lakes. Environmental Science and Technology 32: 1920–1927.

**Cranham, J.E. and W. Danthanarayana**, 1971. Tea tortrix (*Homona coffearia* Nietner). Advisory

**Phamplet**–Tea Research Institute of Ceylon, No. 5–66, 8 p.

**Danthanarayana, W. and A. Kadirawetpillai**, 1969. The bionomics of tea looper (*Bistonsuppressaria* Guen.) Tea Quarterly 40: Para. 1, Sinhala, p. 120.

**Danthanarayana, W. and S.N. Fernando,** 1970. Biology and control of the live–wood termites of tea. Tea Quarterly 41(1): 34–52.

**Damstra, T., Barlow, S., Bergman, A., Kavlock, and Van Der Kraak, G. (eds.)**, 2004. Global

Assessment of the State of the Science of Endocrine Disruptors. International Program on Chemical Safety. Geneva, Switzerland: World Health Organization. http://www.who.int/ipcs/publications/new_issues/endocrine_disruptors/en/

**Ecobichon, D.J.**, 1995. Toxic effects of pesticides: organochlorine insecticides. In: Klaassen, C.D., Amdur, M.O. and Doull, J., editors. Casarett and Doull's Toxicology: the basic science of poisons. New York: McGraw–Hill; p. 649–655.

**Fiedler, H., O. Hutzinger, K. Welsch–Pausch, and A. Schmiedinger**, 2000. Final Report, Evaluation of the Occurrence of PCDD/PCDF and POPs in Wastes and Their Potential to Enter the Food chain, Co–ordination by the Joint Research Centre, Environment Institute Study on behalf of the European Commission

**Gladstone, S.M.**, 2001. Evaluation of the Synthetic Chemical Insecticides Recommended in the Nicaraguan Marketplace for the Control of Leaf-Cutter Ants. Consultant Report, Agrochemical Environmental Assessment USDA/USAID Nicaragua, May 23, 2001.

**Guruge, K.S. and S. Tanabe,** 2001. Contamination by persistent organochlorine and butyltin compounds in the West Coast of Sri Lanka. Marine Pollution Bulletin 42(3): 179–186.

**Guruge, K.S., S. Taniyasu, N. Yamashita, et al.**, 2005. Perfluorinated organic compounds in human blood serum and seminal plasma: a study of urban and rural tea worker populations in Sri Lanka. J. Environ. Monit. 7: 371–377.

**Hagan, P.W. and D.T. Ekanayake,** 1977. Handbook for cut flower growers. Published by the West German Agricultural Team in collaboration with the Royal Botanic Garden, Peradeniya, p. 99.

**Holoubek et al.**, 2004. Project GF/CEH/01/003, Enabling Activities to Facilitate Early Action on the Implementation of the Stockholm Convention on Persistent Organic Pollutants (POPs) in the Czech Republic, Proposal of the National Implementation Plan for Implementation of the Stockholm Convention in the Czech Republic (TOCOEN REPORT) No. 252, Brno.

**Holt, E., R. Weber, G. Stevenson, and C. Gaus**, 2010. Polychlorinated Dibenzo–p–Dioxins and Dibenzofurans (PCDD/Fs) Impurities in Pesticides: A Neglected Source of Contemporary Relevance (and supporting information). Environ. Sci. Tech. 44, 5409–5415.

**Herath, P.R.J. and P.G. Joshi**, 1986. Factors affecting selection for multiple resistances in *Anopheles nigerremus* in Sri Lanka. Trans. Royal Soc. Trp. Med. Hygi. 80: 649–652.

IARC, 1979. Mirex. IARC Monographs on the evaluation of carcinogenic risk of chemicals to humans. Lyon, France: WHO, IARC 20: 283–301.

**ICAR**, 2002. All India Coordinated Research Project on Pesticide Residues. Ann. Report 2001 and Proc. of Group Meeting held at Gujarat Agric. Univ. Anand, Feb. 1–2.

**IPCS**, 1997. Hexachlorobenzene. Environmental Health Criteria 195. WHO.

**Iwata, H., S. Tanabe, N. Sakai, A. Nishimura and R. Tatsukawa**, 1994. Geographical distribution of persistent organochlorines in air, water and sediments from Asia and Oceania and their implications for global redistribution. Environ. Pollution 85: 15–33.

**Jackson, G.J.**, 1991. Agrochemical usage in Asia region, A reference compendium, Asia Technical Department, Asia Agriculture Division, The World Bank, March 1991.

**Jaga, K. and C.H. Dharmani,** 2003. Global Surveillance of DDT and DDE levels in human tissues. Int J Occup Environ Health, 16: 7–20.

**Jani, J.P., J.S. Patel, M.P. Shah, S.K. Gupta and S.K. Kashyam**, 1998. Levels of organochlorine pesticides in human milk. India Intern. Archs. Occupa. Environ. Health. 60: 111–113.

**Jayasinghe, C.K., K.E. Jayasuriya and T.H.P.S. Fernando**, 1995. Pentochlorophenol–effective and economical fungicide for the management of white root disease caused by *Rigidiporus lignosus* in Sri Lanka. Jl. Rubb. Res. Inst. Sri Lanka 75(1): 61–70.

**Jayasuriya, K.E. and B.I. Thennakoon**, 2007. Biological control of *Rigidiporus microporus*, the cause of white root disease in rubber. Cey. J. Sci. (Bio. Sci.) 36(1): 9–16.

**Jayatilake, N, S. Mendis, P. Maheepala, and F.R. Mehta**, 2013. Chronic kidney disease of uncertain aetiology: prevalence and causative factors in a developing country. BMC Nephrol. 14:180.

**Karstensen, K.H., A.M. Mubarak, H.N. Gunadasa, B. Wijegunasekara, N. Ratnayake, A. De Alwis and J. Fernando,** 2010. Test burn with PCB–oil in a local cement kiln in Sri Lanka. Chemosphere 78: 717–723.

**Kutz, F.W., Wood, P.H. and D.P. Bottimore,** 1991. Organochlorine pesticides and polychlorinated biphenyls in human adipose tissue. Rev. Environ. Contam. Toxicol. 120: 1–82.

**Li, S., Y. Tian, Q. Ding and W. Liu,** 2014. The release of persistent organic pollutants from a closed system dicofol production process. Chemosphere 94: 164–168.

**Manuweera, G.K., M. Eddleston, S. Egodage and N.A. Buckley**, 2008. Do targeted bans of insecticides to prevent deaths from self–poisoning result in reduced agricultural output? Environmental Health Perspectives 116(4): 492–495.

**Mingley, S.J. and N.D.R. Weerawardena,** 1986. Termites and their control in Eucalyptus plantations of the community forestry project, Badulla. The Sri Lanka Forester, Vol. XVII, No. 3 & 4, January/December 1986.

**Ministry of Environment, Sri Lanka**, 2006. National Implementation Plan under the Stockholm Convention on POPs for Sri Lanka: ISBN: 955–9120–64–6 Published by: Persistent Organic Pollutants (POPs) Project, June 2006, 160 p.

**Qiu, X., T. Zhu, B. Yao, J. Hu, and S. Hu,** 2005. Contribution of dicofol to the current DDT pollution in China. Environ. Sci. Technol. 39: 4385–4390.

**Ramasundaram, N., S. Nagarajah, W.G. Handasiri, and H.R.J.T. Peiris**, 1978. A survey of organochlorine insecticide residues in Sri Lanka. Tropical Agriculturist 134 (2).

**Ritter, L. Solomon, K.R. Forget, J. Canadian Network of Toxicology Centres; Stemeroff, M. and C. O'Leary,** 1995. Deloitte and Touche Consulting Group, Persistent Organic Pollutants, An Assessment Report on: DDT–Aldrin–Dieldrin–Endrin–Chlordane, Heptachlor–Hexachlorobenzene, Mirex–Toxaphene, Polychlorinated Biphenyls, Dioxins and Furans For: The International Programme on Chemical Safety (IPCS) within the framework of the Inter–Organization Programme for the Sound Management of Chemicals (IOMC).

**Roberts, D.M., A. Karunarathna, N.A. Buckley, G. Manuweera, M.H. Rezvi Sheriff, and M. Eddleston,** 2003. Influence of pesticide regulation on acute poisoning deaths in Sri Lanka. Bulletin of the World Health Organization 81: 789–798.

**Robinson, A.K., Sirbasku, D.A. and Stancel, D.M.,** 1985. DDT supports the growth of an estrogen-responsive tumor. Toxicol. Lett. 27: 109–13.

**Sarkar, A., R. Nagarajah, S. Chaphadkar, S. Patel and S.Y.S. Singbal**, 1997. Contamination of organochlorine pesticides in sediments from the Arabian Sea along the west coast of India. Wat. Res. 31: 195–200.

**Seneviratne, D**., 1995. Shot hole borere (*Xyleborus formicatus*) and tea...a 100 years. Journal of the National Institute of Plantation Management 11 (1–2): 34–48.

**Shailaja, M.S. and S.Y.S. Singhal**, 1994. Organochlorine compounds in organisms from the Bay of Bengal. Estuarine Coastal and Shelf Science. 39(3): 219–226.

**Silva, M.P. de, K. Hicke and W. Thiemann,** 1991. Organophosphorus and volatile organochlorine compounds in the waters of the Nilwala River of southern Sri Lanka. J. Water SRT-Aqua 40(4): 217–221.

**Sweet, L.I., D.R. Passino–Reader, P.G. Meier and G.M. Omann,** 1998. Fish thymocyte viability, apoptosis, and necrosis: *in–vitro* effects of organochlorine contaminants. Fish Shellfish Immunol. 8: 77–90.

**Tanabe, S., Senthilkumar, K., Kannan, K. and A. Subramanian**, 1998. Accumulation features of polychlorinated biphenyls and organochlorine pesticides in resident and migratory birds from South India. Arch. Environ. Contam. Toxicol. 34: 387–397.

**UNEP,** 2001. Destruction and Decontamination Technologies for PCBs and Other POPs Wastes under the Basel Convention, volumes A, B and C. Available at www.basel.int.

**UNEP,** 2013. Toolkit for Identification and Quantification of Releases of Dioxins, Furans and Other Unintentional POPs. January 2013.

**USEPA**, 1999. RED Fact Sheet–Chlorothalonil, Office of Pesticide Programs, Washington DC, EPA–738–F–99–008, April 1999.

**USEPA**, 2005. The Inventory of Sources and Environmental Releases of Dioxin–Like Compounds in the United States: The Year 2000 Update. EPA/600/P–03/002A. External Review Draft. Washington, D.C., March 2005.

**Weber, R. and S. Masunaga**, 2005. PCDD/PCDF Contamination from Historical Pesticide Use and Production – A case study using data from Japan and Germany. International HCH and Pesticides Forum, 26–28 May 2005, Sofia, Bulgaria <risk.kan.ynu.ac.jp/masunaga/8thHCH_FORUM_Weber%20%20Masunaga.pdf>

**Wickramasinghe, M.B.,** 1981. Malaria and its control in Sri Lanka. Ceylon Medical Journal 26: 107–115.

# Annexure 1

## Annex A, B & C of the Stockholm Convention[31]

**CHEMICALS/PESTICIDES LISTED UNDER THE STOCKHOLM CONVENTION AND THE STATUS OF LOCAL LEGISLATIVE ACTIONS**

| Chemical/CAS Number | Remarks |
|---|---|
| Aldrin 309–00–2 | POP(p)/B# |
| *Alpha*–hexachlorocyclohexane 319–84–6 | POP/B# |
| *Beta*–hexachlorocyclohexane 319–85–7 | POP/B# |
| Chlordane 57–74–9 | POP(p)/B# |
| Chlordecone 143–50–0 | POP(p)/C† |
| Dieldrin 60–57–1 | POP(p)/B# |
| Endrin 72–20–8 | POP(p)/B# |
| Heptachlor 76–44–8 | POP(p)/B# |
| Hexabromobiphenyl 36355–01–8 | POP(i)/C† |
| Hexabromodiphenyl ether and heptabromodiphenyl ether | POP(i)/C† |
| Hexachlorobenzene 118–74–1 | POP(p)(i)/C† |
| Lindane (*Gamma*–hexachlorocyclohexane) 58–89–9 | POP(p)/B# |
| Mirex 2385–85–5 | POP(p)/C† |
| Pentachlorobenzene (PeCB) 608–93–5 | POP(p)(i)/C† |
| Polychlorinated biphenyls (PCB) | POP(i)/B* |
| Technical endosulfan and its related isomers | POP(p)/B# ‡ |
| Tetrabromodiphenyl ether and pentabromodiphenyl ether | POP(i)/C† |
| Toxaphene 8001–35–2 | POP(p)/C† |
| DDT (1,1,1–trichloro–2,2–bis (4–chlorophenyl)ethane) 50–29–3 | POP(p)/B# |
| Perfluorooctane sulfonic acid (1763–23–1), its salts and perfluorooctane sulfonyl fluoride (307–35–7)<br>For example: potassium perfluorooctane sulfonate (2795–39–3); lithium perfluorooctane sulfonate (29457–72–5); ammonium perfluorooctane sulfonate (29081–56–9); diethanolammonium perfluorooctane sulfonate (70225–14–8); tetraethylammonium perfluorooctane sulfonate (56773–42– | POP(p)(i)/C† ≠ |

[31] www.pop.int

| | |
|---|---|
| 3); didecyldimethylammonium perfluorooctane sulfonate (251099–16–8) | |
| Hexachlorobenzene (HCB) 118–74–1 | POP/C† |
| Pentachlorobenzene (PeCB) 608–93–5 | POP/C† |
| Polychlorinated biphenyls (PCB) | POP/B* |
| Polychlorinated dibenzo–*p*–dioxins and dibenzofurans (PCDD/F) | POP/C† |
| Polychlorinated naphthalenes | POP(i)/ |
| Hexabromocyclododecane (HCBD) | POP(i)/ |
| Hexachlorobutadiene | POP(i)/ |
| Pentachlorophenol and its salts and esters | POP(p)/B# |
| Hexabromobiphenyl | POP(i)/ |

POP = Chemicals/pesticides regulated under the Stockholm Convention

POP(p) = POPs pesticide

POP(i) = POPs industrial chemical

B = Banned chemicals/pesticides under following local jurisdictions

# Government extraordinary gazette No. 1190/24 of 29.06.2001 under the Control of Pesticides Act No. 33 of 1980

* Government gazette extraordinary No. 1813/14 of 05.06.2013 under the Import and Export (Control) Act No. 01 of 1969

‡ Only Endosulfan 35% EC formulations were officially banned under the Control of Pesticides Act No. 33 of 1980.

C = Controlled chemicals/pesticides under following local jurisdictions

† Government gazette extraordinary No. 1813/14 of 05.06.2013 under the Import and Export (Control) Act No. 01 of 1969.

≠ Only perfluorooctane sulfonic acid (1763–23–1), its salts and perfluorooctane sulfonyl fluoride (307–35–7) were officially declared as a controlled compound under the Import and Export (Control) Act No. 01 of 1969. Sulfluramid is the only PFOS-related compound having insecticidal properties.