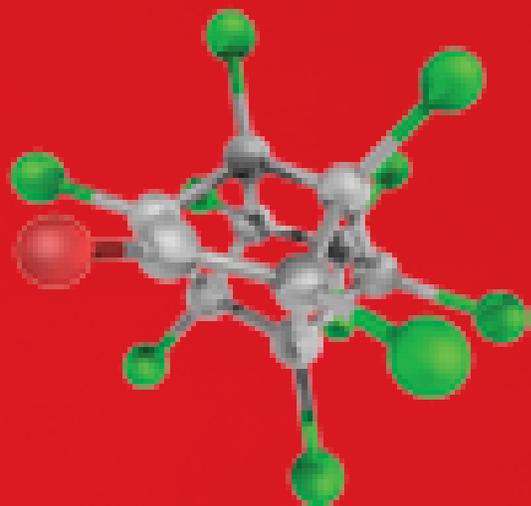
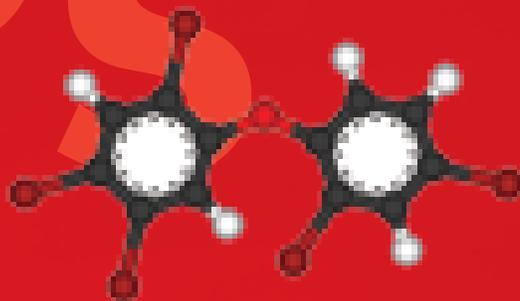
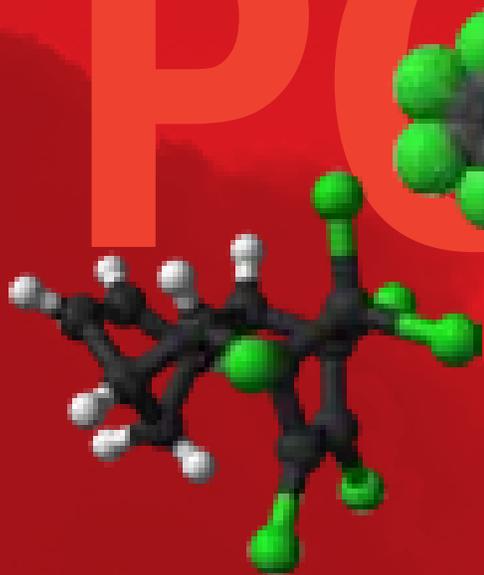
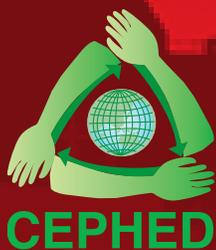
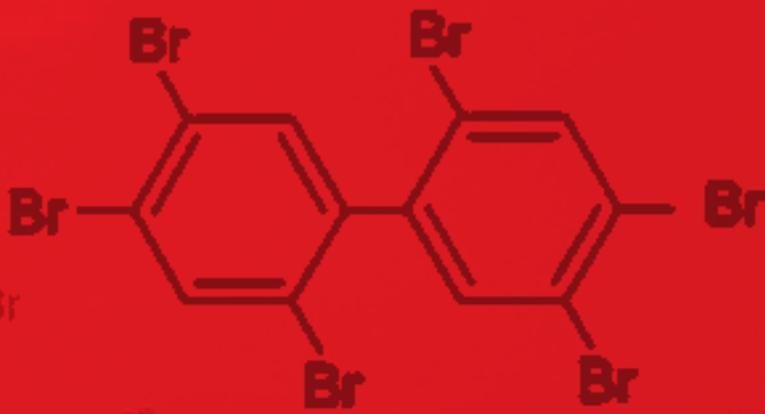
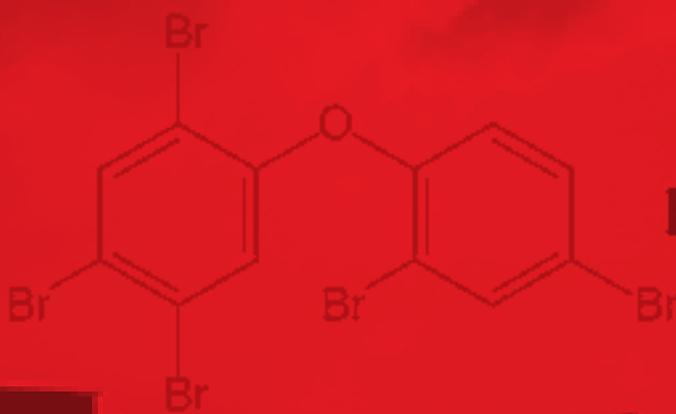


# POPs



## FACT SHEETS OF 22 PERSISTENT ORGANIC POLLUTANTS (POPs) UNDER STOCKHOLM CONVENTION



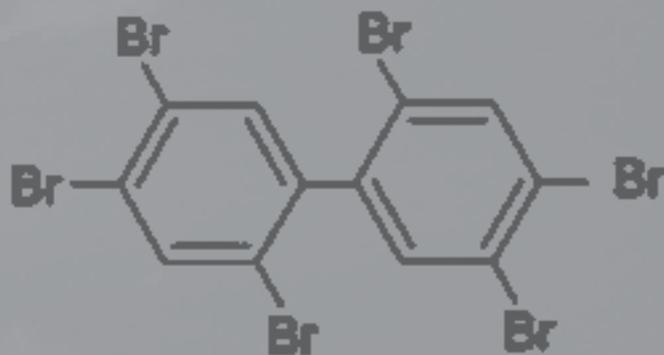
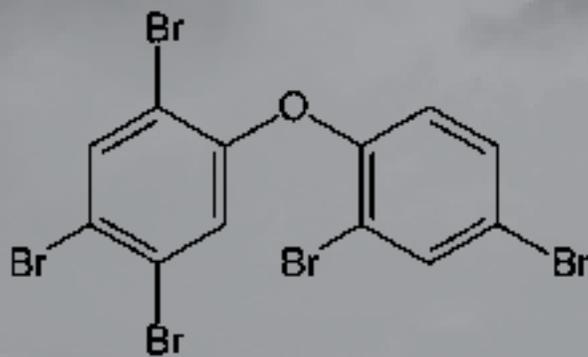
**SGP** The GEF  
Small Grants  
Programme





# POPs

## FACT SHEETS OF 22 PERSISTENT ORGANIC POLLUTANTS (POPs) UNDER STOCKHOLM CONVENTION



SGP The GEF  
Small Grants  
Programme



Authors &

Compilers Ram Charitra Sah  
Keshab Raj Joshi

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Date: 14<sup>th</sup> July 2011

Ref.

## MESSAGE

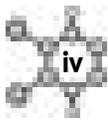
The Ministry of Environment has been engaged in carrying out several important programs towards addressing the issues of the Persistent Organic Pollutants (POPs). The Government of Nepal signed the Stockholm Convention on POPs in the year 2002 and also ratified it in the year 2007. Along with the ratification, Ministry of Environment as focal agency, has completed inventories on obsolete pesticides including POPs pesticides, PCB and Dioxin and Furan towards preparing its first National Implementation Plan (NIP) on POPs. NIP has been developed with some 10 prioritized action plans to be implemented.

It is our pleasure to share the good news with all of you about the implementation of the first three prioritized plan of actions, i.e. safe packaging, safe storage and disposal of obsolete pesticides lying in different parts of the county; remediation and site stabilization; manage stockpiles of PCBs and appropriate measures for handling and disposal of articles in use; identification of stockpiles of PCB contaminated articles in use and waste; ban on sell of PCB contaminated transformer oil; and public awareness raising, information & education about POPs. Towards this end, the Center for Public Health and Environmental Development (CEPHED) has been known to playing a very important role by implementing UNDP GEF Small Grants Programme (SGP) program on Public Awareness and Participation towards the elimination of POPs and its sources from Nepal especially about POPs with the main focus on three most important PCB, Dioxin and Furan.

CEPHED has been actively engaged in educating, capacity building and generating information along with their wide dissemination through all possible means of the print and electronic communication.

Towards this, the initiative taken by CEPHED to bring out the Fact Sheets of all 22 POPs so far listed under the convention in one single publication form is highly appreciable step and not only complement our Ministry of Environment's work but is also helpful towards making access to information about all POPs urgently required by all concerned.

In addition to the generation and exchange of information, the education and capacity building program carried out by CEPHED in the area of Health Care Waste and POPs, PCB and model hospital and Grill workshop developed etc. are most important steps towards curbing the emission of POPs is especially Dioxin and Furan and discouraging their sources from Nepal. Thus



it also helps us to realize the overall aim of the Stockholm Convention on POPs to protect human health and environment from POPs.

I appreciate the initiatives of the CEPHEd in the area of POPs towards generation and sharing of information as well as directly implementing the Best Available Techniques (BAT) and Best Environmental Practice (BEP) in the ground. We wish them all the very success and endeavor in the future.

Thank you !

Mrs Meena Khanal

Joint secretary and National Focal Point (Stockholm Convention on POPs)  
Ministry of Environment  
Singha Durbar, Kathmandu, Nepal



## MESSAGE

The 22 Persistent Organic Pollutants (POPs) listed so far under Stockholm Convention on POPs are notoriously toxic to human health. Exposure to POPs can lead serious health effects including certain cancers, birth defects, dysfunctional immune and reproductive systems, greater susceptibility to disease and even diminished intelligence. When these chemicals were synthesized in early days, due to their persistent nature, they were extensively used for the benefits of human kind. The persistent pesticides were boon to the farmers and general public. But later when the latent threats of these chemicals were understood, their persistence became the cause of peril to life forms.

From the classical example of DDT, one of the 22 POPs, one can easily understand why POPs are called so. Othmar Zeidler, a German chemist first synthesized DDT in 1873. Later in 1939, Paul Müller discovered its insecticidal properties. It was used with great success in the second half of World War II to control spread of malaria, typhus and other vector borne diseases. In 1984, he was awarded the Nobel Prize in Physiology and Medicine. In 1962, Rachel Carson, in her epic book- *Silent Spring* catalogued the environmental impacts of the indiscriminate spraying of DDT in the US and questioned the logic of releasing large amounts of chemicals into the environment without fully understanding their effects on ecology or human health. In 1998, first Intergovernmental Negotiation Committee for an International legally binding instrument for implementing action on certain persistent organic pollutants proposed banning DDT. In 2001, Stockholm Convention on POPs banned production and use of DDT with a temporary health-related exemption for use of DDT for malaria.

I would like to take this opportunity to thank Mr. Ram Charitra Sah and Mr. Keshab Raj Joshi for their hardwork in writing and compiling the Fact sheets on all POPs listed so far under Stockholm Convention. Likewise I would also like to thank Mr. Vivek Dhar Sharma and Mr. Brian Harding for thoroughly reviewing the book.

The compilation of fact sheets of 22 POPs consists of names including the trade names, structures, properties, their standard (permissible limit to human exposure), its persistence and its impact on public health and environment. Thus the fact sheets will be very helpful both to scientist and general public and will be a valuable reference to create awareness on POPs.

Gopal Raj Sherchan  
National Co-ordinator, GEF SGP Nepal UNDP



## FOREWORD

It gives us pleasure to publish this book entitled “Fact Sheets of 22 Persistent Organic Pollutants (POPs) under Stockholm Convention”. This is the outcome of CHPHED’s long continuous work in the sector of POPs. This publication is a single important document having all the updated information on Persistent Organic Pollutants (POPs), Stockholm Convention on POPs, lists of listed POPs under Stockholm Convention, list of all the Articles and their contents of Stockholm Convention Text and criteria as well as the process of enlisting a chemical under the Convention list. This document further mainly includes the fact sheets on all POPs enlisted under the convention. It has been prepared under the ongoing first project of POPs thematic area of the GEF SGP UNDP entitled “Public awareness and participation for elimination of POPs and its sources from Nepal” and introduces basic information on the 22 POPs Chemicals (Twelve + Nine + One) so far listed under the Stockholm Convention on POPs in a single publication form to fulfill the gap of the lack of consolidated reference materials about POPs.

These facts sheets have tried to include the updated information such as name, trade name, CAS number, structures, properties, impact on human health and environment, standard, persistency, alternatives, and country specific issues related to each and every POPs chemicals listed under the Stockholm Convention on Persistent Organic Pollutants.

This publication will be the first published detail reference material about all POPs enlisted under Stockholm Convention on POPs in Nepal. As all the facts including country specific issue of 22 POPs enlisted under Stockholm Convention have been presented in this book, this publication will be helpful for Ministry of Environment, Ministry of Health and Population, Ministry of Local Development, Ministry of Industry, Commerce and Supplies, Ministry of Agriculture and Cooperatives, Ministry of Energy including their concerned Departments of Nepal towards addressing the problems of POPs and their solutions. We are sure that this publication will also be an essential document for the faculties and students of science faculty mainly for the subjects like Chemistry, Environmental Science, Environment Management, Environment Engineering, Public health, and Medicine etc. We believe that this publication will be a breakthrough towards achieving the goal of Nepal’s National Implementation Plan (NIP) for Stockholm Convention on POPs.

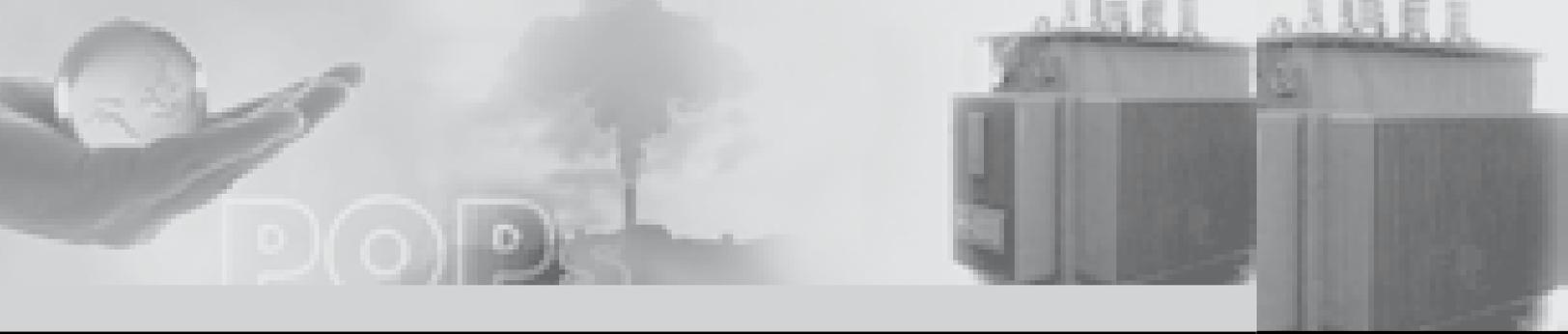
CEPHED would like to acknowledge all who have supported our initiatives to bring this publication in this form and especially to GEF SGP UNDP for its financial support to produce this important manuscript. We would like to thank for generous support of Mr. Keshab Raj Joshi, Ms. Sabina Silwal and Mr. Prakash Shahi.

CEPHED would also like to acknowledge IPEN, HCWH, CHE, ZMWG/EEB, Toxics Link, SSNC, GAIA and individual experts from all these networks for their technical support & cooperation to develop these fact sheets on all listed POPs under Stockholm Convention.

CEPHED always welcomes the feedbacks and suggestions towards improving the contents of the book in the days ahead as this is the first ever attempt to bring all these fact sheets in one single book form.

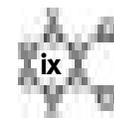
Thank You.

Mr. Ram Charitra Sah  
Executive Director/Environment Scientist  
CEPHED



# ABBREVIATIONS AND ACRONYMS

|                         |   |
|-------------------------|---|
| °C                      | A unit of temperature i.e. Degree Centigrade                          |
| °F                      | A unit of temperature i.e. Degree Fahrenheit                          |
| ABS                     | acrylonitrile-butadiene-styrene                                       |
| Alpha-HCH               | Alpha- hexachlorocyclohexane  |
| APP                     | ammonium polyphosphate  |
| atm-m <sup>3</sup> /mol | A unit of Henry's law constant  |
| BS                      | Bikram Sambat (Nepalese Calendar)                                     |
| Beta-HCH                | Beta- hexachlorocyclohexane   |
| CAS                     | Chemical Abstract Service   |
| CB                      | Chlorobenzenes  |
| CDD                     | Chlorinated Dibenzo-p-dioxins   |
| CERCLA                  | Comprehensive Environmental Response, Compensation, and Liability Act |
| c-octaBDE               | Commercial octabromodiphenyl ether                                    |
| COP                     | Conference of parties   |
| DDE                     | Dichlorodiphenyldichloroethylene                                      |
| DDT                     | Dichlorodiphenyltrichloroethane                                       |
| DHHS                    | Department of Health and Human Services                               |
| DWELs                   | Drinking Water Exposure Concentration Limits                          |
| EE                      | Electronic Equipment  |
| EHC                     | Environmental Health Criteria   |
| EPA                     | Environmental Protection Agency                                       |
| EU                      | European Union  |
| FDA                     | Food and Drug Administration  |
| g mol <sup>-1</sup>     | Unit of molecular mass  |
| g/cm <sup>3</sup>       | A unit of density i.e grams per cubic centimeter                      |
| g/ml                    | A unit of density   |
| g                       | A unit of mass in the SI system i.e.gram                              |
| HBB                     | Hexabromobiphenyl   |
| HCH                     | Hexachlorocyclohexane   |
| HCWH                    | Health Care Without Harm  |
| IARC                    | International Agency for Research on Cancer                           |



|               |   |
|---------------|---|
| IPEN          | International POPs Elimination Network                                  |
| IPM           | Integrated Pest Management  |
| IUPAC         | International Union of Pure and Applied Chemistry                       |
| K             | A Unit of temperature i.e Kelvin  |
| MCL           | Maximum Contaminant Level   |
| mg/L          | A unit of solubility in water i.e. milligrams per litre                 |
| mmHg          | A unit of pressure  |
| NIOSH         | National Institute for Occupational Safety and Health                   |
| octaBDE       | octabromodiphenyl ether   |
| OECD          | Organization for Economic Co-operation and Development                  |
| OSHA          | Occupational Safety and Health Administration                           |
| Pa            | SI derived unit of pressure i.e. Pascal                                 |
| PBBs          | Polybromobiphenyls  |
| PBDEs         | Polybrominated diphenyl ethers  |
| PCBs          | Polychlorinated biphenyls<br>(originally termed “chlorinated diphenyls) |
| PeCB          | Pentachlorobenzene  |
| pentaBDE      | Pentabromodiphenyl ether  |
| PFOS          | Perfluorooctane sulfonate or Perfluorooctanesulfonic acid               |
| PFOS-F        | Perfluorooctane sulfonyl fluoride                                       |
| pH            | Measuring unit of the acidity or basicity of an aqueous solution        |
| pKa           | Symbol of acid dissociation constant                                    |
| POPRC         | POPs Review Committee   |
| POPs          | Persistent Organic Pollutants   |
| ppb           | Parts per billion   |
| ppm           | Parts per million   |
| ppq           | Part per quadrillion  |
| ppt           | part per trillion   |
| PVC           | Polyvinyl chloride  |
| QSAR          | Quantitative Structure-Activity Relationships                           |
| REL           | Recommended Exposure Limit  |
| TCDD          | Tetrachlorodibenzodioxin  |
| TEQ           | Toxic Equivalent  |
| Torr          | Non-SI unit of pressure   |
| WHO           | World Health Organization   |
| $\alpha$ -HCH | alpha-Hexachlorocyclohexane   |
| $\beta$ -HCH  | Beta hexachlorocyclohexane  |
| $\mu$ g/L     | A unit of water solubility i.e micrograms per liter                     |
| ng/l          | A unit of water solubility i.e. nanograms per liter                     |



# CONTENTS

|  |      |
|--|------|
| Message  | iii  |
| Message  | v    |
| Foreword   | vi   |
| Abbreviations and Acronyms   | viii |
| <br>   |      |
| What are “POPs”?   | 1    |
| Aldrin   | 8    |
| Chlordane  | 12   |
| Dieldrin   | 15   |
| Endrin   | 19   |
| Heptachlor   | 22   |
| Mirex  | 25   |
| Toxaphene  | 28   |
| Hexachlorobenzene  | 31   |
| Polychlorinated biphenyls (PCBs)   | 35   |
| DDT  | 41   |
| Polychlorinated dibenzo-p-dioxins (PCDDs)  | 45   |
| Polychlorinated dibenzofurans (PCDFs)  | 50   |
| Alpha-Hexachlorocyclohexane  | 53   |
| Beta hexachlorocyclohexane   | 56   |
| Chlordecone  | 59   |
| Hexabromobiphenyl (HBB)  | 63   |
| Lindane  | 66   |
| Hexabromodiphenyl ether and Heptabromodiphenyl ether   | 70   |
| Tetrabromodiphenyl ether and Pentabromodiphenyl ether  | 74   |
| Pentachlorobenzene (PeCB)  | 78   |
| Perfluorooctane sulfonic acid (PFOS), its salts and perfluorooctane sulfonyl fluoride (PFOS-F) | 81   |
| Endosulfan   | 85   |
| <br>   |      |
| ANNEX  |      |
| Glossary   |      |
| References   |      |



## WHAT ARE “POPs”?

Persistent Organic Pollutants (POPs) are a group of compounds that possess toxic properties, resist degradation, bioaccumulate and are transported through air, water and migratory species, across international boundaries and deposited far from their place of release, where they accumulate in terrestrial and aquatic ecosystems (UNEP, 2009).

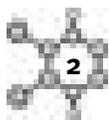
**Persistent organic pollutants have four key characteristics in common** (World Bank & CIDA, 2001):

**1.** Persistent organic pollutants are TOXIC, causing adverse health effects, such as birth defects, damage to immune and respiratory systems, and critical organs. Hormone system dysfunction associated with POPs includes damage to the reproductive system; sex-linked disorders, and shortened lactation periods for nursing mothers. As well, endocrine disruption can have developmental and carcinogenic effects.

Women, infants, and children appear to be especially vulnerable to certain effects of POPs. Evidence suggests that exposure of the fetus to even minute concentrations of some POPs (one tenth of one part per trillion or the equivalent to one second in 3,169 centuries) can cause adverse effects at critical junctures in development that persist later in the individual's life. These effects can include neurophysiological effects, such as attention deficits, learning disorders, behavioral problems (e.g. increased aggressivity) and poor gross and fine motor coordination.

Exposure to POPs can result in death in humans (including aborted fetuses) and wildlife.

**2.** POPs are ENVIRONMENTALLY PERSISTENT. They resist breakdown by natural processes, and, in some cases, remain in the environment for decades. Within the Stockholm Convention, persistence is determined by evidence of a half-life of the chemical in water greater than two months, or a half-life in soil greater than six months, or a half-life in sediment greater than six months.



3. POPs resist breakdown in water but they are soluble in fatty tissue, which makes them bio-available to mammals. They bio-accumulate exponentially up the food chain, reaching the greatest magnitudes in predatory birds, mammals and humans. In addition, these substances bio-concentrate under typical environmental conditions. **Bio-concentration** is the process by which animals absorb high concentrations of POPs directly from their environment, rather than from a combination of eating other animals and environmental exposure. For example, some POPs present in water have been observed to bio-concentrate in the fatty tissue of fish by factors of up to 70,000 times the concentrations of the same POP present in the water column.

4. POPs are semi-volatile and thus are capable of TRAVELLING GREAT DISTANCES through cycles of evaporation and atmospheric cycling and deposition (referred to as the “grasshopper effect”). Wind and water carry these chemicals great distances regionally and globally. POPs are volatile at warm temperatures and condense at cooler temperatures, reaching their highest concentrations in the cooler regions of the world (northern latitudes and high altitudes). POPs have been found on every continent on the planet, and in every major climatic zone, including the world’s most remote regions, such as the open ocean and deserts, and in every wildlife species and human being.

### **Stockholm Convention on Persistent Organic Pollutants (POPs)**

The Stockholm Convention on Persistent Organic Pollutants (POPs) is a global treaty to protect human health and the environment from chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have adverse effects to human health or to the environment. Exposure to Persistent Organic Pollutants (POPs) can lead serious health effects including certain cancers, birth defects, dysfunctional immune and reproductive systems, greater susceptibility to disease and even diminished intelligence. Given their long range transport, no one government acting alone can protect its citizens or its environment from POPs. In response to this global problem, the Stockholm Convention, which was adopted in 2001 (22<sup>nd</sup> May) and entered into force in 2004, 17<sup>th</sup> May), requires Parties to take measures to eliminate or reduce the release of POPs into the environment. The Convention is administered by the United Nations Environment Programme and is based in Geneva, Switzerland (<http://chm.pops.int/Convention/tabid/54/language/en-US/Default.aspx>).

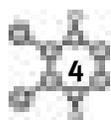
The objective of this Convention is to protect human health and the environment from persistent organic pollutants. The Convention was amended at the first meeting of the Conference of the Parties to add a new Annex G on arbitration and conciliation procedures. The Convention text was also amended in 2009 to include the nine new POPs added to its

Annexes A, B and C. The POPs convention text has 30 Articles and 7 Annexes (Table 1).

Nepal signed this convention on April 5, 2002 and has ratified on 6<sup>th</sup> March 2007 (<http://www.pops.int/reports/StatusOfRatifications.aspx>). Nepal has also submitted its National Implementation Plan (NIP) in 2007.

**Table 1 The Contents of the POPs Convention Text**

| <b>Article/Annex No.</b> | <b>Content of the Articles/Annexes</b>                                       |
|--------------------------|--|
| Article 1                | Objective  |
| Article 2                | Definitions  |
| Article 3                | Measures to reduce or eliminate releases from intentional production and use |
| Article 4                | Register of specific exemptions  |
| Article 5                | Measures to reduce or eliminate releases from unintentional production       |
| Article 6                | Measures to reduce or eliminate releases from stockpiles and wastes          |
| Article 7                | Implementation plans   |
| Article 8                | Listing of chemicals in Annexes A, B and C                                   |
| Article 9                | Information exchange   |
| Article 10               | Public information, awareness and education                                  |
| Article 11               | Research, development and monitoring   |
| Article 12               | Technical assistance   |
| Article 13               | Financial resources and mechanisms   |
| Article 14               | Interim financial arrangements   |
| Article 15               | Reporting  |
| Article 16               | Effectiveness evaluation   |
| Article 17               | Non-compliance   |
| Article 18               | Settlement of disputes   |
| Article 19               | Conference of the Parties  |
| Article 20               | Secretariat  |
| Article 21               | Amendments to the Convention   |
| Article 22               | Adoption and amendment of annexes  |
| Article 23               | Right to vote  |
| Article 24               | Signature  |
| Article 25               | Ratification, acceptance, approval or accession                              |
| Article 26               | Entry into force   |
| Article 27               | Reservations   |
| Article 28               | Withdrawal   |
| Article 29               | Depositary   |
| Article 30               | Authentic texts  |



| Article/Annex No.               | Content of the Articles/Annexes  |
|---------------------------------|--|
| Annex A                         | Elimination  |
|                                 | Part I Exemption Provision   |
|                                 | Part II Polychlorinated biphenyls (PCBs)   |
|                                 | Part III Definitions   |
|                                 | Part IV Hexabromodiphenyl ether and heptabromodiphenyl ether   |
| Annex B                         | Part V Tetrabromodiphenyl ether and Pentabromodiphenyl ether   |
|                                 | Part I Restriction   |
|                                 | Part II DDT (1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane)  |
| Annex C                         | Part III Perfluorooctane sulfonic acid, its salts, and perfluorooctane sulfonyl fluoride                   |
|                                 | Unintentional Production   |
|                                 | Part I: Persistent organic pollutants subject to the requirements of Article 5                             |
|                                 | Part II: Source categories   |
|                                 | Part III: Source categories  |
|                                 | Part IV: Definitions   |
|                                 | Part V: General guidance on best available techniques and best environmental practices                     |
|                                 | A. General prevention measures relating to both best available techniques and best environmental practices |
| B. Best available techniques    |  |
| C. Best environmental practices |  |
| Annex D                         | Information Requirements and Screening Criteria  |
| Annex E                         | Information Requirements for the Risk Profile  |
| Annex F                         | Information on Socio-Economic Considerations   |
| Annex G                         | Arbitration and Conciliation Procedures for Settlement of Disputes   |
|                                 | Part I: Arbitration procedure  |
|                                 | Part II: Conciliation procedure  |

## Listing of the chemicals on annexes of the convention text

Chemicals recognized as persistent with greater bioaccumulation or bio-concentration factor having potential for long-range environmental transport causing the adverse effects on human health or to the environment are listed on the convention text as per the Convention. Listing of the Chemicals under the POPs convention is in accordance with the procedure in **Article 8** (Listing of chemicals in Annexes A, B and C) of the Convention. Information Requirements and Screening Criteria for enlisting POPs are in Annex D of Convention Text. The chemicals targeted by the Stockholm Convention are listed in the annexes of the convention text:

### **Initial 12 POPs**

Initially, twelve POPs have been recognized as causing adverse effects on humans and the ecosystem and these can be placed in 3 categories:

- ▶ **Pesticides:** aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, hexachlorobenzene, mirex, toxaphene;
- ▶ **Industrial chemicals:** hexachlorobenzene, polychlorinated biphenyls (PCBs); and
- ▶ **By-products:** hexachlorobenzene; polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDD/PCDF), and PCBs.

These initial 12 POPs are popularly termed as Dirty Dozen (Table 2).

### **Nine new POPs**

At its fourth meeting held from 4 to 8 May 2009, the Conference of the Parties (COP), by decisions SC-4/10 to SC-4/18, adopted amendments to Annexes A (elimination), B (restriction) and C (unintentional production) of the Stockholm Convention to list nine additional chemicals as persistent organic pollutants (<http://www.unido.org/index.php?id=1001116>). The entry into Force of the Amendments adding Nine Chemicals to the Stockholm Convention on Persistent Organic Pollutants took place on 26 August 2010 for 151 of the 152 Parties to the Stockholm Convention.

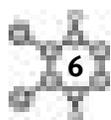
- ▶ **Pesticides:** chlordecone, alpha hexachlorocyclohexane, beta hexachlorocyclohexane, lindane, pentachlorobenzene;
- ▶ **Industrial chemicals:** hexabromobiphenyl, hexabromodiphenyl ether and heptabromodiphenyl ether, pentachlorobenzene, perfluorooctane sulfonic acid, its salts and perfluorooctane sulfonyl fluoride, tetrabromodiphenyl ether and pentabromodiphenyl ether; and
- ▶ **By-products:** alpha hexachlorocyclohexane, beta hexachlorocyclohexane and pentachlorobenzene.

These Nine new POPs are popularly termed as Nasty Nine (Table 3).

### **22<sup>nd</sup> Candidate**

The fifth conference of Parties of the Stockholm Convention on POPs held in Geneva from April 25-29, 2011 has decided to add 22<sup>nd</sup> Candidate “Endosulfan” under POPs list (Table 4).

Convention has categorized the chemicals into **three Annexes** based on the action to be taken in order to reduce and ultimately eliminate these chemicals and its sources from the mother earth.



**Annex A** (Elimination):

Parties must take measures to **eliminate** the production and use 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** (Restriction):

Parties must take measures to **restrict** the production and use of the chemicals listed under Annex B in light of any applicable acceptable purposes and/or specific exemptions listed in the Annex.

**Annex C** (Unintentional production):

Parties must take measures to reduce the **unintentional releases** of chemicals listed under Annex C with the goal of continuing minimization and, where feasible, ultimate elimination.

**Table 2**    **Old Dirty Dozen POPs**

| <b>Chemicals</b>                              | <b>Annex</b> | <b>Pesticides</b> | <b>Industrial Chemicals</b> | <b>By-Products</b> |
|---|--------------|-------------------|-----------------------------|--------------------|
| 1. Aldrin                                     | A            | +                 |                             |                    |
| 2. Chlordane                                  | A            | +                 |                             |                    |
| 3. Dieldrin                                   | A            | +                 |                             |                    |
| 4. Endrin                                     | A            | +                 |                             |                    |
| 5. Heptachlor                                 | A            | +                 |                             |                    |
| 6. Mirex                                      | A            | +                 |                             |                    |
| 7. Toxaphene                                  | A            | +                 |                             |                    |
| 8. Hexachlorobenzene                          | A, C         | +                 | +                           | +                  |
| 9. PCBs                                       | A, C         |                   | +                           | +                  |
| 10. DDT                                       | B            | +                 |                             |                    |
| 11. Polychlorinated dibenzo-p-dioxins (PCDDs) | C            |                   |                             | +                  |
| 12. Polychlorinated dibenzofurans (PCDFs)     | C            |                   |                             | +                  |

**Table 3** New Nasty Nine POPs

| Chemicals   | Annex | Pesticides | Industrial Chemicals | By-Products |
|---|-------|------------|----------------------|-------------|
| 13. Alpha hexachlorocyclohexane (Alpha HCH)   | A     | +          |                      | +           |
| 14. Beta hexachlorocyclohexane (Beta HCH)   | A     | +          |                      | +           |
| 15. Chlordecone   | A     | +          |                      |             |
| 16. Hexabromobiphenyl (HBB)*  | A     |            | +                    |             |
| 17. Lindane **  | A     | +          |                      |             |
| 18. Hexabromodiphenyl ether and Heptabromodiphenyl ether (Commercial Octabromodiphenyl Ether-OctaBDE)*    | A     |            | +                    |             |
| 19. Tetrabromodiphenyl ether and pentabromodiphenyl ether (Commercial Pentabromodiphenyl ether PentaBDE)* | A     |            | +                    |             |
| 20. Pentachlorobenzene (PeCB)   | A, C  | +          | +                    | +           |
| 21. Perfluorooctane sulfonic acid, its salts and perfluorooctane sulfonyl fluoride                        | B     |            | +                    |             |

\* Flame Retardants

\*\* Nepal has asked for exemption for Lindane for pharmaceutical use and harmonizes the related regulations.

**Table 4** Twenty-second POP

| Chemical       | Annex | Pesticides | Industrial Chemicals | By-Products |
|----------------|-------|------------|----------------------|-------------|
| 22. Endosulfan | A     | +          |                      |             |

The details of each POPs chemicals can be found in following section. These facts sheets have tried to include the updated information such as name, trade name, CAS number, structures, properties, impact on human health and environment, standard, persistency, alternatives, and country specific issues related to each and every POPs enlisted under the Stockholm Convention on Persistent Organic Pollutants.

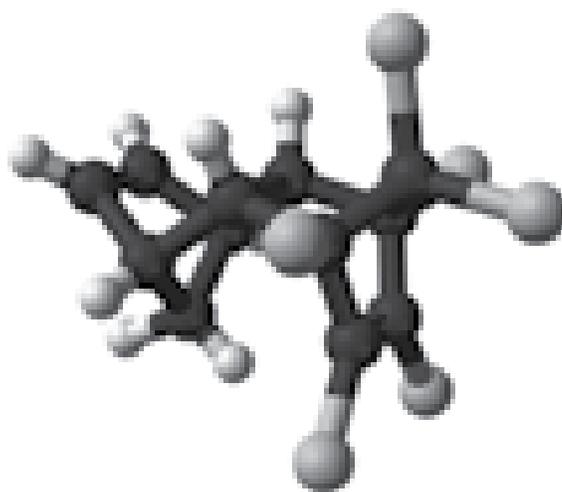
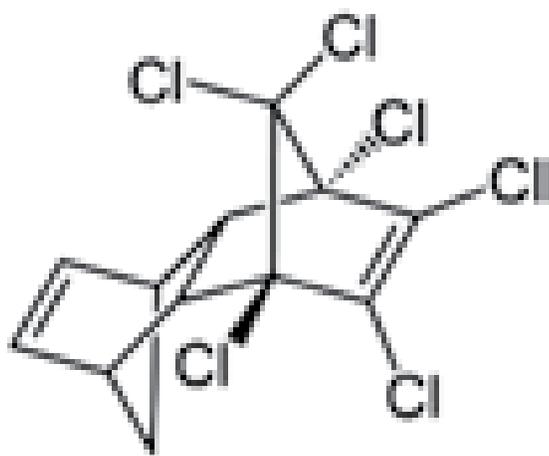
# ALDRIN

Aldrin is an organochlorine insecticide, used to control soil insects such as termites, corn rootworm, wireworms, rice water weevil, and grasshoppers etc. It was widely used until the 1970s, when it was banned in most countries. Before the ban, it was heavily used as a pesticide to treat seed and soil (<http://en.wikipedia.org/wiki/Aldrin>). Once released to the environment, it persists longer, bioaccumulates and adversely affects environment and human health.

|                                 |  |
|---------------------------------|--|
| <b>A. Name</b>                  | Aldrin   |
| <b>Synonyms and Trade Names</b> | Aldrec, Aldrex, Aldrex 30, Aldrite, Aldrosol, Altox, Compound 118, Drinox, Octalene, Seedrin |
| <b>IUPAC Name</b>               | 1,2,3,4,10,10-Hexachloro-1,4,4a,5,8,8a-hexahydro-1,4:5,8-dimethanonaphthalene                |

**B. CAS Number** 309-00-2

## C. Structure



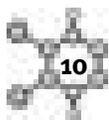
## D. Properties

|                                      |   |
|--------------------------------------|---|
| <b>Molecular formula</b>             | C <sub>12</sub> H <sub>8</sub> Cl <sub>6</sub>  |
| <b>Molar mass</b>                    | 364.91 g mol <sup>-1</sup>  |
| <b>Melting point</b>                 | 104°C   |
| <b>Boiling Point</b>                 | 145°C at 2 mm Hg  |
| <b>Vapor pressure</b>                | 7.5 × 10 <sup>-5</sup> mmHg @ 20°C  |
| <b>Appearance</b>                    | White, odourless crystals when pure; technical grades are tan to dark brown with a mild chemical odour. |
| <b>Physical state</b>                | Crystalline solid   |
| <b>Odor</b>                          | Mild chemical odor  |
| <b>Solubility water at 20 °C</b>     | 0.011 mg/L  |
| <b>organic solvents</b>              | Very soluble in most organic solvents   |
| <b>Vapor pressure at 20 °C</b>       | 7.5×10 <sup>-5</sup> mmHg   |
| <b>at 25 °C</b>                      | 1.2×10 <sup>-4</sup> mmHg   |
| <b>Flammability limits</b>           | Nonflammable  |
| <b>Explosive limits</b>              | Stable  |
| <b>Henry's law constant at 25 °C</b> | 4.9×10 <sup>-5</sup> atm·m <sup>3</sup> /mol  |
| <b>Color</b>                         | White (pure); tan to brown (technical grade)  |

## E. Impact on human health and environment

### *Environmental impact*

Aldrin residues are rarely found in foods and animals as it is readily metabolized to dieldrin by both plants and animals. Sunlight and bacteria in the environment can change aldrin to dieldrin. It binds strongly to soil particles and is very resistant to leaching into groundwater. Due to its persistent nature and hydrophobicity, Aldrin is known to bioconcentrate, mainly as its conversion products. Aldrin has low phytotoxicity with plants and is highly lipophilic. The toxicity of Aldrin to aquatic organisms is quite variable, with aquatic insects being the most sensitive group of invertebrates. Reproductive effects in rats have been observed when pregnant females were dosed with Aldrin subcutaneously. Residues of Aldrin have been detected in fish in Egypt. Aldrin treated rice is thought to have been the cause of deaths in waterfowl, shorebirds and passerines along the Texas Gulf Coast, both by direct poisoning by ingestion of Aldrin treated rice and indirectly by consuming organisms contaminated with Aldrin. Residues of Aldrin have been detected in samples of bird casualties, eggs, scavengers, predators, fish, frogs, invertebrates and soil ([http://www.chem.unep.ch/termites/POPTermiticides\\_Aldrin.html](http://www.chem.unep.ch/termites/POPTermiticides_Aldrin.html)).



### **Human health effects**

Dairy products, such as milk and butter, and animal meats are the primary sources of exposure of Aldrin. Aldrin is toxic to humans and signs and symptoms of Aldrin intoxication may include headache, dizziness, nausea, general malaise and vomiting, followed by muscle twitching, myoclonic jerks, and convulsions. Occupational exposure to Aldrin, in conjunction with Dieldrin and Endrin, is associated with a significant increase in liver and biliary cancer. There is limited information that Aldrin, may affect immune responses. There is, as yet, no evidence of a teratogenic potential for Aldrin. The International Agency for Research on Cancer (IARC) has concluded that there is inadequate evidence for the carcinogenicity of Aldrin in humans. Aldrin is therefore not classifiable as to its carcinogenicity in humans (IARC, Group 3) (<http://www.popstoolkit.com/about/chemical/aldrin.aspx>).

In a study of workers from a plant involved in the manufacture of Aldrin, a statistically significant increase in liver and biliary tract cancers was observed, although the study did have some limitations, including lack of quantitative exposure information (<http://www.popstoolkit.com/about/chemical/endrin.aspx>).

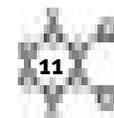
### **F. Standard**

US EPA advises lifetime drinking water exposure concentration limits (DWELs) for Aldrin of 0.001 for protection against adverse non-cancer health effects, which assume all of the exposure to the contaminant is from drinking water. Regarding cancer risk, EPA advises a lower drinking water exposure concentration limit of 0.0002 mg/L for Aldrin that would, in theory, limit the lifetime risk for developing cancer from exposure to each compound to 1 in 10,000.

The US FDA regulates the residues of Aldrin in raw foods. The allowable range for residues is from 0 to 0.1 ppm depending on the type of food product.

EPA has named Aldrin as hazardous solid waste materials. If quantities greater than 1 pound enter the environment, the National Response Center of the federal government must be told immediately.

US OSHA recommended a maximum average amount of Aldrin in the air in the workplace to protect workers. This amount is 250 micrograms in a cubic meter of air ( $\mu\text{g}/\text{m}^3$ ) for an 8-hour workday over a 40-hour workweek. US NIOSH recommended the limit ( $250 \mu\text{g}/\text{m}^3$ ) for up to a 10-hour workday over a 40-hour workweek ([http://www.eoearth.org/article/Public\\_Health\\_Statement\\_for\\_Aldrin/Dieldrin](http://www.eoearth.org/article/Public_Health_Statement_for_Aldrin/Dieldrin)).



## **G. Persistence**

Aldrin was classified as moderately persistent meaning its half-life in soil ranged from 20-100 days (<http://www.speclab.com/compound/c309002.htm>). The half-life for the reaction of vapor phase aldrin with photochemically generated hydroxyl radicals in the atmosphere was estimated to be 35 min (<http://www.speclab.com/compound/c309002.htm>).

## **H. Alternative**

Alternatives have been tabulated in Annex table.

## **I. Country specific issue**

Aldrin pesticide has been banned in Nepal. 22.5 tonnes of mixed Aldrin and HCB were reported from Nepal (UNEP, 2002c in Jones, 2005).

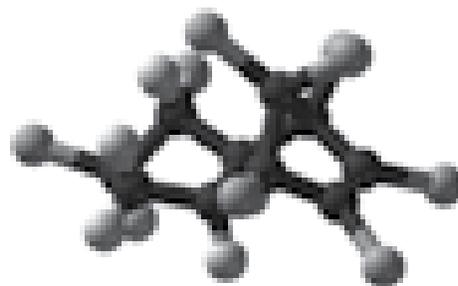
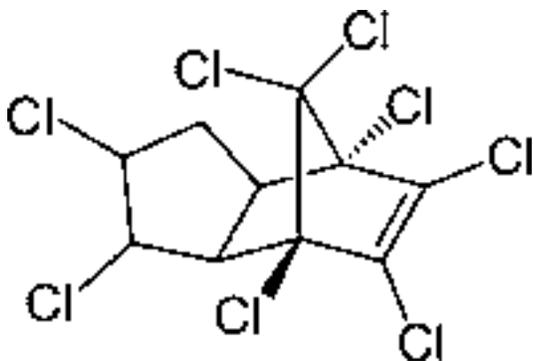
# CHLORDANE

Chlordane was a synthetic chemical, commonly used during 1948-1988, on corn and citrus crops as a pesticide, as well as a method of termite control (<http://en.wikipedia.org/wiki/Chlordane>). It was also used as an insecticide on lawns and domestic gardens, on agricultural crops including vegetables, small grains, maize, other oilseeds, potatoes, sugarcane, sugar beets, fruits, nuts, cotton (<http://www.popstoolkit.com/about/chemical/chlordane.aspx>). Once released to the environment, it persists longer, bioaccumulates and adversely affects environment and human health.

|                                 |   |
|---------------------------------|---|
| <b>A. Name</b>                  | Chlordane (or chlordan)   |
| <b>Synonyms and Trade Names</b> | Aspon, Belt, Chloriandin, Chlorkil, Chlordane, Corodan, Cortilan-neu, Dowchlor, HCS 3260, Kypchlor, M140, Niran, Octachlor, Octaterr, Ortho-Klor, Synklor, Tat chlor 4, Topichlor, Toxichlor, Veliscol-1068 |
| <b>IUPAC Name</b>               | Octachloro-4, 7-methanohydroindane  |

**B. CAS Number** 57-47-9

## C. Structure



## D. Properties

|                          |  |
|--------------------------|--|
| <b>Molecular formula</b> | C <sub>10</sub> H <sub>6</sub> Cl <sub>8</sub>   |
| <b>Molar mass</b>        | 409.779 g/mol  |
| <b>Density</b>           | 1.60 g/cm <sup>3</sup>   |
| <b>Melting point</b>     | 106°C  |
| <b>Boiling point</b>     | 175°C at 1 mmHg  |
| <b>Appearance</b>        | Colourless to yellowish-brown viscous liquid with an aromatic, pungent odour similar to chlorine |
| <b>Solubility</b>        | Highly insoluble in water<br>Soluble in organic solvents   |
| <b>Stability</b>         | High stability   |
| <b>Volatility</b>        | Semi-volatility  |

It is an organochlorine compound.

## E. Impact on human health and environment

### **Environmental impact**

It is semi-volatile and can be expected to partition into the atmosphere as a result. It binds readily to aquatic sediments and bio-concentrates in the fat of organisms. Being hydrophobic, chlordane adheres to soil particles and enters groundwater only slowly owing to its low solubility. It degrades only over the course of years. Chlordane bio-accumulates in animals. The acute toxicity of Chlordane to aquatic organisms is quite variable. It is highly toxic to fish.

The chemical properties of Chlordane (low water solubility, high stability, and semi-volatility) favor its long range transport, and Chlordane has been detected in Arctic air, water and organisms (<http://www.popstoolkit.com/about/chemical/chlordane.aspx>).

### **Human health effects**

Exposure to chlordane metabolites may be associated with testicular cancer. Japanese workers who used chlordane over a long period of time had minor changes in liver function. In a survey of 1105 workers associated with pest control, most of whom used Chlordane, however, only three attributed illness to it (mild dizziness, headache, weakness). Chlordane exposure has not been associated with increased risk of mortality from cancer. Significant changes in the immune system were reported in individuals who complained of health effects which they associated with Chlordane exposure. IARC has classified chlordane as a possible human carcinogen (Group 2B) (<http://www.popstoolkit.com/about/chemical/chlordane.aspx>).



## F. Standard

The US EPA guidelines for drinking water suggest that no more than 60 ppb chlordane should be present in drinking water that children consume for no longer than 10 days. Drinking water should contain no more than 0.5 ppb for children or 2 ppb for adults if they drink the water for longer periods.

The US Food and Drug Administration (US FDA) has established that the levels of chlordane and its breakdown products in most fruits and vegetables should not be greater than 300 ppb and in animal fat and fish should not be greater than 100 ppb.

US Federal regulations limit the amount of chlordane that factories can release into waste water. The EPA requires industry to report releases or spills of 1 pound or more. A temporary guideline of the National Research Council indicated that 0.005 mg/m<sup>3</sup> should be the maximum amount allowed in the air of military housing.

The Occupational Safety and Health Administration (OSHA) of USA regulate chlordane levels in the workplace. The maximum allowable level in workplace air is 0.5 mg/m<sup>3</sup> for a person who is exposed for 8 hours per workday and 40 hours per workweek. The National Institute for Occupational Health and Safety (NIOSH) of USA also recommends an exposure limit of 5 mg/m<sup>3</sup> for a person exposed to chlordane in the workplace for 8 hours per workday and 40 hours per workweek ([http://www.eoearth.org/article/Public\\_Health\\_Statement\\_for\\_Chlordane](http://www.eoearth.org/article/Public_Health_Statement_for_Chlordane)).

## G. Persistence

The half-life in soil has been reported to be approximately one year (<http://www.popstoolkit.com/about/chemical/chlordane.aspx>). In soils, chlordane is very persistent. Its soil half-life is 4 years, and it may persist in soils for as long as 20 years (<http://pmep.cce.cornell.edu/profiles/extoxnet/carbaryl-dicrotophos/chlordane-ext.html>).

## H. Alternative

Alternative can be seen in the Annex table.

## I. Country specific issue

Chlordane has been banned in Nepal.

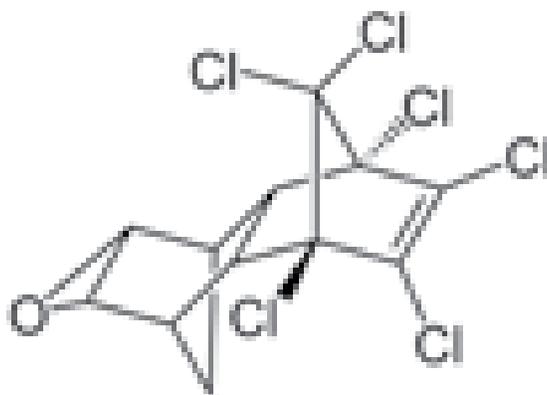
# DIELDRIN

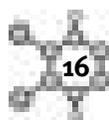
Dieldrin is a chlorinated hydrocarbon originally produced in 1948 as an insecticide. It is used principally to control termites and textiles pest and is also used to control insect-borne diseases and insects living in agricultural soils. Dieldrin is closely related to aldrin, which reacts further to form dieldrin. Sunlight and bacteria in the environment can change aldrin to dieldrin. Therefore, we can find dieldrin in places where aldrin was originally released. Originally developed in the 1940s as an alternative to DDT, dieldrin proved to be a highly effective insecticide and was very widely used during the 1950s to early 1970s. However, it is an extremely persistent organic pollutant. For this reason it is now banned in most of the world (<http://en.wikipedia.org/wiki/Dieldrin>). Once released to the environment, it persists longer, bioaccumulates and adversely affects environment and human health.

|                                 |   |
|---------------------------------|---|
| <b>A. Name</b>                  | Dieldrin  |
| <b>Synonyms and Trade Names</b> | Alvit, Dielprite, Dielatrix, Illoxol, Panoram D-31, Quintox, Octalox, Red Shield  |
| <b>IUPAC Name</b>               | (1aR,2R,2aS,3S,6R,6aR,7S,7aS)-3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a,7,7a-octahydro-2,7:3,6-dimethanonaphtho[2,3-b]oxirene |

**B. CAS Number** 60-57-1

## C. Structure





## D. Properties

|  |   |
|--|---|
| <b>Molecular formula</b>                             | $C_{12}H_8Cl_6O$  |
| <b>Molar mass</b>                                    | 380.91 g mol <sup>-1</sup>  |
| <b>Density</b>                                       | 1.75 g/cm <sup>3</sup>  |
| <b>Melting point</b>                                 | 176-177°C   |
| <b>Boiling point</b>                                 | 385°C   |
| <b>Appearance</b>                                    | A stereo-isomer of endrin, Dieldrin may be present as white crystals or pale tan flakes, odourless to mild chemical odour |
| <b>Physical state</b>                                | Crystalline solid   |
| <b>Odor</b>  | Mild chemical odor  |
| <b>Solubility water at 20°C<br/>organic solvents</b> | 0.110 mg/L<br>Moderately soluble in common organic solvents except aliphatic petroleum solvents and methyl alcohol        |
| <b>Vapor pressure at 20°C<br/>at 25°C</b>            | 3.1x10 <sup>-6</sup> mmHg<br>5.89x10 <sup>-6</sup> mmHg   |
| <b>Flammability limits</b>                           | Nonflammable  |
| <b>Explosive limits</b>                              | Stable  |
| <b>Henry's law constant at<br/>25°C</b>              | 5.2x10 <sup>-6</sup> atm-m <sup>3</sup> /mol  |
| <b>Color</b>   | White (pure); light brown (technical grade)   |

## E. Impact on human health and environment

### *Environmental impact*

It is an extremely persistent organic pollutant, It does not easily break down. Furthermore it tends to bio-magnify as it is passed along the food chain. Long-term exposure has proven toxic to a very wide range of animals including humans, far greater than to the original insect targets. Dieldrin residues have been detected in air, water, soil, fish, birds and mammals.

As with other organochlorine compounds, the liver is the major target organ in rats, with effects that included increased liver/body weight ratio, hypertrophy and histopathological changes. When rats were fed Dieldrin in their diet over three generations, no changes in reproductive capacity were observed at any dose level tested. There was no evidence for teratogenic potential in studies in rats, mice or rabbits using oral doses of up to 6 mg/kg body weight. Abnormal development and fetotoxicity were observed in hamsters and mice. There is limited evidence that cyclodienes such as Dieldrin may affect immune responses.

Dieldrin has low phytotoxicity. The acute toxicity of Dieldrin is quite variable for aquatic invertebrates, with insects being the most sensitive group (<http://www.pops.int/documents/meetings/inc1/RITTER-En.html>). It is highly toxic to most species of fish tested in the laboratory. The acute toxicity of Dieldrin to avian species varies widely.

This persistence, combined with high lipid solubility, provides the necessary conditions for Dieldrin to bio-concentrate and bio-magnify in organisms. Dieldrin's chemical properties (low water solubility, high stability, and semi-volatility) favor its long range transport, and Dieldrin has been detected in Arctic air, water and organisms (<http://www.popstoolkit.com/about/chemical/dieldrin.aspx>).

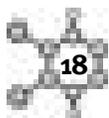
Dieldrin in soil or water breaks down (degrades) very slowly. Dieldrin sticks to soil and may stay there unchanged for many years. Water does not easily wash Dieldrin off soil. Dieldrin does not dissolve in water very well and is therefore not found in water at high concentrations. Most Dieldrin in the environment attaches to soil and to sediments at the bottoms of lakes, ponds, and streams. Dieldrin can travel large distances by attaching to dust particles, which can then be transported great distances by the wind. Dieldrin can evaporate slowly from surface water or soil. In the air, Dieldrin changes to photodieldrin within a few days. Plants can take up Dieldrin from the soil and store it in their leaves and roots. Fish or animals that eat Dieldrin-contaminated materials store a large amount of the Dieldrin in their fat. Animals or fish that eat other animals have levels of Dieldrin in their fat many times higher than animals or fish that eat plants ([http://www.eoearth.org/article/Public\\_Health\\_Statement\\_for\\_Aldrin/Dieldrin](http://www.eoearth.org/article/Public_Health_Statement_for_Aldrin/Dieldrin)).

### **Human health effects**

Dieldrin residues have been detected in humans and human breast milk. Long-term exposure has proven toxic to humans. It has been linked to health problems such as Parkinson's, Breast Cancer, and immune, reproductive, and nervous system damage. It can also adversely affect testicular descent in the fetus if a pregnant woman is exposed to Dieldrin. In a study of workers from a plant involved in the manufacture of Dieldrin, a statistically significant increase in liver and biliary tract cancers was observed. IARC has concluded that there is inadequate evidence of the carcinogenicity of Dieldrin in humans and has been classified by IARC in Group 3 (<http://www.popstoolkit.com/about/chemical/dieldrin.aspx>).

## **F. Standard**

US EPA advises lifetime drinking water exposure concentration limits (DWELs) for Dieldrin of 0.002 mg/L for protection against adverse noncancer health effects, that assume all of the exposure to the contaminant is from drinking water. Regarding cancer risk, EPA advises a lower drinking water exposure concentration limit of 0.0002 mg/L for Dieldrin that would, in



theory, limit the lifetime risk for developing cancer from exposure to each compound to 1 in 10,000.

The US FDA regulates the residues of Dieldrin in raw foods. The allowable range for residues is from 0 to 0.1 ppm depending on the type of food product.

EPA has named Dieldrin as hazardous solid waste materials. If quantities greater than 1 pound enter the environment, the National Response Center of the federal government must be told immediately.

US OSHA recommended a maximum average amount of Dieldrin in the air in the workplace to protect workers. This amount is 250 micrograms in a cubic meter of air ( $\mu\text{g}/\text{m}^3$ ) for an 8-hour workday over a 40-hour workweek. US NIOSH recommended the limit ( $250 \mu\text{g}/\text{m}^3$ ) for up to a 10-hour workday over a 40-hour workweek ([http://www.eoearth.org/article/Public\\_Health\\_Statement\\_for\\_Aldrin/Dieldrin](http://www.eoearth.org/article/Public_Health_Statement_for_Aldrin/Dieldrin)).

## **G. Persistence**

The half life in temperate soils is approximately 5 years (<http://www.popstoolkit.com/about/chemical/dieldrin.aspx>).

## **H. Alternative**

Alternatives can be seen at the Annex table.

## **I. Country specific issue**

Dieldrin has been banned in Nepal.

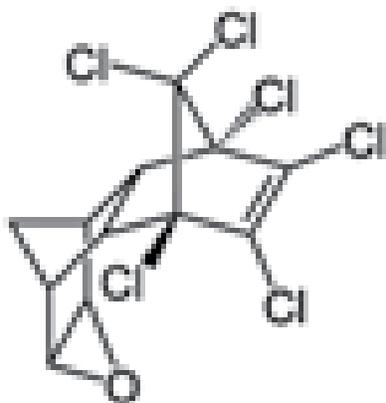
# ENDRIN

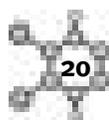
Endrin is an organochloride that was primarily used as an insecticide. This insecticide is sprayed on the leaves of crops such as cotton and grains and to some extent on sugar cane. It is also used as a rodenticide to control mice, voles, and other rodents. The majority of endrin (about 80%) was consumed as a spray to control insect pests of cotton. It was also used on rice, to some extent on sugar cane, in a limited way on grain crops and sugar beets, and in Australia on tobacco and cole crops. It was occasionally used in orchards as a control of rodents, where it is sprayed on the ground under the trees in autumn or spring, often as a solution in mineral oil. As a seed treatment, it was used for cotton seed in the United States, and for beans seeds in Australia (<http://en.wikipedia.org/wiki/Endrin>). This compound became infamous as persistent organic pollutant and for this reason is banned in many countries. Once released to the environment, it persists longer, bioaccumulates and adversely affects environment and human health.

|  |   |
|--|---|
| <b>A. Name</b>                                 | Endrin  |
| <b>Synonyms and Trade Names (partial list)</b> | Compound 269, Endrex, Hexadrin, Isodrin Epoxide, Mendrin, Nendrin.  |
| <b>IUPAC Name</b>                              | (1aR,2S,2aS,3S,6R,6aR,7R,7aS)-3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a,7,7a-octahydro-2,7:3,6-dimethanonaphtho[2,3-b]oxirene |

**B. CAS Number** 72-20-8

**C. Structure**





## D. Properties

|  |   |
|--|---|
| <b>Molecular formula</b>                         | C <sub>12</sub> H <sub>8</sub> Cl <sub>6</sub> O  |
| <b>Molar mass</b>                                | 380.91 g mol <sup>-1</sup>  |
| <b>Melting point</b>                             | 226-230°C (above 200°C decomposition)   |
| <b>Appearance</b>                                | White, odourless, crystalline solid when pure; light tan colour with faint chemical odour for technical grade   |
| <b>Flash-point</b>                               | None  |
| <b>Explosion limits</b>                          | Stable  |
| <b>Vapour pressure at 25°C</b>                   | 2.7 x 10 <sup>-7</sup> mmHg   |
| <b>at 25°C</b>                                   | 3.6 x 10 <sup>-5</sup> Pa   |
| <b>Relative molecular mass</b>                   | 380.9   |
| <b>Density</b>                                   | 1.64 g/ml at 20°C   |
| <b>Solubility in water</b>                       | Practically insoluble   |
| <b>Solubility in organic</b>                     | Sparingly soluble in alcohols, petroleum  |
| <b>Solvents</b>                                  | hydrocarbons, moderately soluble in aliphatic hydrocarbons, and quite soluble in solvents, such as acetone, benzene, carbon tetrachloride, and xylene |
| <b>Partition coefficient log P octanol/water</b> | 5.34  |

## E. Impact on human health and environment

### *Environmental impact*

Like related organochlorine pesticides, it is lipophilic. Thus, it tends to accumulate in fatty tissues of organisms living in water (<http://en.wikipedia.org/wiki/Endrin>). It is very toxic to aquatic organisms, namely fish, aquatic invertebrates, and phytoplankton. It can enter the atmosphere by volatilization, and can contaminate surface water from soil run-off.

### *Human health effects*

Acute Endrin, poisoning in humans affects primarily the nervous system. Food contaminated with Endrin, caused several clusters of poisonings worldwide, especially affecting children. In a study of workers from a plant involved in the manufacture of Endrin, a statistically significant increase in liver and biliary tract cancers was observed.

It may cause poisoning in contact with skin and cause irritation to eyes. Dusts and mist may cause poisoning by inhalation and accidental or intentional ingestion may cause poisoning.

IARC has concluded that there is inadequate evidence for the carcinogenicity of Endrin in humans. Endrin is therefore not classifiable as to its carcinogenicity in humans (Group 3) (<http://www.popstoolkit.com/about/chemical/endrln.aspx>).

## F. Standard

EPA has set a freshwater acute criterion of 0.086ug/L and a chronic criterion of 0.036ug/L. In saltwater, the numbers are acute 0.037 and chronic 0.0023ug/L. Human health contaminate criterion for water plus organism is 0.059ug/L.

The US EPA's proposed maximum contaminant level (MCL) in drinking water is 0.0002 milligrams per liter (mg/L; 1 mg/L = 1 ppm). The EPA has also set health advisories which are levels of a chemical in water that are safe. The 1-day and 10-day health advisories for Endrin, are 0.02 mg Endrin, per liter of water for both children and adults. The longer-term health advisories for children and adults are 0.003 mg/L and 0.01 mg/L, respectively. The lifetime health advisory for children and adults is 0.002 mg/L. The EPA recommends an ambient water quality criteria level of 0.001 mg/L to protect human health.

The National Institute of Occupational Safety and Health (NIOSH) and the Occupational Safety and Health Administration (OSHA) of USA have established a limit of 0.1 mg Endrin, per cubic meter of air (0.1 mg/m<sup>3</sup>) averaged over an 8-hour day in an occupational setting for a 40-hour work week. In addition, NIOSH considers that a person could escape within 30 minutes from a concentration of 2,000 mg/m<sup>3</sup> without respiratory protection and without experiencing any escape-impairing or irreversible health effects ([http://www.eoearth.org/article/Public\\_Health\\_Statement\\_for\\_Endrin](http://www.eoearth.org/article/Public_Health_Statement_for_Endrin)).

## G. Persistence

Its half-life in soil is over 10 (upto 12) years. In comparison with Dieldrin, endrin is less persistent in the environment (<http://en.wikipedia.org/wiki/Endrin>).

## H. Alternative

Alternatives can be seen in the Annex table.

## I. Country specific issue

Endrin pesticide has been banned in Nepal.

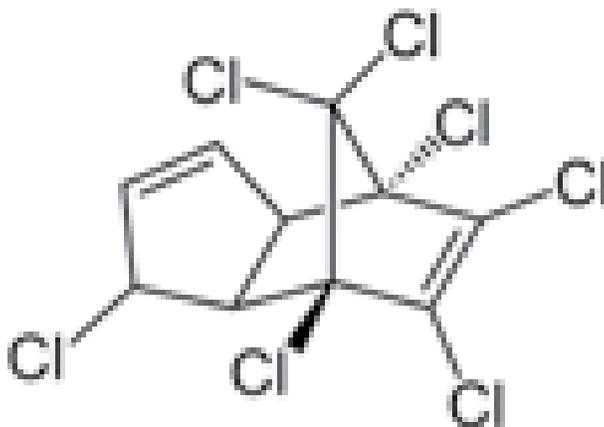
# HEPTACHLOR

Heptachlor is an organochlorine compound that was used as an insecticide. Heptachlor is a non-systemic stomach and contact insecticide, used primarily against soil insects and termites. It has also been used against cotton insects, grasshoppers, some crop pests and to combat malaria (<http://www.popstoolkit.com/about/chemical/heptachlor.aspx>). Usually sold as a white or tan powder, heptachlor is one of the cyclodiene insecticides. In 1962, Rachel Carson's *Silent Spring* questioned the safety of heptachlor and other chlorinated insecticides. Due to its highly stable structure, heptachlor can persist in the environment for decades. Once released to the environment, it persists longer, bioaccumulates and adversely affects environment and human health.

|  |   |
|--|---|
| <b>A. Name</b>                                 | Heptachlor  |
| <b>Synonyms and Trade Names (partial list)</b> | Aahepta, Agroceres, Baskalor, Drinox, Drinox H-34, Heptachlorane, Heptagran, Heptagranox, Heptamak, Heptamul, Heptasol, Heptox, Soleptax, Rhodiachlor, Veliscol 104, Veliscol heptachlor. |
| <b>IUPAC Name</b>                              | 1,4,5,6,7,8,8-Heptachloro-3a,4,7,7a-tetrahydro-4,7-methano-1H-indene  |

**B. CAS Number** 76-44-8

**C. Structure**



## D. Properties

|                          |   |
|--------------------------|---|
| <b>Molecular formula</b> | C <sub>10</sub> H <sub>5</sub> Cl <sub>7</sub>                                  |
| <b>Molar mass</b>        | 373.32 g/mol  |
| <b>Density</b>           | 1.58 g/cm <sup>3</sup>  |
| <b>Melting point</b>     | 95-96°C   |
| <b>Boiling point</b>     | 135-145°C at 1-1.5 mmHg   |
| <b>Appearance</b>        | White to light tan, waxy solid or crystals with a camphor-like odour            |
| <b>Solubility</b>        | Poorly soluble in water (0.056 mg/L at 25°C) and is soluble in organic solvents |
| <b>Volatility</b>        | Quite volatile  |

## E. Impact on human health and environment

### **Environmental impact**

Since heptachlor is lipophilic and poorly soluble in water, it tends to accumulate in the body fat of animals. It binds readily to aquatic sediments and bioconcentrates in the fat of living organisms. Heptachlor is metabolised in animals to heptachlor epoxide, whose toxicity is similar to that of heptachlor, and which may also be stored in animal fat. Symptoms of Heptachlor exposure in animals include tremors and convulsions. Animals exposed to Heptachlor epoxide during gestation and infancy are found to have changes in nervous system and immune function. Higher doses of Heptachlor when exposed to newborn animals caused decrease in body weight and death. Heptachlor has been strongly implicated in the decline of several wild bird populations including Canada Geese and the American Kestrel in the Columbia Basin in the US. Heptachlor epoxide residues were detected in the brains of dead birds and in the eggs of nests. The presence of residues in the eggs indicates that heptachlor is transferred through the food chain. The chemical properties of heptachlor (low water solubility, high stability, and semi-volatility) favor its long range transport, and heptachlor and its epoxide have been detected in Arctic air, water and organisms. Heptachlor has been detected in the blood of cattle from both the US and Australia. WHO has reported no evidence of teratogenicity of heptachlor in rats and rabbits. IARC has concluded that there is sufficient evidence for the carcinogenicity of heptachlor in experimental animals (<http://www.popstoolkit.com/about/chemical/heptachlor.aspx>).

### **Human health effects**

WHO suggests that food is the major source of exposure of heptachlor to the general population. Humans are exposed to heptachlor through drinking water and foods, including breast milk. It tends to accumulate in the body fat of humans. A study of workers from



a plant involved in the production of heptachlor and Endrin found a significant increase in bladder cancer. There is limited evidence that cyclodienes such as heptachlor may affect immune responses. There is no information on accidental or suicidal intoxication by heptachlor in humans (<http://www.popstoolkit.com/about/chemical/heptachlor.aspx>).

IARC has concluded that there is inadequate evidence for the carcinogenicity of heptachlor in humans. It is classified as an (IARC Group 2B) carcinogen.

## F. Standard

For exposures of up to 10 days, US EPA recommends that a child weighing 22 pounds or less not drink water containing levels of heptachlor or heptachlor epoxide more than 0.01 mg heptachlor or heptachlor epoxide per liter of water (0.01 mg/L or 0.01 ppm). EPA requires that drinking water should not contain more than 0.0004 mg/L (0.004 ppm) heptachlor and 0.0002 mg/L (0.0002 ppm) of heptachlor epoxide.

US FDA controls the amount of heptachlor and heptachlor epoxide on raw food crops and on edible seafood. The limit on food crops is from 0.01 to 0.05 parts heptachlor per million parts food (0.01-0.05 ppm) depending on the type of food product. The limit on edible seafood is 0.3 ppm.

US OSHA recommends that the highest average amount of heptachlor in workplace air over an 8 hour workday for a 40-hour workweek not be more than 0.5 mg/m<sup>3</sup> ([http://www.eoearth.org/article/Public\\_Health\\_Statement\\_for\\_Heptachlor\\_and\\_Heptachlor\\_Epoxide](http://www.eoearth.org/article/Public_Health_Statement_for_Heptachlor_and_Heptachlor_Epoxide)).

## G. Persistence

It has a half life of ~1.3-4.2 days in air, ~0.03-0.11 years in water and ~0.11-0.34 years in soil. One study described its half life to be 2 years and claimed that its residues could be found in soil 14 years after its initial application. The half life of heptachlor in temperate soil is up to 2 years (<http://www.popstoolkit.com/about/chemical/heptachlor.aspx>).

## H. Alternative

Alternatives can be seen in Annex table.

## I. Country specific issue

Heptachlor pesticide has been banned in Nepal.

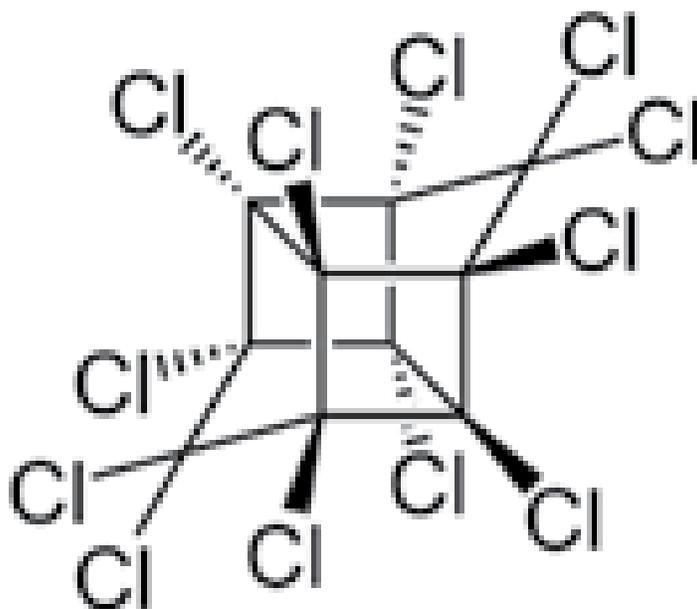
# MIREX

Mirex is a chlorinated hydrocarbon that was commercialized as an insecticide (<http://en.wikipedia.org/wiki/Mirex>). Mirex is a stomach insecticide with little contact activity. This insecticide is mainly used against leaf-cutting ants, termites in buildings and outdoors, and also as a fire retardant and for other industrial purposes. Once released to the environment, it persists longer, bioaccumulates and adversely affects environment and human health.

|  |   |
|--|---|
| <b>A. Name</b>                                 | Mirex   |
| <b>Synonyms and Trade Names (partial list)</b> | Dechlorane, Ferriamicide, GC 1283.  |
| <b>IUPAC Name</b>                              | (1 <i>r</i> ,2 <i>R</i> ,3 <i>S</i> ,4 <i>r</i> ,5 <i>R</i> ,6 <i>S</i> )-1,2,3,4,5,6-hexachlorocyclohexane |

**B. CAS Number** 2385-85-5

## C. Structure



## D. Properties

|   |  |
|---|--|
| <b>Molecular formula</b>  | C <sub>10</sub> Cl <sub>12</sub>                 |
| <b>Molar mass</b>   | 545.54 g mol <sup>-1</sup>                       |
| <b>Melting point</b>  | 485°C, 758 K, 905°F                              |
| <b>Appearance</b>   | White crystalline, odourless solid               |
| <b>Solubility</b>   | Very insoluble in water<br>High lipid solubility |
| <b>Vapour pressure (at 25°C)</b>                                | 3 x 10 <sup>-7</sup> mm Hg                       |
| <b>Stability</b>  | Extreme  |
| <b>Partion coefficient-LogKow</b>                               | 5.28   |
| <b>Henry's Law Constant at 20°C<br/>(Pa m<sup>3</sup>/mole)</b> | 839.37   |
| <b>Flammability limits</b>                                      | Nonflammable (supports combustion)               |

## E. Impact on human health and environment

### *Environmental impact*

Mirex is very resistant to breakdown, is very insoluble in water, and has been shown to bioaccumulate and biomagnify. Due to its insolubility, Mirex binds strongly to aquatic sediments. By virtue of its chemical robustness and lipophilicity it was recognized as a bio-accumulative pollutant. This persistence, combined with lipophilicity, provides the conditions necessary for Mirex to bio-concentrate in organisms. The chemical properties of Mirex (low water solubility, high lipid solubility, high stability, and semi-volatility) favor its long range transport, and Mirex has been detected in Arctic freshwater and terrestrial organisms. It is highly cumulative and amount depends upon the concentration and duration of exposure. There is evidence of accumulation of Mirex in aquatic and terrestrial food chains to harmful levels ([http://www.chem.unep.ch/termite/POPTermiticides\\_Mirex.html](http://www.chem.unep.ch/termite/POPTermiticides_Mirex.html)).

Short term effects of animal exposure includes decreased body weight, hepatomegaly, induction of mixed function oxidizes, and morphological changes in liver cells. Crustaceans are the most sensitive aquatic organisms, with larval and juvenile stages being the most sensitive. Uptake, accumulation and translocation of Mirex by a variety of plant species has also been seen. A reduction in germination and emergence in several plant species was observed (<http://www.popstoolkit.com/about/chemical/mirex.aspx>).

### **Human health effects**

The main route of exposure of Mirex to the general population is through food, especially meat, fish and wild game. There are no reports of injuries to humans resulting from exposure to Mirex. Mirex residues in human adipose have been reported. IARC has classified Mirex as a possible human carcinogen (Group 2B) (<http://www.popstoolkit.com/about/chemical/mirex.aspx>).

### **F. Standard**

US EPA suggests that taking into your body each day an amount equal to 200 picograms (pg) of Mirex per kilogram (kg) of your body weight is not likely to cause any significant (non-cancer) harmful health effects. The Food and Drug Administration (FDA) of USA has determined that concentrations of Mirex below 100 ppt in fish and other foods are not likely to harm people who eat these foods. EPA has set a limit of 1 ppt in surface waters to protect aquatic life from the harmful effects of Mirex ([http://www.eoearth.org/article/Public\\_Health\\_Statement\\_for\\_Mirex\\_and\\_Chlordecone](http://www.eoearth.org/article/Public_Health_Statement_for_Mirex_and_Chlordecone)).

### **G. Persistence**

Mirex is considered to be one of the most stable and persistent pesticides, with a half life of up to 10 years ([http://www.chem.unep.ch/termite/POPTermiticides\\_Mirex.html](http://www.chem.unep.ch/termite/POPTermiticides_Mirex.html)).

### **H. Alternative**

Alternates can be seen at Annex Table.

### **I. Country specific issue**

Mirex pesticide has been banned in Nepal.

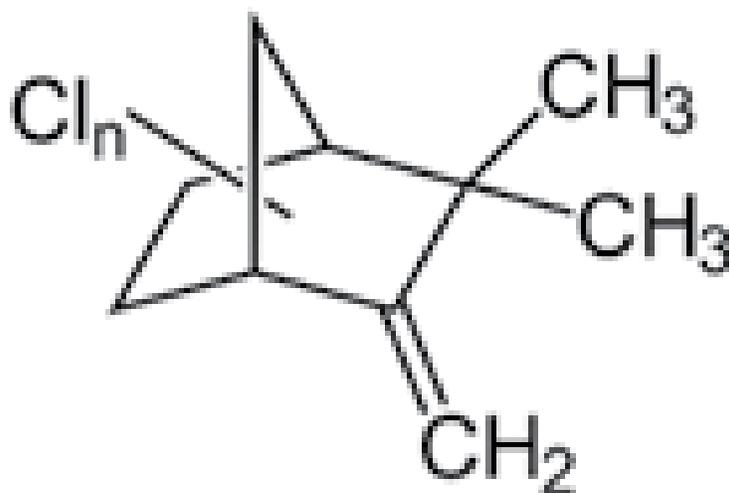
# TOXAPHENE

Toxaphene was used as an insecticide. Toxaphene is a nonsystemic and contact insecticide that was used primarily on cotton; cereal grains fruits, nuts and vegetables. It has also been used to control ticks and mites in livestock (<http://www.popstoolkit.com/about/chemical/toxaphene.aspx>). Once released to the environment, it persists longer, bioaccumulates and adversely affects environment and human health.

|  |   |
|--|---|
| <b>A. Name</b>                                 | Toxaphene   |
| <b>Synonyms and Trade Names (partial list)</b> | Alltex, Alltox, Attac 4-2, Attac 4-4, Attac 6, Attac 6-3, Attac 8, Camphechlor, Camphochlor, Camphoclor, Chemphene M5055, chlorinated camphene, Chloro-camphene, Clor chem T-590, Compound 3956, Huilex, Kamfochlor, Melipax, Motox, Octachlorocamphene, Penphene, Phenacide, Phenatox, Phenphane, Polychlorocamphene, Strobane-T, Strobane T-90, Texadust, Toxakil, Toxon 63, Toxyphen, Vertac 90% |
| <b>IUPAC Name</b>                              | Toxaphene   |

**B. CAS Number** 8001-35-2

## C. Structure



## D. Properties

|  |  |
|--|--|
| <b>Chemical formula</b>                                  | Ranging from C <sub>10</sub> H <sub>11</sub> Cl <sub>5</sub> to C <sub>10</sub> H <sub>6</sub> Cl <sub>12</sub> ,<br>mean formula of C <sub>10</sub> H <sub>10</sub> Cl <sub>8</sub> |
| <b>Density</b>   | 1,65 g·cm <sup>-3</sup>  |
| <b>Melting point</b>                                     | 65–90°C  |
| <b>Boiling point</b>                                     | Decomposition at 155°C   |
| <b>Color</b>   | Yellow to amber  |
| <b>Molecular Weight</b>                                  | 413.82 g/mol   |
| <b>Appearance</b>  | Yellow, waxy solid with a chlorine/terpene-like odor   |
| <b>Solubility in water</b>                               | Low (550 µg/L at 20°C)   |
| <b>Vapour pressure</b>                                   | 0.2-0.4 mm Hg at 25°C  |
| <b>Stability</b>   | High   |
| <b>Volatility</b>  | Semi   |
| <b>log octanol/water partition coefficient (log Kow)</b> | 2.474  |

Toxaphene is a mixture of approximately 200 organic compounds.

## E. Impact on human health and environment

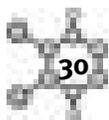
### **Environmental impact**

Toxaphene is highly insoluble in water. It has been shown to bio-concentrate in aquatic organisms and is known to undergo atmospheric transport. Female ring-necked pheasants exposed to 300 mg Toxaphene/kg diet experienced reductions in egg laying and hatchability. Toxaphene is found to be highly toxic to rainbow trout and bluegill. It is essentially nontoxic to plants. In general, toxic effects have been observed only at levels much higher than the recommended usage level (<http://www.popstoolkit.com/about/chemical/toxaphene.aspx>).

The chemical properties of Toxaphene favor its long range transport, and Toxaphene has been detected in Arctic air (<http://www.popstoolkit.com/about/chemical/toxaphene.aspx>). IARC has concluded that there is sufficient evidence for the carcinogenicity of Toxaphene in experimental animals.

### **Human health effects**

Exposure of the general population is most likely through food. When inhaled or ingested, sufficient quantities of Toxaphene can damage the lungs, nervous system, and kidneys, and may cause death. IARC has classified Toxaphene as a possible human carcinogen (Group 2B). US EPA considers Toxaphene to be a probable human carcinogen and has classified it as a Group B2 carcinogen (<http://www.epa.gov/ttnatwo1/hlthef/toxaphen.html>).



## F. Standard

The US EPA concludes that the amount of Toxaphene in drinking water should not exceed 0.003 parts of Toxaphene per million parts (ppm) of water and that any release to the environment greater than one pound should be reported. The EPA has also established limits on how much Toxaphene can be released from a factory into waste water. The limit is set at 0-1.5 milligrams (mg) of Toxaphene per liter (approximately a quart) of water. The EPA has determined that Toxaphene is a “hazardous air pollutant” under the Clean Air Act, but the agency has not yet established standards for it. For short-term exposures, EPA concludes that drinking water levels should not exceed 0.5 ppm for 1 day or 0.04 ppm for 10 days.

The Food and Drug Administration of USA has set a limit of 6 ppm of Toxaphene in crude soybean oil, and EPA has set limits that range from 0.1 to 7 ppm for other raw agricultural products such as sunflower seeds, soybeans, grains, cottonseed, vegetables, and fruits (including bananas and pineapples). Since the EPA has banned the importation of all food containing Toxaphene residues, and Toxaphene can no longer be used in the United States or its territories, the likelihood of eating contaminated food is small.

The Occupational Safety and Health Administration (OSHA) of USA has set a legally enforceable limit (permissible exposure limit or PEL) of 0.5 milligrams of Toxaphene per cubic meter of air in workroom air to protect workers during an 8-hour shift over a 40-hour workweek ([http://www.eoearth.org/article/Public\\_Health\\_Statement\\_for\\_Toxaphene](http://www.eoearth.org/article/Public_Health_Statement_for_Toxaphene)). The acute lethal dose of Toxaphene for humans has been estimated to be 2–7 g/person (Conley, 1952 in <http://monographs.iarc.fr/ENG/Monographs/vol79/mono79-19.pdf>).

## G. Persistence

The half-life of Toxaphene in soil ranges from 100 days up to 12 years, depending on the soil type and climate (<http://www.popstoolkit.com/about/chemical/toxaphene.aspx>).

## H. Alternative

Alternatives can be seen at Annex Table.

## I. Country specific issue

Toxaphene pesticide has been banned in Nepal.

## HEXACHLOROBENZENE

Hexachlorobenzene is a chlorocarbon. It was widely used as a pesticide to protect the seeds of onions and sorghum, wheat, and other grains against fungus. It was also used to make fireworks, ammunition, and synthetic rubber. It is a fungicide formerly used as a seed treatment, especially on wheat to control the fungal disease bunt (<http://kirkmanlabs.com/Pages/65/PesticidesFe-Im/>).

It does not occur naturally in the environment. It is formed as a by-product while making other chemicals, in the waste streams of chloralkali and wood-preserving plants, and when burning municipal waste (<http://www.atsdr.cdc.gov/toxfaqs/faq.asp?id=626&tid=115>).

In Anatolia, Turkey between 1955 and 1959, during a period when bread wheat was unavailable, 500 people were fatally poisoned and more than 4,000 people fell ill by eating bread made with HCB-treated seed that was intended for agriculture use. Most of the sick were affected with a liver condition called *porphyria cutanea tarda*, which disturbs the metabolism of hemoglobin and results in skin lesions. Almost all breastfeeding children under the age of two, whose mothers had eaten tainted bread, died from a condition called “pembe yara” or “pink sore,” most likely from high doses of HCB in the breast milk. In one mother’s breast milk the HCB level was found to be 20 parts per million in lipid, approximately 2,000 times the average levels of contamination found in breast-milk samples around the world. Follow-up studies 20 to 30 years after the poisoning found average HCB levels in breast milk were still more than seven times the average for unexposed women in that part of the world (56 specimens of human milk obtained from mothers with porphyria, average value was 0.51 ppm in HCB-exposed patients compared to 0.07 ppm in unexposed controls), and 150 times the level allowed in cow’s milk. In the same follow-up study of 252 patients (162 males and 90 females, avg. current age of 35.7 years), 20–30 years postexposure, many subjects had dermatologic, neurologic, and orthopedic symptoms and signs. The observed clinical findings include scarring of the face and hands (83.7%), hyperpigmentation (65%), hypertrichosis (44.8%), pinched faces (40.1%), painless arthritis (70.2%), small hands (66.6%), sensory shading (60.6%), myotonia (37.9%), cogwheeling (41.9%), enlarged thyroid (34.9%), and enlarged liver (4.8%). Urine and stool porphyrin levels were determined in all patients, and 17 have at least one of the porphyrins elevated. Offspring of mothers with three decades of HCB-induced porphyria appear normal (<http://en.wikipedia.org/wiki/Hexachlorobenzene>).

Once released to the environment, it persists longer, bioaccumulates and adversely affects environment and human health.

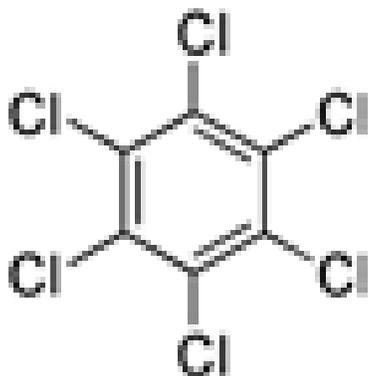
**A. Name** Hexachlorobenzene (or perchlorobenzene)

Synonyms and Trade Names Amaticin, Anticarie, Bunt-cure, Bunt-no-more, Co-op hexa,  
(partial list) Granox, No bunt, Sanocide, Smut-go, Sniecotox

IUPAC Name Hexachlorobenzene

**B. CAS Number** 118-74-1

### C. Structure



### D. Properties

|                          |  |
|--------------------------|--|
| <b>Molecular formula</b> | $C_6Cl_6$  |
| <b>Molar mass</b>        | 284.80 g/mol   |
| <b>Density</b>           | 2.04 g/cm <sup>3</sup>   |
| <b>Appearance</b>        | White monoclinic crystals or crystalline solid                                   |
| <b>Melting point</b>     | 231°C, 504 K, 448°F  |
| <b>Boiling point</b>     | 323-326°C  |
| <b>Solubility</b>        | Negligible in water<br>Soluble in diethyl ether, benzene, ethanol and chloroform |
| <b>Vapour pressure</b>   | $1.09 \times 10^{-5}$ mmHg (1.45 mPa) at 20°C                                    |
| <b>Flash point</b>       | 242°C (sublimes at 322°C)  |

## **E. Impact on human health and environment:**

### ***Environmental impact***

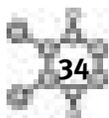
Hexachlorobenzene can remain in the environment for a long time and breaks down very slowly. It does not dissolve in water very well, so most of it will remain in particles on the bottom of lakes and rivers. It sticks strongly to soil and high levels can build up in fish, marine mammals, birds, lichens, and animals that eat lichens (like caribou) or fish. It can also build up in wheat, grasses, some vegetables, and other plants. Hexachlorobenzene is an animal carcinogen. Animal carcinogenicity data for Hexachlorobenzene show increased incidences of liver, kidney (renal tubular tumours) and thyroid cancers. Neurological changes have been reported in rodents exposed to Hexachlorobenzene. Hexachlorobenzene may cause embryo lethality and teratogenic effects. HCB is very toxic to aquatic organisms. It may cause long term adverse effects in the aquatic environment. Therefore, release into waterways should be avoided. It is persistent in the environment. Ecological investigations have found that bio-magnification up the food chain does occur. HCB is toxic to aquatic organisms and may cause long term adverse effects in the aquatic environment. Risk of bioaccumulation in an aquatic species is high. The immune system of rats that breathed Hexachlorobenzene for a few weeks was harmed. Animals that ate Hexachlorobenzene for months or years developed cancer of the liver, kidneys, and thyroid (<http://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=626&tid=115>).

### ***Human health effects***

Exposure to Hexachlorobenzene occurs primarily from eating low levels in contaminated food. Nursing infants can be exposed to Hexachlorobenzene through breast milk if their mothers have been exposed. Unborn children may also be affected if their mother has been exposed. Hexachlorobenzene crosses the placenta to accumulate in foetal tissues and is transferred in breast milk. The people in Turkey who ate the contaminated bread suffered from a liver disease called porphyria cutanea tarda. This disease can cause red-colored urine, skin sores, change in skin color, arthritis, and problems of the liver, nervous system, and stomach (ASDR, 2002).

Chronic oral exposure in humans has been shown to give rise to a liver disease (*porphyria cutanea tarda*), skin lesions with discoloration, ulceration, photosensitivity, thyroid effects, bone effects and loss of hair (<http://en.wikipedia.org/wiki/Hexachlorobenzene>).

There is no strong evidence that it causes cancer in people. A factory worker who breathed air for several years that contained many chemicals, but mostly Hexachlorobenzene, developed liver cancer. The U.S. Department of Health and Human Services (DHHS) has determined that Hexachlorobenzene may reasonably be expected to be a carcinogen. IARC has classified HCB as a possible human carcinogen (Group 2B).



## **F. Standard**

US EPA has proposed that drinking water should not contain more than 0.05 parts of Hexachlorobenzene per million parts of water (ppm) in water that children drink, and should not exceed 0.2 ppm in water that adults drink for longer periods (approximately 7 years) ([http://www.eoearth.org/article/Public\\_Health\\_Statement\\_for\\_Hexachlorobenzene](http://www.eoearth.org/article/Public_Health_Statement_for_Hexachlorobenzene)).

## **G. Persistence**

It has a half life in the soil of between 3 and 6 years (<http://en.wikipedia.org/wiki/Hexachlorobenzene>). According to World Bank and CIDA (2001), its soil half-life ranges from 2.7-22.9 years.

## **H. Alternative**

Alternatives can be seen at Annex Table.

## **I. Country specific issue**

7.9 tonnes of HCB and 22.5 tonnes of mixed Aldrin and HCB were reported from Nepal (UNEP, 2002c in Jones, 2005).

## POLYCHLORINATED BIPHENYLS (PCBs)

There are no known natural sources of PCBs. PCBs were used as coolants and insulating fluids (transformer oil) for transformers and capacitors, especially in components of early fluorescent light fittings and electrical transformers, and as plasticizers in paints and cements, stabilizing additives in flexible PVC coatings of electrical wiring and electronic components, pesticide extenders, cutting oils, reactive flame retardants, lubricating oils, hydraulic fluids, and sealants (for caulking in schools and commercial buildings, adhesives, wood floor finishes (such as *Fabulon* and other products of Halowax in the U.S.), paints, de-dusting agents, water-proofing compounds, casting agents, vacuum pump fluids, fixatives in microscopy, surgical implants, and in carbonless copy (“NCR”) paper (<http://blog.ebsconsultants.net/>).

PCBs, originally termed “chlorinated diphenyls,” were commercially produced as complex mixtures containing multiple isomers at different degrees of chlorination. PCBs were also commonly used as stabilizing additives in the manufacture of flexible PVC coatings for electrical wiring and electronic components to enhance the heat and fire resistance of the PVC ([http://en.wikipedia.org/wiki/Polychlorinated\\_biphenyls](http://en.wikipedia.org/wiki/Polychlorinated_biphenyls)).

The toxicity associated with PCBs and other chlorinated hydrocarbons, including polychlorinated naphthalenes was recognized very early due to a variety of industrial incidents.

One of the most important impact episode of the PCB contamination was happened in Japan during 1968, where about 280 Kg of PCB contaminated oil has been used in the poultry feeds results the development of YUSO diseases in over 14000 peoples. The symptoms of that diseases includes swelling of eyes and skins, alternation in menstruation, head ache, weakens immune system, skin and eye sore and obstruction of developmental growth etc.

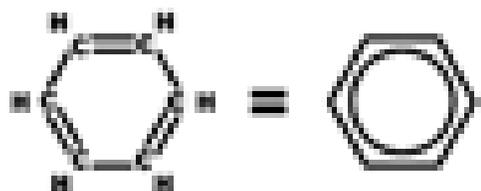
Similarly during 1976, Hudson River in New York, U.S.A. has been polluted from PCB and government banned to eat fish as well as fishing activities along the 30 KM stretch of the river.

Once released to the environment, it persists longer, bioaccumulates and adversely affects environment and human health.

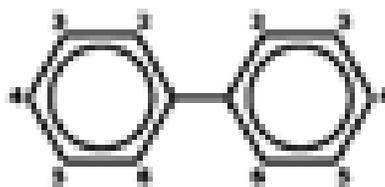
|  |   |
|--|---|
| <b>A. Name</b>   | Polychlorinated biphenyls (originally termed “chlorinated diphenyls)  |
| <b>Trade Names for different mixtures (partial list)</b> | Aroclor, Pyranol, Pyroclor, Phenochlor, Pyralene, Clophen, Elaol, Kanechlor, Santotherm, Fenchlor, Apirolio, Sovol. |
| <b>IUPAC Name</b>  | The IUPAC name for PCB 156 is 2,3,3',4,4',5-hexachlorobiphenyl.   |

**B. CAS Number** 1336-36-3

### C. Structure



*Basic aromatic structure*



*Basic PCB structure*

### D. Properties

|  |  |
|--|--|
| <b>Chemical formula</b>                    | $C_{12}H_{10-x}Cl_x$ , where $x = 1-10$  |
| <b>Density</b>                             | Varies from 1.182 to 1.566 kg/L  |
| <b>Solubility</b>                          | Low water solubilities — 0.0027-0.42 ng/L for Aroclors<br>High solubilities in most organic solvents, oils, and fats |
| <b>Vapor pressures at room temperature</b> | Low  |
| <b>Dielectric constants</b>                | High   |
| <b>Flash points</b>                        | High (from 170 to 380°C)   |
| <b>Resistance</b>                          | Extremely resistant to oxidation, reduction, addition, elimination, and electrophilic substitution                   |
| <b>Stability</b>                           | Very stable even when exposed to heat and pressure.  |

Other physical and chemical properties vary widely across the class.

In the concentrated form, PCBs are either oily liquids or solids with no discernable taste or odor. PCBs don't burn easily and are good insulating material. PCBs are either oily liquids or solids that are colorless to light yellow. Some PCBs can exist as a vapor in air. PCBs are mixtures of up to 209 individual chlorinated compounds (known as congeners). PCB congeners are odorless, tasteless, clear to pale-yellow, viscous liquids (the more highly

chlorinated mixtures are more viscous and deeper yellow). These chlorinated oils have a low degree of reactivity. They are not flammable, have high electrical resistance, good insulating properties and are very stable even when exposed to heat and pressure. PCBs readily penetrate skin, PVC (polyvinyl chloride), and latex (natural rubber). PCBs are very stable compounds and do not degrade readily (<http://www.docstoc.com/docs/6453221/PCBs>).

## **E. Impact on human health and environment:**

### ***Environmental impact***

PCBs are very stable compounds and do not degrade readily. Their destruction by chemical, thermal, and biochemical processes is extremely difficult, and presents the risk of generating extremely toxic Dibenzodioxins and Dibenzofurans through partial oxidation. Since PCBs do not break down they remain in the environment and continue to build up more are introduced into the environment. Worms consume organic matter contaminated with PCBs, and small fishes eat the worms. Small fish are then eaten by larger fish, and perhaps the large fish are eaten by an eagle. Worms may only live for a short time, but eagles live for a long time. They continue to eat lots of large fish that ate lots of small fish that ate lots of contaminated worms. Over a lifetime, the PCB concentration in the fatty tissue of the eagle would continue to increase as it ate more and more contaminated fish (<http://humano.ya.com/bicthor/varios/bioquimica/chemistry.pdf>).

Due to their low vapor pressure, in the environment PCBs goes mainly in the hydrosphere (despite their Hydrophobicity, the great amount of water in the oceans can dissolve a fair great amount of PCBs), in the organic fraction of soil, and in organisms.

Whereas the hydrosphere is the main reservoir, the atmosphere serves as the primary route for global transport of PCBs, particularly for those congeners with 1 to 4 chlorine atoms. In the atmosphere, PCBs may be degraded by hydroxyl radical, or directly by photolysis of carbon - chlorine bonds (even if this is a less important process). Atmospheric concentrations of PCBs tend to be lowest in rural areas, where they are typically in the picogram per cubic meter range, higher in suburban and urban areas, and highest in city centres, where they can reach 1 ng/m<sup>3</sup> or more. Volatilization of PCBs in soil was thought to be the primary source of PCBs in the atmosphere, but recent research suggests that ventilation of PCB-contaminated indoor air from buildings is the primary source of PCB contamination in the atmosphere. In biosphere, PCBs can be degraded by either bacteria or eukariotes, but the speed of the reaction depends on both the number and the disposition of chlorine atoms in the molecule: less substituted, meta- or para- substituted PCBs undergoes biodegradation faster than more substituted congeners. PCBs also bind strongly to soil.

Animals that eat PCB-contaminated food even for short periods of time suffer liver damage and may die (<http://www.newworldorderreport.com/News/tabid/266/ID/3871/13-toxins-and-poisons-in-your-environment-These-are-things-everyone-should-know-about.aspx>). Animals that ate food containing large amounts of PCBs for short periods of time had mild liver damage and some died. Animals that ate smaller amounts of PCBs in food over several weeks or months developed various kinds of health effects, including anemia; acne-like skin conditions; and liver, stomach, and thyroid gland injuries. Other effects of PCBs in animals include changes in the immune system, behavioral alterations, and impaired reproduction. PCBs are not known to cause birth defects. In 1968 in Japan, 400,000 birds died after eating poultry feed that was contaminated with PCBs. Animals that ingest smaller amounts of PCBs in food over several weeks or months develop various health effects, including anemia; acne-like skin conditions (chloracne); and liver, stomach, and thyroid gland injuries (including hepatocarcinoma). Other effects of PCBs in animals include changes in the immune system, behavioral alterations, and impaired reproduction. PCBs are not known to cause birth defects in humans, although those that have dioxin-like activity are known to cause a variety of teratogenic effects in animals.

PCBs are known to cause cancer in animals. Rats that ate food containing high levels of PCBs for two years developed liver cancer.

### **Human health effects**

The most common exposure routes to PCBs include: food, surface soils, drinking water and groundwater, indoor air, in the workplace. Using old fluorescent lighting fixtures and electrical devices and appliances, such as television sets and refrigerators, that were made 30 or more years ago, eating contaminated food (the main dietary sources of PCBs are fish, meat, and dairy products), breathing air near hazardous waste sites and drinking contaminated well water, workplace during repair and maintenance of PCB transformers; accidents, fires or spills involving transformers, fluorescent lights, and other old electrical devices; and disposal of PCB materials are the sources/routes of exposure to PCBs.

The toxicity of PCBs varies considerably among congeners. The most commonly observed health effects in people exposed to extremely high levels of PCBs are skin conditions such as chloracne and rashes. Women who were exposed to relatively high levels of PCBs in the workplace or ate large amounts of fish contaminated with PCBs had babies that weighed slightly less than babies from women who did not have these exposures. Health effects that have been associated with exposure to PCBs include acne-like skin conditions in adults and neurobehavioral and immunological changes in children. PCBs have been demonstrated to exert effects on thyroid hormone levels in humans.

Studies in workers exposed to PCBs have shown changes in blood and urine that may indicate liver damage. Studies have shown that PCBs alter estrogen levels in the body and contribute to reproduction problems. In the womb, males can be feminized or the baby may be intersex, neither a male nor a female. Also, both sets of reproductive organs may develop. A few studies of workers indicate that PCBs were associated with specific kinds of cancer in humans, such as cancer of the liver and biliary tract. Polychlorinated biphenyls (PCBs) have been shown to mimic the action of oestrogen in breast cancer cells and can enhance breast carcinogenesis (<http://www.newworldorderreport.com/News/tabid/266/ID/3871/13-toxins-and-poisons-in-your-environment-These-are-things-everyone-should-know-about.aspx>). Studies in humans suggest that long term exposure to PCBs can suppress the immune system.

The International Agency for Research on Cancer (IARC) has determined that PCBs are probably carcinogenic to humans. PCBs are also classified as probable human carcinogens by World Health Organization (WHO).

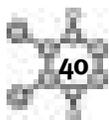
## F. Standard

The US EPA standard for PCBs in drinking water is 0.5 parts of PCBs per billion parts (ppb) of water. For the protection of human health from the possible effects of drinking the water or eating the fish or shellfish from lakes and streams that are contaminated with PCBs, the EPA regulates that the level of PCBs in these waters be no greater than 0.17 parts of PCBs per trillion parts (ppt) of water.

The US FDA has set residue limits for PCBs in various foods to protect from harmful health effects. FDA required limits include 0.2 parts of PCBs per million parts (ppm) in infant and junior foods, 0.3 ppm in eggs, 1.5 ppm in milk and other dairy products (fat basis), 2 ppm in fish and shellfish (edible portions), and 3 ppm in poultry and red meat (fat basis).

US OSHA regulates that workers not be exposed by inhalation over a period of 8 hours for 5 days per week to more than 1 milligram per cubic meter of air ( $\text{mg}/\text{m}^3$ ) for 42% chlorine PCBs, or to  $0.5 \text{ mg}/\text{m}^3$  for 54% chlorine PCBs.

US NIOSH recommends that workers not breathe air containing 42 or 54% chlorine PCB levels higher than 1 microgram per cubic meter of air ( $\mu\text{g}/\text{m}^3$ ) for a 10-hour workday, 40-hour workweek ([http://www.eoearth.org/article/Public\\_Health\\_Statement\\_for\\_Polychlorinated\\_Biphenyls\\_\(PCBs\)](http://www.eoearth.org/article/Public_Health_Statement_for_Polychlorinated_Biphenyls_(PCBs))).



## G. Persistence

The estimated half-life of a PCB is approximately 8 to 15 years depending on the specific chemical make-up of the PCB (<http://www.cevl.msu.edu/~long/pcb.htm>). A maximum intrinsic elimination half-life for PCBs is approximately 10-15 years (<http://lymphomactivist.wordpress.com/2010/10/20/pcb-half-life/>). According to World Bank and CIDA (2001), its Soil Half-life ranges from 10 days to 1.5 years.

## H. Alternative

Technical alternative: Dry isolated transformers has also been mentioned as an alternative to PCB filled transformers. Dry isolated transformers avoids the problems of fire but are less suitable from every other point of view e. g. sensitivity to overload and voltage spikes, compared to oil filled transformers.

Chemical Alternatives most frequently used as transformer fluids includes mineral and silicon oils, but a number of other alternatives are mentioned in the literature ([http://www.tomasoberg.com/pdf/pcb\\_pres.pdf](http://www.tomasoberg.com/pdf/pcb_pres.pdf)).

## I. Country specific issue

The PCBs contaminated transformer oil as well as PCB contaminated waste has been unsafely stored in several locations. This oil has been massively used in the Metal Grill Workshops as welding machine fuel which releases the FURAN gases. In addition, this PCBs contaminated oil has been also used traditionally for the medication purposes for massage, pain relief, wound healing, blood coagulation etc. Additionally, the PCB contaminated sites might need remediation and reclamation soon.

## DDT

DDT (Dichloro Diphenyl Trichloroethane) is a man-made chemical and is not found in nature. It is one of the most well-known synthetic pesticides. First synthesized in 1873 by a German chemist Othmar Zeidler for no purpose but in 1939, its Insecticide properties discovered by Paul Müller. For which he has been awarded the Nobel Prize in Physiology and Medicine in 1948. DDT's insecticidal properties were not discovered until 1939, and it was used with great success in the second half of World War II to control from the spread of malaria, typhus and other vector borne diseases. After the war, DDT was made available for use as an agricultural insecticide, and soon its production and use skyrocketed. From 1950 to 1980, DDT was extensively used in agriculture—more than 40,000 tonnes were used each year worldwide—and it has been estimated that a total of 1.8 million tonnes have been produced globally since the 1940s. In 1955, the World Health Organization commenced a program to eradicate malaria worldwide, relying largely on DDT (<http://en.wikipedia.org/wiki/DDT>). It is still being produced and used for vector control.

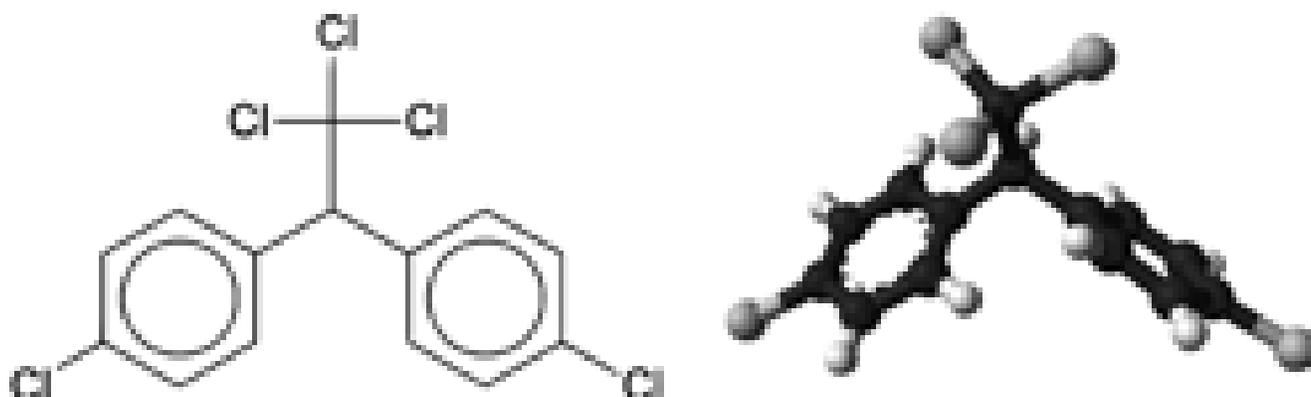
The book- Silent Spring published in 1962 by American biologist Rachel Carson catalogued the environmental impacts of the indiscriminate spraying of DDT in the US and questioned the logic of releasing large amounts of chemicals into the environment without fully understanding their effects on ecology or human health (<http://en.wikipedia.org/wiki/DDT>).

In 1998, first Intergovernmental Negotiation Committee for an International legally binding instrument for implementing action on certain persistent organic pollutants proposed banning DDT. In 2001, Stockholm Convention on POPs banned production and use of DDT with a temporary health-related exemption for use of DDT for malaria. WHO approved DDT use for vector control till safer alternatives are developed since 2006. Once released to the environment, it persists longer, bioaccumulates and adversely affects environment and human health.

|  |   |
|--|---|
| <b>A. Name</b>                                 | DDT (Dichlorodiphenyltrichloroethane)   |
| <b>Synonyms and Trade Names (partial list)</b> | Agritan, Anofex, Arkotine, Azotox, Bosan Supra, Bovidermol, Chlorophenothan, Chloropenothane, Clorophenotoxum, Citox, Clofenotane, Dedelo, Deoval, Detox, Detoxan, Dibovan, Dicophane, Didigam, Didimac, Dodat, Dykol, Estonate, Genitox, Gesafid, Gesapon, Gesarex, Gesarol, Guesapon, Gyron, Havero-extra, Ivotan, Ixodex, Kopsol, Mutoxin, Neocid, Parachlorocidum, Pentachlorin, Pentech, PPzeidan, Rudseam, Santobane, Zeidane, Zerdane. |
| <b>IUPAC Name</b>                              | 1,1,1-trichloro-2,2-di(4-chlorophenyl)ethane  |

**B. CAS Number** 50-29-3

### C. Structure



### D. Properties

|                          |   |
|--------------------------|---|
| <b>Molecular formula</b> | $C_{14}H_9Cl_5$   |
| <b>Molar mass</b>        | 354.49 g/mol  |
| <b>Density</b>           | 0.99 g/cm <sup>3</sup>  |
| <b>Melting point</b>     | 109°C   |
| <b>Appearance</b>        | Odorless to slightly fragrant colorless crystals or white powder  |
| <b>Solubility</b>        | Highly insoluble in water and is soluble in most organic solvents |
| <b>Volatility</b>        | Semi-volatile   |
| <b>Family</b>            | Organic halogen compounds   |
| <b>Stability</b>         | High  |
| <b>Water solubility</b>  | 0.0012 mg/L   |
| <b>Vapor pressure</b>    | $2.5 \times 10^{-5}$ Pa   |

## **E. Impact on human health and environment:**

### ***Environmental impact***

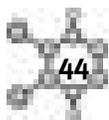
DDT is persistent, accumulates in the food chain and is toxic. It degrades much more slowly in the cold northern environment. Its presence is ubiquitous in the environment and residues have even been detected in the Arctic. It is lipophilic and partitions readily into the fat of all living organisms and has been demonstrated to bio-concentrate and bio-magnify. DDT is also carried to northern regions by migratory birds.

DDT has been detected in air, rain, snow, surface water and soil, as well as in the tissues of plants and animals. In the North, the highest concentrations of DDT have been found in carnivorous predators and scavengers such as hawks, gulls, seals and polar bears. The chemical properties of DDT (low water solubility, high stability and semi-volatility) favor its long range transport and DDT and its metabolites have been detected in Arctic air, water and organisms.

DDT is highly toxic to fish. It also affects fish behavior. Atlantic salmon exposed to DDT as eggs experienced impaired balance and delayed appearance of normal behavior patterns. DDT also affects temperature selection in fish. It is acutely toxic to birds (<http://www.popstoolkit.com/about/chemical/ddt.aspx>).

### ***Human health effects***

DDT is moderately toxic to humans. It mainly affects the nervous system and the liver. Acute effects in humans exposed to low-to-moderate levels of DDT may include nausea, diarrhea, increased liver enzyme activity, and irritation of the eyes, nose and/or throat. Tremors and convulsions may occur with higher doses. Deaths from exposure to DDT are rare. Potential mechanisms of DDT on humans are genotoxicity and endocrine disruption. DDT may have direct genotoxicity, but may also induce enzymes that produce other genotoxic intermediates and DNA adducts. It is an endocrine disruptor; The DDT metabolite DDE acts as an antiandrogen (but not as an estrogen). *o,p'*-DDT, a minor component in commercial DDT has weak estrogenic activity. DDT has also been detected in human breast milk. A non-significant increase in mortality from liver and biliary cancer and a significant increase in mortality from cerebrovascular disease have been observed in workers involved in the production of DDT. There is some evidence to suggest that DDT may be suppressive to the immune system, possibly by depressing humoral immune responses. Perinatal administration of weakly estrogenic pesticides such as DDT produces estrogen-like alterations of reproductive development. DDT has been found in human fat tissue and milk. IARC has classified DDT as a possible human carcinogen (Group 2B).



## **F. Standard**

US OSHA states that workers may not be exposed to amounts of DDT greater than 1 milligram of DDT per cubic meter of air ( $1 \text{ mg/m}^3$ ) for an 8-hour workday, 40-hour work week. US EPA estimates that drinking 2 liters of water per day containing 0.59 nanograms of DDT per liter of water (1 nanogram is one billionth of a gram) and eating 6.5 grams of fish and shellfish per day (from waters containing 0.59 nanograms DDT per liter) would be associated with an increased lifetime cancer risk of one in one million.

## **G. Persistence**

Its half life in soil can range from 22 days to 30 years. As much as 50% can remain in the soil 10-15 years after application.

## **H. Alternative**

Its alternatives can be seen at Annex Table.

## **I. Country specific issue**

DDT is still used to control mosquito vectors of malaria in numerous countries including Nepal. DDT (as a pesticide for agricultural use) has been banned in Nepal.

## POLYCHLORINATED DIBENZO-P-DIOXINS (PCDDs)

Dioxins are not produced commercially, and they have no known use. Dioxins occur as by-products in the manufacture of organochlorides, in the incineration of chlorine-containing substances such as PVC (polyvinyl chloride), in the bleaching of paper, and from natural sources such as volcanoes and forest fires. In addition, certain kinds of metal recycling and pulp and paper bleaching can release dioxins. Dioxins have also been found in automobile exhaust, tobacco smoke and wood and coal smoke (UNEP, 2005). These have been detected in emissions from the incineration of hospital waste, municipal waste, and hazardous waste. Once released to the environment, it persists longer, bioaccumulates and adversely affects environment and human health.

There have been many incidents of dioxin pollution resulting from industrial emissions and accidents; the earliest such incidents were in the mid 19th century during the Industrial Revolution. The much recent impact of the Dioxin poisoning was the poisoning of the Ukrainian opposition leader Mr Yushchenko in the year 2004. His blood and tissue registered concentrations of dioxin 1,000 times above normal levels.

Polychlorinated dibenzopdioxins (PCDDs) are a family of 75 different compounds commonly referred to as polychlorinated dioxins or just dioxins. With general chemical formula of  $C_{12}H_{8X}Cl_XO_2$ , these compounds have varying harmful effects. The PCDD family is divided into eight groups of chemicals based on the number of chlorine atoms in the compound:

- mono-chlorinated dioxin
- di-chlorinated dioxin (DCDD)
- tri-chlorinated dioxin (TrCDD)
- tetra-chlorinated dioxin (TCDD)
- penta-chlorinated dioxin (PeCDD)
- hexa-chlorinated dioxin (HxCDD)
- hepta-chlorinated dioxin (HpCDD)
- octa-chlorinated dioxin (OCDD)

The chlorine atoms can be attached to the dioxin molecule at any one of eight positions. The name of each dioxin indicates both the number and the positions of the chlorine atoms. For example, the dioxin with four chlorine atoms at positions 2, 3, 7, and 8 on the dioxin

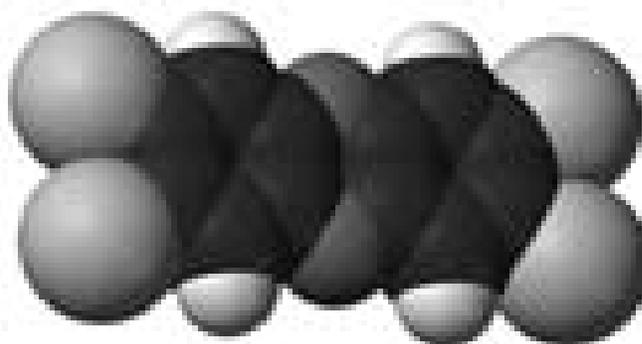
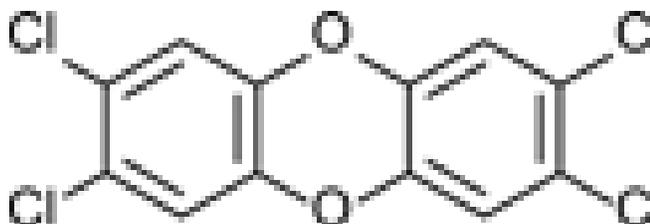
molecule is called 2,3,7,8 tetrachlorodibenzodioxin or 2,3,7,8 TCDD. 2,3,7,8 TCDD is one of the most toxic to mammals of all PCDDs and has received the most attention and it serves as a prototype for the PCDDs. Dioxins with toxic properties similar to 2,3,7,8 TCDD are called dioxinlike compounds (<http://www.unido.org/index.php?id=5180>).

Name, CAS Number, Structure and Properties of 2,3,7,8-Tetrachlorodibenzodioxin have been presented below.

|                    |   |
|--------------------|---|
| <b>A. Name</b>     | 2,3,7,8-Tetrachlorodibenzodioxin (TCDD)                           |
| <b>Other Names</b> | Tetradoxin; Tetrachlorodibenzodioxin; Tetrachlorodibenzo-p-dioxin |
| <b>IUPAC Name</b>  | 2,3,7,8-Tetrachlorooxanthrene                                     |

**B. CAS Number** 1746-01-6

### C. Structure



### D. Properties

|                            |                             |
|----------------------------|-----------------------------|
| <b>Molecular formula</b>   | $C_{12}H_4Cl_4O_2$          |
| <b>Molar mass</b>          | 321.97 g/mol                |
| <b>Density</b>             | 1.8 g cm <sup>-3</sup>      |
| <b>Melting point</b>       | 305°C, 578 K, 581°F         |
| <b>Solubility in water</b> | 0.2 µg/L at 25°C            |
| <b>log P</b>               | 6.8                         |
| <b>Vapor pressure</b>      | 1.5 × 10 <sup>-9</sup> mmHg |

## **E. Impact on human health and environment**

### ***Environmental impact***

Dioxins are considered to be lipophilic, very stable and persistent. This persistence, combined with high partition coefficients provides the necessary conditions for these compounds to bio-concentrate in organisms. The chemical properties of dioxins (low water solubility, high stability and semi-volatility) favor their long range transport and these compounds have been detected in Arctic organisms.

Effects of dioxin exposure that are common to most, and sometimes all species include wasting, lymphoid involution, hepatotoxicity, chloracne and epidermal changes, and gastric lesions. Other characteristic responses include: edema, ascites and hypopericardium in chickens; fetal death and resorption in rats; and fetal wastage, embryotoxicity and malformations in mice. Some teratogenic effects have been observed in mice in association with dioxin exposure, including hydronephrosis and cleft palate. Exposure of fish to dioxins results in a delayed mortality that can continue many days post-exposure.

Among the animals for which TCDD toxicity has been studied, there is strong evidence for the effects of birth defects (teratogenicity), hepatotoxicity (liver toxicity), endocrine disruption, and immunosuppression.

IARC has concluded that while there is inadequate evidence for the carcinogenicity of dioxins in humans, there is sufficient evidence in experimental animals.

### ***Human health effects***

As with most other organochlorines, food is a major source of dioxins in the general population, with food of animal origin contributing the most to human body burdens. In humans, the highly chlorinated dioxins are stored in fatty tissues and are neither readily metabolized nor excreted. Dioxins build up primarily in fatty tissues over time (bio-accumulate), so even small exposures may eventually reach dangerous levels. At the present time, the only persistent effect associated with Dioxin exposure in humans is Chloracne (an acne-like eruption of blackheads, cysts, and pustules). Other health effects that have been reported include peripheral neuropathies, fatigue, depression, personality changes, hepatitis, enlarged liver, abnormal enzyme levels etc. though no causal relationships were established in every case (<http://www.popstoolkit.com/about/chemical/dioxin.aspx>).

High levels of exposures to dioxins have been shown by epidemiological studies to lead to an increased risk of tumors at all sites. Other effects in humans may include: developmental abnormalities in the enamel of children's teeth, central and peripheral nervous system pathology, thyroid disorders, Damage to the immune systems, endometriosis, diabetes.



IARC has classified dioxins as a possible human carcinogen (Group 2B). TCDD, the most toxic of the Dibenzodioxins, is classified as a Group 1 carcinogen by IARC.

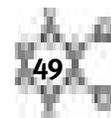
## F. Standard

The Food and Drug Administration (FDA) of USA recommends against consuming fish and shellfish with 2,3,7,8-TCDD levels greater than 50 ppt. Such levels have resulted in the closing of several commercial fishing areas. In addition, The US Environmental Protection Agency (EPA) has issued guidance to states on how to evaluate health risks to recreational and subsistence fishers, and how to issue fish consumption advisories when concentrations of CDDs in fish and shellfish pose a risk to these populations. Currently, 66 health advisories have been issued by 21 states restricting consumption of fish and wildlife contaminated with CDDs. EPA also has recommended limits on how much 2,3,7,8-TCDD can be present in drinking water. EPA advises that children should not have more than 1 nanogram 2,3,7,8-TCDD per liter of water (ng/L) (ppt) in 1 day, or more than 0.01 ng/L per day for long-term exposure. For long-term exposure in adults, EPA recommends that there should not be more than 0.04 ng/L (ppt) in drinking water. EPA has set an enforceable regulation for dioxin, called a maximum contaminant level (MCL), at 0.0000003 mg/L or 30 ppq.

The Joint Expert Committee on Food Additives, an expert group of the World Health Organization and the Food and Agriculture Organization of the United Nations, has set a “tolerable monthly intake” level for dioxins, furans and similar substances. The “tolerable” level (meaning no serious health effects are expected) is 70 picograms per kilogram of body weight/month. This is roughly 2.3 picograms per kilogram of body weight/day (<http://www.hc-sc.gc.ca/hl-vs/iyh-vsv/environ/dioxin-eng.php>).

## G. Persistence

Dioxins are considered to be very stable and persistent, as illustrated by the half life of TCDD in soil of 10-12 years (<http://www.popstoolkit.com/about/chemical/dioxin.aspx>). The biological half-lives and the environmental half-lives of the seventeen most toxic dioxins vary considerably. TCDD has a biological half-life in humans of approximately 6 to 7.6 years and the other highly toxic dioxins have biological half-lives in humans ranging from 3 years to almost 20 years. The biological half-life of dioxins varies according to the age of the human. At birth, the average half-life for all dioxins is approximately 6 months; at one year of age, approximately 12 months; at five years of age, 48 months (4 years) and at 55 years of age, more than 13 years ([http://www.dioxinspin.com/tox\\_chem\\_structure1.htm](http://www.dioxinspin.com/tox_chem_structure1.htm)).



## **H. Country specific issue**

According to the national inventory conducted for the Dioxin and Furan for Nepal in 2003, production of Dioxin and Furan was estimated to 335.972 gm TEQ/year. Uncontrolled combustion process was the major contributor with the annual production of 156.8929 TEQ and 12.006 TEQ/year production was from waste incineration (MOEST, 2007).

## POLYCHLORINATED DIBENZOFURANS (PCDFs)

Polychlorinated dibenzofurans (PCDFs) are a group of halogenated organic compounds. PCDFs tend to co-occur with polychlorinated dibenzodioxins (PCDDs) which are not produced commercially and they have no known use. These compounds are produced unintentionally from the same processes that release dioxins, and they are also found in commercial mixtures of PCBs. PCDFs can be formed by pyrolysis or incineration at temperatures below 1200 °C of chlorine containing products, such as PVC, PCBs, and other organochlorides, or of non-chlorine containing products in the presence of chlorine donors ([http://en.wikipedia.org/wiki/Polychlorinated\\_dibenzofurans](http://en.wikipedia.org/wiki/Polychlorinated_dibenzofurans)). The incomplete combustion of the PCB contaminated transformer oil such as in grill welding machine results the release of the Furan and Dioxin. Once released to the environment, it persists longer, bioaccumulates and adversely affects environment and human health.

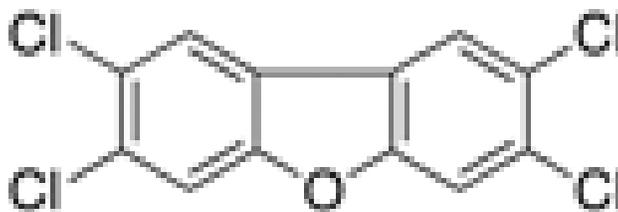
Polychlorinated dibenzofurans (PCDFs) are a family of chemicals known as polychlorinated dibenzofurans or simply furans. These chemicals contain one to eight chlorine atoms attached to the carbon atoms of the parent chemical, dibenzofuran. The PCDF family contains 135 individual compounds (known as congeners) with varying harmful health and environmental effects. Of these 135 compounds, those that contain chlorine atoms at the 2,3,7,8-positions of the parent dibenzofuran molecule are especially harmful.

Name, CAS Number, Structure and Properties of 2,3,7,8-Tetrachlorodibenzofuran (TCDF) have been presented below.

|                                 |   |
|---------------------------------|---|
| <b>A. Name</b>                  | 2,3,7,8-Tetrachlorodibenzofuran (TCDF)  |
| <b>Synonyms and other names</b> | Dibenzofuran, 2,3,7,8-tetrachloro-; NCI-C56611; 2,3,7,8-Tetrachlorodibenzo[b,d]furan; F 83; PCDF 83; TCDF |
| <b>IUPAC Name</b>               | 2,3,7,8-Tetrachlorodibenzofuran   |

**B. CAS Number** 51207-31-9

### C. Structure



### D. Properties

|  |                       |
|--|-----------------------|
| Chemical Formula                                     | $C_{12}H_4Cl_4O$      |
| Molecular mass                                       | 305.96                |
| Density (g/dm <sup>3</sup> )                         | No data               |
| Melting point (°C)                                   | 219-221               |
| Boiling point (°C)                                   | No data               |
| Octanol/Water Partition (log K <sub>ow</sub> )       | 5.82                  |
| Solubility in water in 25°C (mg/dm <sup>3</sup> )    | $4.2 \times 10^{-4}$  |
| Vapour pressure at 25°C (mm <sup>3</sup> Hg)         | $9.21 \times 10^{-7}$ |
| Henry's law coefficient (KH) atm m <sup>3</sup> /mol | $1.48 \times 10^{-5}$ |

### E. Impact on human health and environment:

#### **Environmental impact**

Furans are considered to be very stable and persistent. This persistence, combined with high partition coefficients provides the necessary conditions for these compounds to bio-concentrate in organisms. The chemical properties of furans (low water solubility, high stability and semi-volatility) favor their long range transport and these compounds have been detected in Arctic organisms. Some teratogenic effects have been observed in mice in association with furan exposure, including hydronephrosis and cleft palate. Exposure of fish to furans results in a delayed mortality that can continue many days post-exposure (<http://www.popstoolkit.com/about/chemical/dioxin.aspx>).

#### **Human health effects**

It is toxic and may be carcinogenic. It is classified as an IARC Group 2B carcinogen. As with most other organochlorines, food is a major source of furans in the general population, with food of animal origin contributing the most to human body burdens.



## F. Standard

The Joint Expert Committee on Food Additives, an expert group of the World Health Organization and the Food and Agriculture Organization of the United Nations, has set a “tolerable monthly intake” level for dioxins, furans and similar substances. The “tolerable” level (meaning no serious health effects are expected) is 70 picograms per kilogram of body weight / month. This is roughly 2.3 picograms per kilogram of body weight/day (<http://www.hc-sc.gc.ca/hl-vs/iyh-vsv/environ/dioxin-eng.php>).

## G. Persistence

Furans are considered to be very stable and persistent, as illustrated by the half life of TCDD in soil of 10-12 years (<http://www.popstoolkit.com/about/chemical/dioxin.aspx>). The biological half-lives and the environmental half-lives of the seventeen most toxic furans vary considerably. TCDD has a biological half-life in humans of approximately 6 to 7.6 years and the other highly toxic furans have biological half-lives in humans ranging from 3 years to almost 20 years. The biological half-life of furans varies according to the age of the human. At birth, the average half-life for all furans is approximately 6 months; at one year of age, approximately 12 months; at five years of age, 48 months (4 years) and at 55 years of age, more than 13 years ([http://www.dioxinspin.com/tox\\_chem\\_structure1.htm](http://www.dioxinspin.com/tox_chem_structure1.htm)).

## H. Country specific issue

According to the national inventory conducted for the Dioxin and Furan for Nepal in 2003, production of Dioxin and Furan was estimated to 335.972 gm TEQ/year. Uncontrolled combustion process was the major contributor with the annual production of 156.8929 TEQ and 12.006 TEQ/year productions was from waste incineration (MOEST, 2007).

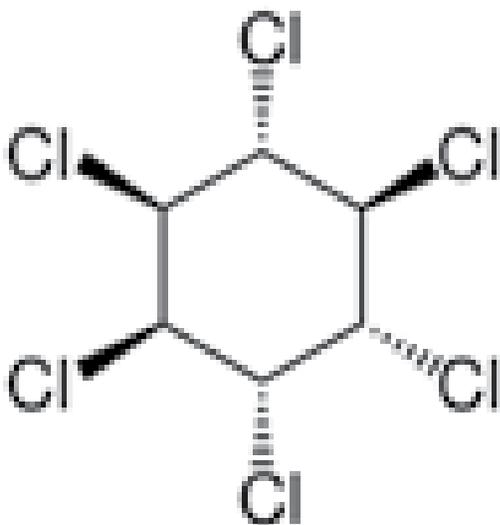
# ALPHA-HEXACHLOROCYCLOHEXANE

$\alpha$ -Hexachlorocyclohexane ( $\alpha$ -HCH) is an organochloride which is one of the isomers of hexachlorocyclohexane (HCH). It is a byproduct of the production of the insecticide lindane ( $\gamma$ -HCH) and it is typically still contained in commercial grade lindane used as insecticide (<http://en.wikipedia.org/wiki/Alpha-Hexachlorocyclohexane>). Although the intentional use of  $\alpha$ -HCH as an insecticide was phased out years ago, this chemical is still produced as unintentional by-product of lindane. For each ton of lindane produced, around 6-10 tons of the other isomers including  $\alpha$ -HCH are created. Large stockpiles of  $\alpha$ -HCH are therefore present in the environment. Once released to the environment, it persists longer, bioaccumulates and adversely affects environment and human health.

|                    |   |
|--------------------|---|
| <b>A. Name</b>     | alpha-Hexachlorocyclohexane( $\alpha$ -HCH)   |
| <b>Other names</b> | $\alpha$ -HCH, $\alpha$ -Benzenehexachloride, $\alpha$ -BHC, alpha-hexachloran(e), alpha -Lindane |
| <b>IUPAC Name</b>  | $\alpha$ -1,2,3,4,5,6-hexachlorocyclohexane   |

**B. CAS Number** 319-84-6

## C. Structure



## D. Properties

|                                   |   |
|-----------------------------------|---|
| <b>Molecular formula</b>          | C <sub>6</sub> H <sub>6</sub> Cl <sub>6</sub> |
| <b>Molar mass</b>                 | 290.83 g/mol                                  |
| <b>Appearance</b>                 | Crystalline Powder                            |
| <b>Color</b>                      | Brownish to white                             |
| <b>Physical state</b>             | Crystalline solid monclinic prisms            |
| <b>Melting point</b>              | 159–160°C                                     |
| <b>Boiling point</b>              | 288°C at 760 mmHg                             |
| <b>Density (g/cm<sup>3</sup>)</b> | 1.87 at 20°C                                  |
| <b>Odor</b>                       | Phosgene-like odor                            |
| <b>Water Solubility</b>           | 10 ppm; 69.5 mg/L at 28°C                     |
| <b>Partition coefficients:</b>    |   |
| <b>Log Kow</b>                    | 3.8   |
| <b>Log Koc</b>                    | 3.57  |
| <b>Vapor pressure</b>             | 4.5x10 <sup>-5</sup> mmHg at 25°C             |
| <b>Henry's law constant</b>       | 6.86x10 <sup>-6</sup>                         |

## E. Impact on human health and environment:

### *Environmental impact*

Alpha-HCH is highly persistent in water in colder regions and may bio-accumulate and biomagnify in biota and arctic food webs. This chemical is subject to long-range transport (<http://chm.pops.int/Implementation/NewPOPs/The9newPOPs/tabid/672/language/en-US/Default.aspx>). This substance may be hazardous to the environment; special attention should be given to water organisms and shellfish. In the food chain important to humans, bioaccumulation takes place, specifically in seafood. It adversely affects the wildlife in contaminated regions. This substance decomposes on heating or on burning producing toxic fumes. It reacts violently with dimethylformamide in the presence of iron. Alpha-HCH has been shown to be neurotoxic, hepatotoxic, and to cause immunosuppressive effects and cancer in laboratory animals. Animals that have been fed Alpha HCH have had convulsions. Long-term oral administration of Alpha HCH or technical-grade HCH to laboratory rodents has been reported to result in liver cancer.

### *Human health effects*

The substance can be absorbed into the body by inhalation of its aerosol, through the skin and by ingestion. In humans, breathing toxic amounts of Alpha HCH can result in blood disorders, dizziness, headaches, and possible changes in the levels of sex hormones in the

blood. The substance irritates the eyes, the skin and the respiratory tract. The substance may cause effects on the central nervous system. Exposure may result in death.

The substance may have effects on the liver. This substance is possibly carcinogenic to humans. IARC has classified HCH (all isomers) as possibly carcinogenic to humans. The US Department of Health and Human Services (DHHS) has determined that HCH (all isomers) may reasonably be anticipated to cause cancer in humans. The US-EPA has classified Alpha HCH as a probable human carcinogen. All HCH isomers can produce liver and kidney effects. Several epidemiological studies indicate that Alpha-HCH might play a role in human breast cancer as well as hormonal disorders leading to infertility and abortions (<http://www.ipen.org/ipenweb/poprc/newpops.html>).

## **F. Standard**

US EPA advises that children should not have more than 1.2 milligrams HCH per liter of water (mg/L) for up to 10 days. For lifetime exposure in adults, EPA recommends that there should not be more than 0.0002 mg/L of HCH in drinking water. EPA has classified HCH as a hazardous waste that must meet certain disposal requirements (<http://www.atsdr.cdc.gov/phs/phs.asp?id=752&tid=138>).

## **G. Persistence**

The Arctic Ocean as the final reservoir for  $\alpha$ -HCH is likely to be slowly depleted, with a half-life of approximately one decade.

## **H. Alternative**

This chemical is by product in the manufacture of Lindane. No alternatives have been identified.

## **I. Country specific issue**

Not well studied in Nepal.

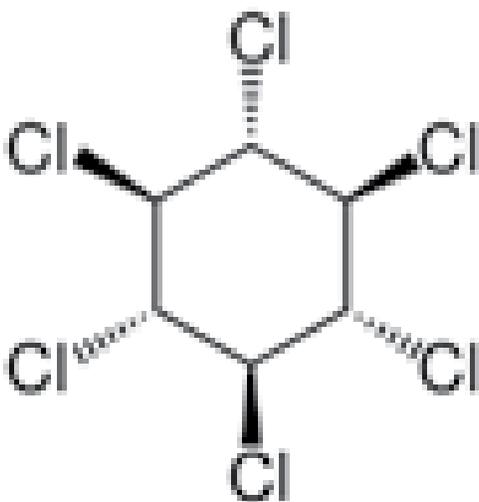
## BETA HEXACHLOROCYCLOHEXANE

$\beta$ -hexachlorocyclohexane ( $\beta$ -HCH) is an organochloride which is one of the isomers of hexachlorocyclohexane (HCH). It is a byproduct of the production of the insecticide lindane ( $\gamma$ -HCH). This pesticide was widely used during the 1960s and 1970s, particularly on cotton plants. Although the intentional use of beta-HCH as an insecticide was phased out years ago, this chemical is still produced as unintentional by-product of lindane. For each ton of lindane produced, around 6-10 tons of the other isomers including beta-HCH are created. Large stockpiles of beta-HCH are therefore present in the environment (<http://chm.pops.int/Implementation/NewPOPs/TheNewPOPs/tabid/672/language/en-US/Default.aspx>). Once released to the environment, it persists longer, bioaccumulates and adversely affects environment and human health.

|                    |  |
|--------------------|--|
| <b>A. Name</b>     | Beta hexachlorocyclohexane ( $\beta$ -HCH)               |
| <b>Other names</b> | $\beta$ -HCH, $\beta$ -Benzenehexachloride, $\beta$ -BHC |
| <b>IUPAC Name</b>  | $\beta$ -1,2,3,4,5,6-hexachlorocyclohexane               |

**B. CAS Number** 319-85-7

### C. Structure



## D. Properties

|                                   |   |
|-----------------------------------|---|
| <b>Molecular formula</b>          | C <sub>6</sub> H <sub>6</sub> Cl <sub>6</sub> |
| <b>Molar mass</b>                 | 290.83 g/mol                                  |
| <b>Color</b>                      | No data                                       |
| <b>Physical state</b>             | Crystalline solid                             |
| <b>Melting point</b>              | 314–315°C                                     |
| <b>Boiling point</b>              | 60 °C at 0.5 mmHg                             |
| <b>Density (g/cm<sup>3</sup>)</b> | 1.89 at 19°C                                  |
| <b>Odor</b>                       | No data                                       |
| <b>Water solubility</b>           | 5 ppm   |
| <b>Partition coefficients:</b>    |   |
| <b>Log Kow</b>                    | 3.78  |
| <b>Log Koc</b>                    | 3.57  |
| <b>Vapor pressure</b>             | 3.6x10 <sup>-7</sup> at 20°C                  |
| <b>Henry's law constant</b>       | 4.5x10 <sup>-7</sup>                          |

## E. Impact on human health and environment

### *Environmental impact*

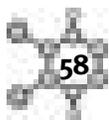
Due to its persistence, beta-HCH can still be detected at low background levels in all environmental media except in regions with recent usage and/or high pollution. Fairly high concentrations of beta-HCH have been found in Arctic marine mammals and birds.

Beta-HCH is present in terrestrial and aquatic food chain. Beta-HCH may bioaccumulate and biomagnify in biota and Arctic food webs, especially in upper trophic levels. Beta-HCH is highly persistent in water in colder regions and may bioaccumulate and biomagnify in biota and arctic food webs. This chemical is subject to long-range transport.

Beta HCH is acutely toxic to aquatic organisms and shows estrogenic effects in fish. It adversely affects the wildlife in contaminated regions. Animal studies show that organochlorine pesticides, including beta-HCH, are neurotoxic, cause oxidative stress, and damage the brain's dopaminergic system (<http://en.wikipedia.org/wiki/Beta-Hexachlorocyclohexane>).

### *Human health effects*

In humans, breathing toxic amounts of beta-HCH can result in blood disorders, dizziness, headaches, and possible changes in the levels of sex hormones in the blood. These effects



have occurred in workers exposed to HCH vapors during pesticide manufacturing. All HCH isomers can produce liver and kidney effects. Human studies show that exposure to beta-HCH is linked to Parkinson's and Alzheimer's disease.

In humans, accumulation in fat tissue and high concentrations in blood and in breast milk may occur. Beta-HCH transfers from mothers to embryos and lactating infants (POPRC, 2007a). Toxicological studies with Beta-HCH have demonstrated neurotoxicity and hepatotoxicity. Also reproductive and immunosuppressive effects and effects on fertility were seen in laboratory animals. Several epidemiological studies indicate that beta-HCH might play a role in human breast cancer. It is classified as potentially carcinogenic to humans and adversely affects human health in contaminated regions. The US DHHS has determined that HCH (all isomers) may reasonably be anticipated to cause cancer in humans. The US-EPA has classified Beta HCH as possibly human carcinogenic. IARC has classified HCH (all isomers) as possibly carcinogenic to humans.

## **F. Standard**

US EPA advises that children should not have more than 1.2 milligrams HCH per liter of water (mg/L) for up to 10 days. For lifetime exposure in adults, EPA recommends that there should not be more than 0.0002 mg/L of HCH in drinking water. EPA has classified HCH as a hazardous waste that must meet certain disposal requirements (<http://www.atsdr.cdc.gov/phs/phs.asp?id=752&tid=138>).

## **G. Persistence**

Beta-HCH showed half-lives in soil laboratory and field studies of 91–184 days. Beta-HCH is, due to its chemical structure, the most persistent HCH isomer. It comprised 80–100 per cent of the total HCH residues found in soil and vegetation on land surrounding an industrial landfill in Germany 10 years after the final HCH input (<http://chm.pops.int/Portals/o/Repository/poprc2/UNEP-POPS-POPRC.2-POPRC-2-10.English.PDF>).

## **H. Alternative**

This chemical is by product in the manufacture of Lindane. No alternatives have been identified.

## **I. Country specific issue**

Not well studied in Nepal.

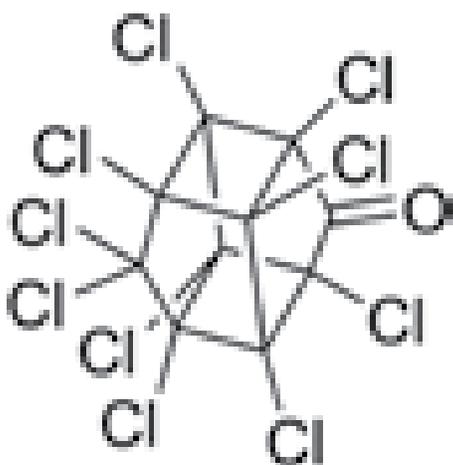
# CHLORDECONE

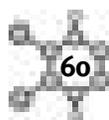
Chlordecone is a synthetic chlorinated organic compound. It is chemically related to Mirex and is a chlorinated polycyclic ketone. Chlordecone, also known as Kepone, is an insecticide related to mirex. Chlordecone is a synthetic chlorinated organic compound, which was mainly used as an agricultural pesticide. Chlordecone was formerly used as pesticide on banana root borer, fly larvicide, apple scab, powdery mildew, Colorado potato beetle, rust mite, wireworm, and household ant and roach traps (<http://www.ipen.org/ipenweb/poprc/newpops.html>). It was first produced in 1951 and introduced commercially in 1958. Currently, no use or production of the chemical is reported. Once released to the environment, it persists longer, bioaccumulates and adversely affects environment and human health.

|  |   |
|--|---|
| <b>A. Name</b>                                 | Chlordecone   |
| <b>Synonyms and Trade Names (partial list)</b> | GC 1189, Kepone, Merex  |
| <b>IUPAC Name</b>                              | 1,1a,3,3a,4,5,5,5a,5b,6-Decachlorooctahydro-2H-1,3,4- (methanetriyl)cyclobuta[cd]pentalen-2-one |

**B. CAS Number** 143-50-0

## C. Structure





## D. Properties

|  |   |
|--|---|
| <b>Molecular formula</b>               | $C_{10}Cl_{10}O$  |
| <b>Molar mass</b>                      | 490.64 g mol <sup>-1</sup>  |
| <b>Density</b>                         | 1.6 g/cm <sup>3</sup>   |
| <b>Appearance</b>                      | An odorless tan-white crystalline solid   |
| <b>Solubility</b>                      | Low water solubility (1-3 mg/L),<br>Soluble in strongly alkaline aqueous solutions, alcohols,<br>ketones, dimethyl sulfoxide, acetic acid, and hydrocarbon<br>solvents such as hexane and benzene |
| <b>Vapour Pressure Pa at 25°C</b>      | 3x10 <sup>-5</sup> to 4x10 <sup>-5</sup>  |
| <b>Henry's law constant at 20 °C</b>   | 2.50x10 <sup>-8</sup> atm m <sup>3</sup> /mole  |
| <b>Partition Coefficient (Log Kow)</b> | 4.50  |

## E. Impact on human health and environment:

### ***Environmental impact***

Chlordecone is very stable in the environment. No degradation products have been identified. Chlordecone breaks down slowly in the environment, and it may stay for years in soil and water. It also does not evaporate to any great extent from surface water or surface soil. Chlordecone does not dissolve easily in water, but will preferentially bind to soil and sediment particles. In soils, It is fairly immobile and is unlikely to migrate far through soil or in groundwater. In the air, Chlordecone will directly photodegrade or react with photochemically produced hydroxy radicals or ozone. It will adsorb into particulate matter in the atmosphere, so it will also be subject to gravitational settling. Like Mirex and other POPs, Chlordecone can bio-accumulate in fish or other organisms that live in contaminated water or that eat other contaminated animals. It is very toxic to aquatic organisms, with the most sensitive group being the invertebrates. Animal studies have shown effects similar to those seen in people, as well as harmful kidney effects, developmental effects, and effects on the ability of females to reproduce(<http://kirkmanlabs.com/Pages/61/PesticidesBi-Ch/>).

### ***Human health effects***

The primary routes of potential human exposure to Chlordecone are inhalation, ingestion, and dermal contact. It is both acutely and chronically toxic, producing neurotoxicity, immunotoxicity, reproductive, musculoskeletal and liver toxicity. The dry powder is readily absorbed through the skin and respiratory tract. Some unprotected production workers

exposed to kepone powder suffered tremors, jerky eye movements, memory loss, headaches, slurred speech, unsteadiness, lack of coordination, loss of weight, rash, enlarged liver, decreased libido, sterility, chest pain, arthralgia, and the increased risk of developing cancer. Workers who were exposed to high levels of Chlordecone over a long period (more than one year) showed harmful effects on the nervous system, skin, liver, and male reproductive system. These workers were likely exposed primarily through touching Chlordecone, although they may have inhaled or ingested some as well.

The U.S. DHHS has determined that Chlordecone may reasonably be anticipated to be a carcinogen. There are no studies available on whether Chlordecone is carcinogenic to humans. However, studies in mice and rats have shown that ingesting Chlordecone can cause liver, adrenal gland and kidney tumors. It is classified as an IARC Group 2B carcinogen.

## F. Standard

Its NIOSH Recommended Exposure Limit (REL) is  $0.001 \text{ mg/m}^3$ . The US National Institute for Occupational Safety and Health (NIOSH) recommends that the average workroom air levels of chlordecone should not exceed 50 parts per trillion (ppt) over an 8-hour period. US FDA has determined that concentrations of chlordecone below 400 ppt in fish, crabs, and shellfish are not likely to harm people who eat these foods (<http://www.atsdr.cdc.gov/phs/phs.asp?id=641&tid=118#>).

## G. Persistence

Kepone persists in the environment, with a Half-life of about 30 years. (<http://en.wikipedia.org/wiki/Kepone>). The half-life of kepone in a model river is 2.8 to 46 years (<http://ntp.niehs.nih.gov/ntp/roc/eleveth/profiles/s10okepo.pdf>). The estimated half-life of chlordecone in soil is between 1-2 years ([http://www.pops.int/documents/meetings/cop\\_1/chemlisting/chlordecone\\_f.pdf](http://www.pops.int/documents/meetings/cop_1/chemlisting/chlordecone_f.pdf)).

## H. Alternative

Alternatives to Chlordecone exist and can be implemented inexpensively.



| <b>Name</b>  | <b>Use</b>                                   |
|--|--|
| Ethoprop, oxamyl   | Pesticide to control banana root borer       |
| Cyfluthrin, Imidacloprid   | Pesticide to control tobacco wireworms       |
| Azadirachtin, bifenthrin, boric acid, carbaryl, capsaicin, cypermethrin, cyfluthrin, deltamethrin, diazinon, dichlorvos, esfenvalerate, imidacloprid, lambda-cyhalothrin, malathion, permethrin, piperonyl butoxide, pyrethrins, pyriproxyfen, resmethrin, s-bioallerthrin, tetramethrin | Pesticide to control ants and/or cockroaches |

(Guidance Material on New POPs, 2009)

## **I. Country specific issue**

Not well studied in Nepal.

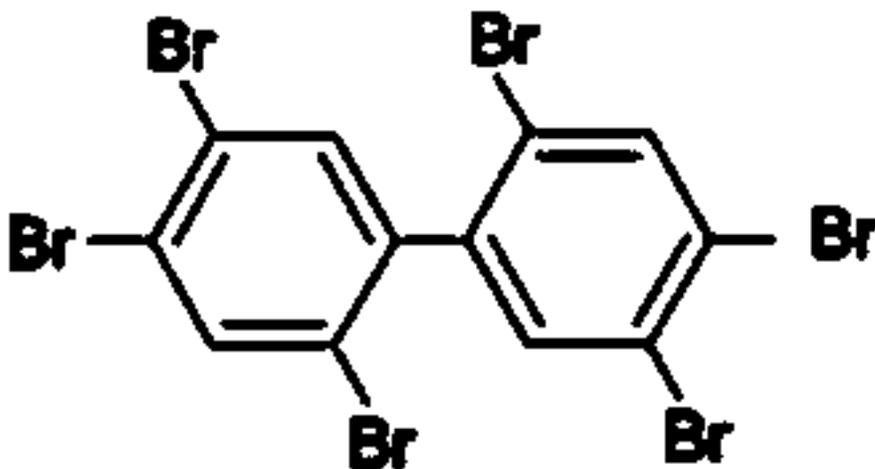
## HEXABROMOBIPHENYL (HBB)

Hexabromobiphenyl is an industrial chemical that has been used as a flame retardant in acrylonitrile-butadiene-styrene (ABS) thermoplastics for constructing business, machine housings and in industrial and electrical products and in polyurethane foam for auto upholstery, mainly in the 1970s (UNEP, 2006). According to available information, hexabromobiphenyl is no longer produced or used in most countries. Once released to the environment, it persists longer, bioaccumulates and adversely affects environment and human health. It belongs to the group of polybrominated biphenyls (PBBs).

|                                 |  |
|---------------------------------|--|
| <b>A. Name</b>                  | Hexabromobiphenyl  |
| <b>Trade names and Synonyms</b> | Firemaster BP-6; Firemaster FF-1; nci-c53634; polybromobiphenyl; hexabromo-biphenyl; hexabromo-1'-biphenyl; hexabromo-1,1'-biphenyl; Polybrominated biphenyl; 1,1-Biphenyl, hexabromo; HBB |
| <b>IUPAC Name</b>               | 1, 2,3-tribromo-4-(2,3,4-tribromophenyl) benzene   |

**B. CAS Number** 36355-01-8

### C. Structure



## D. Properties

|  |   |
|--|---|
| <b>Molecular Formula</b>                           | $C_{12}H_4Br_6$   |
| <b>Molecular Weight</b>                            | 627.584160 (g/mol)  |
| <b>General Description</b>                         | White solid or tan powder   |
| <b>Reactivity Profile</b>                          | Very unreactive   |
| <b>Fire Hazard</b>                                 | Nonflammable  |
| <b>Volatility</b>                                  | Less  |
| <b>Boiling Point (°C)</b>                          | No Data   |
| <b>Melting Point (°C)</b>                          | 72  |
| <b>Density (20°C) (g/ml)</b>                       | 11  |
| <b>Solubility in water (µg/litre)</b>              | 3   |
| <b>Vapor Pressure (kPa)</b>                        | $6.9 \times 10^{-6}$ (25°C) $7.5 \times 10^{-4}$ (liquid, sub-cooled) |
| <b>Log KOW</b>                                     | 6.39  |
| <b>Henry's Law Constant (Pa m<sup>3</sup>/mol)</b> | $1.40 \times 10^{-1}$   |

## E. Impact on human health and environment

### *Environmental impact*

According to available data, Hexabromobiphenyl can be considered to be highly persistent in the environment. There is evidence of low or no degradation in water, soil and sediment, in the laboratory as well as in the field. Extensive data on monitoring shows that it is found throughout the Arctic wildlife, demonstrating that it does have a high potential for long range environmental transport. Hexabromobiphenyl is considered to be highly bio-accumulative and to have a high potential for bio-magnification. Recent monitoring data in soil, water and sediments for PBBs are limited. Historical monitoring data from the United States indicate that environmental PBB concentrations are confined to areas near former manufacturing facilities and regions of Michigan affected by the farm accident of the early 1970's. The only available data for environmental concentrations of PBBs in areas outside the vicinity of former production sites are those from sediment samples from Greenland, where PBBs (including PBB 153) were not detected in any sample (the limits of detection/quantification are, however, not well defined in the paper). PBBs are lipophilic and have the ability to bio-concentrate in the food chain.

### *Human health effects*

Hexabromobiphenyl is readily absorbed into the body and accumulates following prolonged exposure. There is epidemiological evidence of hypothyroidism in workers exposed to polybrominated biphenyls and of increased incidence of breast cancer in exposed women. IARC

has classified Hexabromobiphenyl as a possible human carcinogen (IARC group 2B). The PBBs are endocrine disrupting chemicals, and effects are seen on reproductive capacity in rats, mink and monkeys. There is epidemiological evidence of hypothyroidism in workers exposed to polybrominated biphenyls and of increased incidence of breast cancer in exposed women.

## F. Persistence

Hexabromobiphenyl belongs to a wider group of polybrominated biphenyls. The EHC review concludes that polybrominated biphenyls (PBBs) are stable and persistent in the environment. The degradation of PBBs by purely abiotic chemical reactions (excluding photochemical reactions) is considered unlikely. PBBs have been reported to be persistent under field conditions. Soil samples from a former PBB manufacturing site, analyzed several years after accidental release, still contained PBBs. However, the congener composition was different, indicating partial degradation of the PBB residue in the soil samples.

According to the EHC Review, follow-up surveys over a three year period following the termination of PBB production showed no significant decline in PBB levels in sediments from a river. In laboratory investigations, mixtures of PBBs appear to be fairly resistant to microbial degradation ([http://www.pops.int/documents/meetings/cop\\_1/chemlisting/HBB\\_f.pdf](http://www.pops.int/documents/meetings/cop_1/chemlisting/HBB_f.pdf)).

## G. Alternative

Alternatives are available for all uses of Hexabromobiphenyl.

| Name  | Use                   |
|---|-----------------------|
| Tris-chloropropyl-phosphate (TCPP), tris-chloroethyl-phosphate, and tris dichloropropyl phosphate (TDCPP), triphenyl phosphate (TPP), tricresyl phosphate (TCP), resorcinol bis(diphenylphosphate) (RDP), and phosphonic acid (2-((hydroxymethyl) carbamyl)ethyl)-dimethyl ester (Pyrovatex®) | ABS plastics          |
| Aluminium trihydroxide and zinc borate  | Coatings and lacquers |
| Ammonium polyphosphate (APP) is commonly used in combination with Aluminium hydroxide and Melamine  | Polyurethane foams    |

(Guidance Material on New POPs, 2009)

## H. Country specific issue

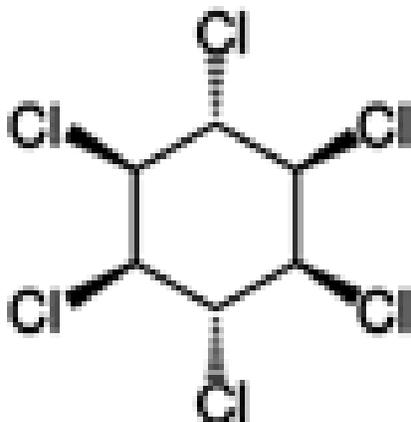
Not well studied in Nepal.

# LINDANE

Lindane is an organochlorine chemical variant of hexachlorocyclohexane that has been used both as an agricultural insecticide and as a pharmaceutical treatment. Lindane has been used as a broad-spectrum insecticide for seed and soil treatment, foliar applications, tree and wood treatment and against ectoparasites in both veterinary and human applications including treatment of human lice and scabies. The chemical was originally synthesized in 1825 by Faraday, but its pesticidal action was discovered only in 1942. It has been used to treat food crops and to forestry products, as a seed treatment, a soil treatment, and to treat livestock and pets. It has also been used as pharmaceutical treatment for lice and scabies, formulated as a shampoo or lotion. It is estimated that between 1950 and 2000, around 600,000 tonnes of lindane were produced globally, and the vast majority of which was used in agriculture (<http://en.wikipedia.org/wiki/Lindane>). It has been manufactured by several countries, including the United States, China, Brazil, and several European countries. The production of lindane has decreased rapidly in the last few years and only few countries are still known to produce lindane but are in use in many countries as pharmaceutical products. Once released to the environment, it persists longer, bioaccumulates and adversely affects environment and human health.

|                      |  |
|----------------------|--|
| <b>A. Name</b>       | Lindane (gamma-HCH)  |
| <b>Trade Names</b>   | Agrocide, Aparasin, Arbitex, BBH, Ben-hex, Bentox, Celanex, Chloresene, Dvoran, Dol, Entomoxan, Exagamma, Forlin, Gallogama, Gamaphex, Gammalin, Gammex, Gammexane, Hexa, Hexachloran, Hexaverm, Hexicide, Isotos, Kwell, Lendine, Lentox, Linafor, Lindafor, Lindagam, Lindatox, Lintox, Lorexane, Nexit, Nocochloran, Novigam, Omnitox, Quellada, Silvanol, Tri-6, Vitron. |
| <b>IUPAC Name</b>    | (1r,2R,3S,4r,5R,6S)-1,2,3,4,5,6-hexachlorocyclohexane  |
| <b>B. CAS Number</b> | 58-89-9  |

## C. Structure



## D. Properties

|  |   |
|--|---|
| Formula                                | C <sub>6</sub> H <sub>6</sub> Cl <sub>6</sub> |
| Molecular mass                         | 290.83 g/mol                                  |
| Protein binding                        | 91%   |
| Boiling point (°C)                     | 323.4   |
| Melting point(°C)                      | 112.5   |
| Density (20°C) (g/ml)                  | 1.84  |
| Solubility in water (mg/litre at 20°C) | 0.0007  |
| Vapour pressure (mmHg) (20 °C)         | 4.2x10 <sup>-5</sup>                          |
| Henry's Law constant at 25°C           | 3.5x10 <sup>-6</sup> atm m <sup>3</sup> /mol  |
| Physical state                         | Crystalline solid                             |

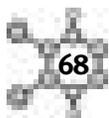
## E. Impact on human health and environment

### *Environmental impact*

It is relatively long-lived in the environment, it is transported long distances by natural processes like global distillation, and it can bio-accumulate in food chains and bio-concentrates rapidly. There is evidence for long-range transport. Hepatotoxic, immunotoxic, reproductive and developmental effects have been reported for Lindane in laboratory animals (<http://www.ipen.org/ipenweb/poprc/newpops.html>).

### *Human health effects*

In humans, Lindane primarily affects the nervous system, liver and kidneys, and may be a carcinogen and/or endocrine disruptor. The most commonly reported effects associated with



oral exposure to it are neurological including seizures and convulsions in individuals who have accidentally or intentionally ingested Lindane in insecticide pellets, liquid scabicide or contaminated food. It affects the central nervous and endocrine systems. In humans, effects from acute exposure at high concentrations to Lindane may range from mild skin irritation to dizziness, headaches, diarrhea, nausea, vomiting, and even convulsions and death. Respiratory, cardiovascular, hematological, hepatic and endocrine effects have also been reported for humans, following acute or chronic Lindane inhalation. Hematological alterations like leukopenia, leukocytosis, granulocytopenia, granulocytosis, eosinophilia, monocytosis, and thrombocytopenia, have been reported, following chronic human occupational exposure to gamma-HCH at production facilities (ATSDR, 2005 in POPRC, 2006). It is classified as an IARC Group 2B carcinogen.

## F. Standard

US EPA has set an enforceable regulation for Lindane, called a MCL, at 0.0002 mg/L or 200 ppt. OSHA regulates levels of  $\gamma$ -HCH in the workplace. The maximum allowable amount in workplace air during an 8-hour workday in a 40-hour work week is 0.5 mg per cubic meter of air (<http://www.atsdr.cdc.gov/phs/phs.asp?id=752&tid=138>).

## G. Persistence

Lindane is highly persistent in most soils, with a field half-life of approximately 15 months (<http://extoxnet.orst.edu/pips/lindane.htm>). It has a half life of 2.3 to 13 days in air and a half life of 30 to 300 days in water. It is stable to light, high temperatures and acid but it can be hydrolyzed at high pH. Lindane degrades very slowly by microbial action. Brubaker and Hites (1998) estimated a lifetime in air of 96 days for Lindane (POPRC, 2006). Lindane has half-lives of 3-30 days in rivers and 30 to 300 days in lakes. Other studies report calculated or experimental hydrolysis half-lives ranging from 92 to 3090 hours depending on the study; a persistence of about 2 to 3 years in soil is also reported (Mackay et al., 1997 in POPRC, 2006).

## H. Alternative

Alternatives for Lindane are generally available, except for use as a human health pharmaceutical to control head lice and scabies.



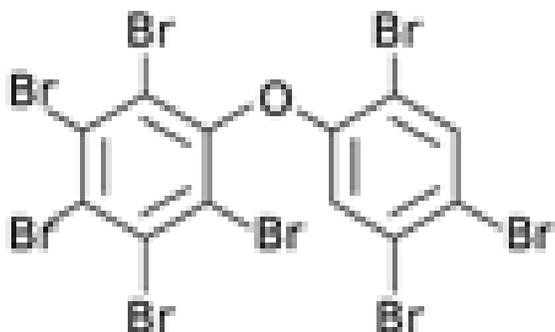
## HEXABROMODIPHENYL ETHER AND HEPTABROMODIPHENYL ETHER

Hexabromodiphenyl ether and heptabromodiphenyl ether are the main components of commercial octabromodiphenyl ether. Octabromodiphenyl ether is used in conjunction with antimony trioxide as a flame retardant in the housings of electrical and electronic equipment, mainly in the plastic acrylonitrile butadiene styrene, but also in high impact polystyrene, polybutylene terephthalate and polyamides. Typically 12–15% of the weight of the final product will consist of octaBDE. Commercial Octabromodiphenyl ether (c-octaBDE) is a mixture of several polybrominated diphenyl ethers and congeners. The annual demand worldwide was estimated as 3,790 tonnes in 2001, of which Asia accounted for 1,500 tonnes, the America 1,500 tonnes, and Europe 610 tonnes ([http://en.wikipedia.org/wiki/Octabromodiphenyl\\_ether](http://en.wikipedia.org/wiki/Octabromodiphenyl_ether)). Once released to the environment, it persists longer, bioaccumulates and adversely affects environment and human health.

|                                    |   |
|------------------------------------|---|
| <b>A. Name</b>                     | Hexabromodiphenyl ether and Heptabromodiphenyl ether (Commercial Octabromodiphenyl ether)   |
| <b>Other Names and Trade Names</b> | Diphenyl ether, octabromo derivative, Octabromodiphenyl oxide, Octabromobiphenyl oxide, Octabromodiphenyl ether, Phenyl ether, Bromkal 79-8DE, CD 79, DE 79, EB 8, FR 1208, FR 143, Tardex 80 |
| <b>IUPAC Name</b>                  | 2,2',3,4,4',5,5',6-octabromodiphenyl ether  |

**B. CAS Number** 68631-49-2, 207122-15-4, 446255-22-7, 207122-16-5

## C. Structure



## D. Properties

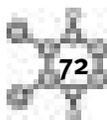
|   |                       |
|---|-----------------------|
| <b>Molecular formula</b>                                    | $C_{12}H_2Br_8O$      |
| <b>Molar mass</b>   | 801.31 g/mol          |
| <b>Appearance</b>   | white solid           |
| <b>Density</b>  | 2.9 g/cm <sup>3</sup> |
| <b>Solubility in water</b>                                  | 0.0005 (mg/litre)     |
| <b>Vapour pressure (Pa) at 21 °C.</b>                       | $6.59 \times 10^{-6}$ |
| <b>Henry's Law Constant at 25 °C (Pa m<sup>3</sup>/mol)</b> | 10.6                  |
| <b>Log Kow</b>  | 6.29                  |

## E. Impact on human health and environment:

### **Environmental impact**

In the environment, photolysis, anaerobic degradation and metabolism in biota can cause debromination of octaBDE, which produces PBDEs with fewer bromine atoms which may have higher toxicity and bioaccumulation potential ([http://en.wikipedia.org/wiki/Octabromodiphenyl\\_ether](http://en.wikipedia.org/wiki/Octabromodiphenyl_ether)).

The available ecotoxicity data for the c-octaBDE product show little or no effect on aquatic organisms (short-term fish study and a longer-term *Daphnia magna* study), sediment organisms (*Lumbriculus variegatus*) and soil organisms (three species of plant and earthworms *Eisenia fetida*) (European Commission 2003 in <http://www.popstoolkit.com/about/chemical/c-octabde.aspx>). However, the EU Risk Assessment Report identifies a risk of secondary poisoning in other species (via ingestion of earthworms) for the hexabromodiphenyl ether component in the c-octaBDE product (from use in polymer applications).



Unfortunately, the available information on the toxicity and ecotoxicity of hexa to nonaBDE [which make up commercial OctaBDE] is very limited. Effects on mammals and birds include slight fetotoxicity, increased liver weights, and delayed skeletal ossification (<http://www.ipen.org/ipenweb/poprc/newpops.html>).

Besides, octaBDE is predicted to adsorb strongly onto sediment and soil, which means that only a fraction of this PBDE will be exposed to sunlight, thus having the potential to photodegrade. No information is available on the hydrolysis of octaBDE, but it is not expected to be an important process for octaBDE in the environment.

### **Human health effects**

The chemical has no proven health effects in humans; however, based on animal experiments, octaBDE may have effects on the liver, thyroid, and neurobehavioral development. It is stored mainly in body fat and may stay in the body for years. The presence of lower brominated diphenyl ethers in the c-octaBDE products is of concern also from the human health point of view as they are likely to have a higher potential to cause adverse effects.

Within the EU, c-octaBDE has been classified as “Toxic”, due to its effects on human health, with the risk phrases “may cause harm to unborn child”, and “possible risk of impaired fertility” (<http://www.popstoolkit.com/about/chemical/c-octabde.aspx>).

## **F. Persistence**

OctaBDE has been found to photodegrade rapidly in a mixture of organic solvents, with a half life of around 5 hours, but the environmental significance of such a finding is uncertain (European Commission, 2003 in <http://www.popstoolkit.com/about/chemical/c-octabde.aspx>). Regarding biotic degradation, octaBDE is not readily biodegradable in standard tests (no degradation seen over 28 days) and is not expected (by analogy with other brominated diphenyl ethers) to degrade rapidly under anaerobic conditions. Nevertheless, other more highly brominated congeners (deca and nonabromodiphenyl ether) have been found to degrade anaerobically in sewage sludge, although at a very slow rate (Gerecke et al. 2005 in POPRC, 2007b). The evidence seems to indicate that there is little significant biotic or abiotic degradation of octaBDE (<http://www.popstoolkit.com/about/chemical/c-octabde.aspx>).

## G. Alternative

| Name  | Use                      |
|---|--------------------------|
| Tetrabromobisphenol-A, 1,2-bis(pentabromophenoxy) ethane, 1,2-bis(tribromophenoxy) ethane, triphenyl phosphate, resorcinol bis (diphenylphosphate) and brominated polystyrene | For ABS plastic          |
| Reactive phosphorous constituents and hexabromocyclododecane  | Textiles                 |
| Bis (tribromophenoxy) ethane and tribromophenyl allyl ether   | Thermoplastic elastomers |
| Polypropylene-dibromostyrene, dibromostyrene, and tetrabromobisphenol A (TBBPA)   | Polyolefins              |

(Guidance Material on New POPs, 2009)

## H. Country specific issue

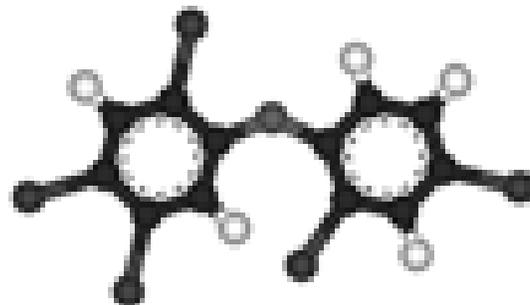
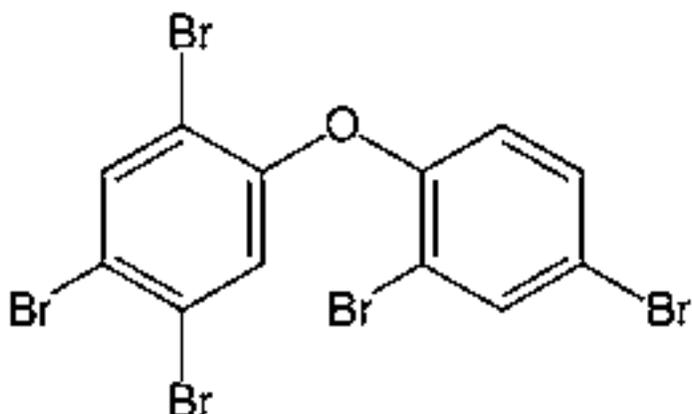
Not well studied in Nepal.

## TETRABROMODIPHENYL ETHER AND PENTABROMODIPHENYL ETHER

C-PentaBDE has been used as a flame retardant additive in flexible polyurethane foam for furniture and upholstery and in electronic equipment. It was also used in printed circuit boards. They are also used to some extent in specialized applications in textiles and in industry. The main source in North America and Western Europe has been the C-PentaBDE incorporated in polyurethane foam, used in domestic and public furniture. This use is now mainly phased out. Emissions of PentaBDE can also occur from recycling and dismantling activities such as dismantling of vehicles, buildings and constructions. Emissions can occur from electronic waste recycling plants and shredder plants. Potentially toxic products such as brominated dibenzo-p-dioxins and furans might be generated during incineration of articles containing C-PentaBDE (<http://www.popstoolkit.com/about/chemical/c-pentabde.aspx>). Once released to the environment, it persists longer, bioaccumulates and adversely affects environment and human health.

|                                    |   |
|------------------------------------|---|
| <b>A. Name</b>                     | Tetrabromodiphenyl ether and Pentabromodiphenyl ether   |
| <b>Other Names and Trade Names</b> | Diphenyl ether, pentabromo derivative, Pentabromodiphenyl oxide, Pentabromodiphenyl ether, Pentabromophenoxybenzene Bromkal G 1, DE 6oFTM, Planelon PB 501, Saytex 125, Tardex 50 |
| <b>IUPAC Name</b>                  | 1,2,4-tribromo-5-(2,4-dibromophenoxy)benzene  |
| <b>B. CAS Number</b>               | 5436-43-1, 60348-60-9   |

### C. Structure



### D. Properties

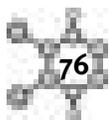
|                                   |  |
|-----------------------------------|--|
| <b>Molecular formula</b>          | C <sub>12</sub> H <sub>5</sub> Br <sub>5</sub> O   |
| <b>Molar mass</b>                 | 564.69 g/mol   |
| <b>Appearance</b>                 | Amber solid or coarse white powder   |
| <b>Solubility in water</b>        | Commercial pentabromodiphenyl ether components have water solubility between 2 and 13 µg/l |
| <b>Boiling Point (decomposes)</b> | 200-300°C  |
| <b>Melting Point</b>              | -7 to -3°C   |
| <b>Relative Density (water=1)</b> | 2.25-2.28  |
| <b>Vapor Pressure, Pa</b>         | Negligible (between 9.6 x 10 <sup>-8</sup> -4.7 x 10 <sup>-5</sup> )                       |

They belong to group of chemicals known as “polybromodiphenyl ethers” (PBDEs).

### E. Impact on human health and environment

#### **Environmental impact**

Commercial mixture of pentaBDE is highly persistent in the environment, bio-accumulative and has a high potential for long-range environmental transport. There is evidence of its potential for toxic effects in wildlife, including mammals. Toxicological studies have demonstrated reproductive toxicity, neurodevelopmental toxicity and effects on thyroid hormones in aquatic organisms and in mammals (<http://www.ipen.org/ipenweb/poprc/newpops.html>). Elevated concentrations can be found in air, water, soil, food, sediment, sludge, and dust.



### **Human health effects**

The chemical has no proven health effects in humans. However, based on animal experiments, pentaBDE may have effects on the liver, thyroid, and neurobehavioral development (<http://www.popstoolkit.com/about/chemical/c-pentabde.aspx>). Information is lacking on the effects in humans of short-term and long-term exposure, although it is to be expected that vulnerable groups can be pregnant women, embryos and infants. These chemicals have been detected in humans in all regions.

### **F. Standard**

US EPA requires that companies that transport, store, or dispose of p-bromodiphenyl ether (a particular PBDE compound not found in any commercial PBDE product) follow the rules and regulations of the federal hazardous waste management program. EPA also limits the amount of p-bromodiphenyl ether put into publicly owned waste water treatment plants. To minimize exposure of people to p-bromodiphenyl ether, EPA requires that industry tell the National Response Center each time 100 pounds or more of p-bromodiphenyl ether have been released to the environment ([http://www.eoearth.org/article/Public\\_Health\\_Statement\\_for\\_Polybrominated\\_Diphenyl\\_Ethers\\_\(PBDEs\)](http://www.eoearth.org/article/Public_Health_Statement_for_Polybrominated_Diphenyl_Ethers_(PBDEs))).

### **G. Persistence**

PentaBDE does meet the criterion of persistence in water and sediment. According to a standard OECD test, pentaBDE is not readily biodegradable. Degradation in water, soil and sediment has not been reported in any experimental study, the data shown here refers to QSAR estimates (<http://www.lec.lancs.ac.uk/download/ccm/pebde.pdf>).

|                                      |                                     |
|--------------------------------------|-------------------------------------|
| Degradation in water (half-life):    | 150 days (BDE-47)                   |
|                                      | 150 days (BDE-99)                   |
| Degradation in soil (half-life):     | 150 days (BDE-47)                   |
|                                      | 150 days (BDE-99)                   |
| Degradation in sediment (half-life): | 600 days (BDE-47, aerobic sediment) |
|                                      | 600 days (BDE-99, aerobic sediment) |

### **H. Alternative**

Alternatives are available and used to replace these substances in many countries, although they might also have adverse effects on human health and the environment.

| <b>Name</b>   | <b>Use</b>                      |
|---|---------------------------------|
| Melamine, tris (1,3-dichloro-2-propyl) phosphate (TDCPP) (or TCPP) and ammonium polyphosphate (APP).  | PUR foam                        |
| Bromine-free circuit boards, phosphorus-based flame retardants for printed circuit boards, flame resistant plastic, halogen-free materials and low-voltage internal wires | Electronic equipment-appliances |
| Antimony trioxide and borax   | Textiles                        |

(Guidance Material on New POPs, 2009)

## I. Country specific issue

Not well studied in Nepal.

## PENTACHLOROBENZENE (PeCB)

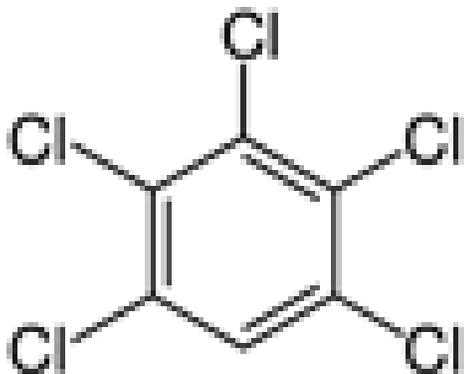
PeCB was used in PCB products, in dyestuff carriers, as a fungicide, a flame retardant and as a chemical intermediate e.g. previously for the production of quintozene. PeCB might still be used as an intermediate. PeCB was a component of a mixture of chlorobenzenes added to products containing polychlorinated biphenyls in order to reduce viscosity. PeCB is also produced unintentionally during combustion, thermal and industrial processes. It is also present as impurities in products such as solvents or pesticides (<http://chm.pops.int/Implementation/NewPOPs/The9newPOPs/tabid/672/language/en-US/Default.aspx>).

PeCB can be produced as a byproduct of the manufacture of carbon tetrachloride and benzene. It is extracted by distillation and crystallization. The direct production of pure PeCB is not practical because of the simultaneous production of other chlorinated compounds. Since PeCB is generally produced in small quantities in the chlorination of benzene, it is also contained in other chlorobenzenes (dichlorobenzenes, trichlorobenzenes, etc.) Today, a majority of the PeCB released into the environment is a result of backyard trash burning and municipal waste incineration (<http://en.wikipedia.org/wiki/Pentachlorobenzene>). Once released to the environment, it persists longer, bioaccumulates and adversely affects environment and human health.

|  |   |
|--|---|
| <b>A. Name</b>                               | Pentachlorobenzene  |
| <b>Trade names and names of preparations</b> | Benzene, pentachloro-; Pentachlorobenzene: 1,2,3,4,5-Pentachloroben;zene; pentachlorinated benzene: quinto;zene |
| <b>IUPAC Name</b>                            | 1,2,3,4,5-Pentachlorobenzene  |

**B. CAS Number**                      608-93-5

## C. Structure



## D. Properties

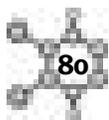
|                            |                             |
|----------------------------|-----------------------------|
| <b>Molecular formula</b>   | $C_6HCl_5$                  |
| <b>Molar mass</b>          | 250.34 g mol <sup>-1</sup>  |
| <b>Appearance</b>          | White or colorless crystals |
| <b>Density</b>             | 1.8 g/cm <sup>3</sup>       |
| <b>Melting point</b>       | 86°C                        |
| <b>Boiling point</b>       | 275-277°C                   |
| <b>Solubility in water</b> | 0.56 mg/l at 20°C           |
| <b>Vapour pressure</b>     | 2.2 Pa at 25°C              |
| <b>Log Kow</b>             | 4.8 - 5.18                  |

PeCB belongs to a group of chlorobenzenes. It is a chlorinated aromatic hydrocarbon.

## E. Impact on human health and environment

### ***Environmental impact***

PeCB is persistent in the environment, highly bio-accumulative in the food chain and has a potential for long-range environmental transport. It is very toxic to aquatic organisms, and decomposes on heating or on burning with the formation of toxic, corrosive fumes including hydrogen chloride. Combustion of PeCB may also result in the formation of polychlorinated dibenzodioxins (“dioxins”) and polychlorinated dibenzofurans (<http://en.wikipedia.org/wiki/Pentachlorobenzene>).



### **Human health effects**

PeCB is moderately toxic to humans.

### **F. Standard**

Under The US Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Pentachlorobenzene is designated a hazardous substance, and releases greater than or equal to 10 pounds must be reported to the National Response Center. It has also been listed as a Bio-accumulative Chemical of Concern in EPA's Great Lakes Water Quality Guidance (<http://www.epa.gov/bns/levelii/leviisubsus.html>).

### **G. Persistence**

The half-life of PeCB in surface water was estimated to range from 194 to 1250 days, the estimated half-life for the anaerobic biodegradation in deeper water ranged from 776 to 1380 days (CEPA, 1993). Beck and Hansen (1974) observed a half-life of 194-345 days in soils. Min-Jian Wang et al. (1994, 1995) have done research on behaviour and fate of chlorobenzenes (CB) in spiked and sewage sludge-amended soil from a long term (from 1942 to 1961) agricultural experiment. Their conclusion is that about 10% of the applied total CBs became recalcitrant and that the main loss of CBs is by volatilisation. Half-lives of 219 and 103 days were reported for PeCB. Its calculated Half-life is 277 days in air and its estimated half-life in air is 45 to 467 days (<http://www.unece.org/env/lrtap/TaskForce/popsxg/2000-2003/pentachloorbenzeen.pdf>).

### **H. Alternative**

There is no current commercial demand for PeCB. For the production of quintozone, an alternative process using the chlorination of nitrobenzene is available (UNEP, 2008).

### **I. Country specific issue**

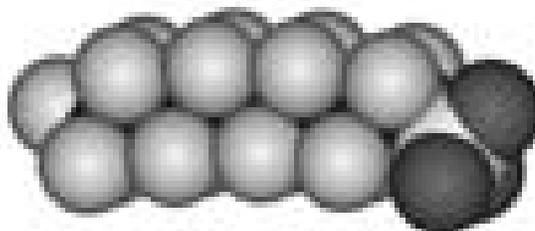
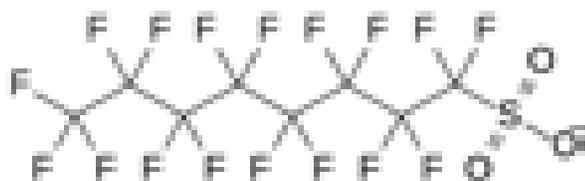
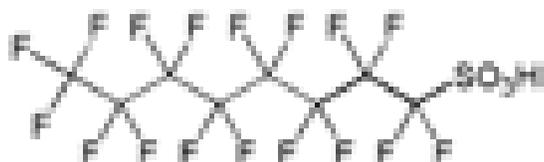
Not well studied in Nepal.

## PERFLUOROOCTANE SULFONIC ACID (PFOS), ITS SALTS AND PERFLUOROOCTANE SULFONYL FLUORIDE (PFOS-F)

PFOS is both intentionally produced and an unintended degradation product of related anthropogenic chemicals. The current intentional use of PFOS is widespread. PFOS uses include: fire fighting foams, carpets, leather/apparel, textiles/upholstery, paper and packaging, coatings and coating additives, industrial and household cleaning products, pesticides and other insecticides, photographic industry, photolithography and semiconductor manufacturing, hydraulic fluids, and metal plating (<http://www.ipen.org/ipenweb/poprc/newpops.html>). Once released to the environment, it persists longer, bioaccumulates and adversely affects environment and human health.

|                               |  |
|-------------------------------|--|
| <b>A. Name</b>                | Perfluorooctane sulfonic acid, its salts and perfluorooctane sulfonyl fluoride   |
| <b>Synonyms/abbreviations</b> | 1-Octanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptafluoro-; 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptafluoro-1-octanesulfonic acid; 1 Octanesulfonic acid, heptafluoro-; 1-Perfluorooctanesulfonic acid; Heptafluoro-1-octanesulfonic acid; Perfluoro-n-octanesulfonic acid; Perfluorooctanesulfonic acid; Perfluorooctylsulfonic acid |
| <b>IUPAC Name</b>             | 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptafluorooctane-1-sulfonic acid  |
| <b>B. CAS Number</b>          | PFOS as an anion, does not have a specific CAS number. The parent sulfonic acid has a recognized CAS number (1763-23-1). Some examples of its commercially important salts are listed below: Potassium salt (2795-39-3), Diethanolamine salt (70225-14-8), Ammonium salt (29081-56-9), Lithium salt (29457-72-5)                               |

### C. Structure



### D. Properties

|                            |                                      |
|----------------------------|--------------------------------------|
| <b>Molecular formula</b>   | $C_8H_{17}F_{17}O_3S$                |
| <b>Molar mass</b>          | 500.13 g/mol, 506.1 (potassium salt) |
| <b>Boiling point</b>       | 133°C at 6 torr                      |
| <b>Melting point</b>       | >400°C                               |
| <b>Vapour pressure</b>     | $3.31 \times 10^{-4}$ Pa (20°C)      |
| <b>Solubility in water</b> | 0.57 g/l                             |
| pKa                        | - 3.27                               |

PFOS is a fully fluorinated anion. PFOS and its closely related compounds, which may contain PFOS impurities or substances that can result in PFOS, are members of the large family of perfluoroalkyl sulfonate substances. PFOS is a fluorosurfactant that lowers the surface tension of water more than that of hydrocarbon surfactants.

The  $C_8F_{17}$  subunit of PFOS is hydrophobic and lipophobic, like other fluorocarbons, while the sulfonic acid/sulfonate group adds polarity.

### E. Impact on human health and environment:

#### ***Environmental impact***

PFOS is extremely persistent and has substantial bio-accumulating and biomagnifying properties. It has a capacity to undergo long-range transport. PFOS has been shown to affect the immune system of male mice. A variety of wildlife species have had PFOS levels measured in egg, liver, kidney, serum, and plasma samples.

In animal studies PFOS also causes cancer, physical development delays, endocrine disruption, and neonatal mortality; neonatal mortality might be the most dramatic result of laboratory animal tests with PFOS. PFOS reduces the birth size of animals; in humans, correlations between PFOS levels and reduced fetal growth are inconsistent.

The PFOS levels that have been detected in wildlife are considered high enough to affect health parameters.

PFOS has demonstrated toxicity towards mammals in sub-chronic repeated dose studies at low concentrations, as well as rat reproductive toxicity with mortality of pups occurring shortly after birth. Environmental toxicity data for PFOS is predominantly found for aquatic organisms such as fish, invertebrates and algae, and for birds. PFOS is toxic to aquatic organisms with mysid shrimp and *Chironomus tentans* being the most sensitive organisms.

### **Human health effects**

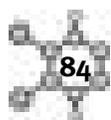
PFOS is detected in the blood serum of almost all people in the U.S., where concentrations are decreasing; by contrast, blood levels of PFOS appear to be rising in China. PFOS levels in pregnant women have been associated with *preeclampsia*. Levels have also been associated with altered thyroid hormone values and an increased risk of high cholesterol. Although it does not follow the classic pattern of other POPs by partitioning into fatty tissues but instead binds to proteins in the blood and the liver.

## **F. Standard**

The United Kingdom Health Protection Agency advises that the maximum acceptable concentration of PFOS in drinking water is 0.3µg/L. Minnesota State (USA) has issued a Health Risk Limit for PFOS (0.3 ug/L) in drinking water ([http://www.epa.gov/bns/reports/dec2008/dec2-3/TC-PFOS\\_2008.pdf](http://www.epa.gov/bns/reports/dec2008/dec2-3/TC-PFOS_2008.pdf)).

## **G. Persistence**

A study on the hydrolysis of in water performed at a range of temperatures and pH values with no observable degradation determined its half-life to be over 41 years. The atmospheric half-life of Perfluorooctane sulfonate is expected to be greater than two days, based on its extreme resistance to degradation in all tests performed. The indirect photolytic half-life of Perfluorooctane sulfonate has been estimated to be over 3.7 years ([http://www.pops.int/documents/meetings/poprc/meeting\\_docs/en/K0582622%201-9%20edited%20EJF.pdf](http://www.pops.int/documents/meetings/poprc/meeting_docs/en/K0582622%201-9%20edited%20EJF.pdf)).



## H. Alternative

While alternatives to PFOS are available for some applications, this is not always the case in developing countries where existing alternatives may need to be phased in. For some applications like photo imaging, semi-conductor or aviation hydraulic fluids, technically feasible alternatives to PFOS are not available to date.

| <b>Name</b>                   | <b>Use</b>   |
|-------------------------------|--|
| Cr (III)                      |  |
| Telomers and related products | Metal plating, fire fighting foam, electric and electronic parts |

(Guidance Material on New POPs, 2009)

## I. Country specific issue

Not well studied in Nepal.

## ENDOSULFAN

Endosulfan is a derivative of hexachlorocyclopentadiene and is chemically similar to aldrin, chlordane, and heptachlor. Endosulfan is an off-patent organochlorine insecticide and acaricide. It was developed in early 1950s. Endosulfan has been used in agriculture around the world to control insect pests including whiteflies, aphids, leafhoppers, Colorado potato beetles and cabbage worms. The World Health Organization estimated worldwide annual production to be about 9,000 metric tonnes (t) in the early 1980s. From 1980–89, worldwide consumption averaged 10,500 t per year, and for the 1990s use increased to 12,800 t per year. Along with several developed country, some of the states of the India had previously banned its production and use. This year 2011, Fifth Conference of Parties (COP5) of Stockholm Convention on Persistent Organic Pollutants (POPs) decided to list Endosulfan as 22<sup>nd</sup> POPs chemicals. Once released to the environment, it persists longer, bioaccumulates and adversely affects environment and human health.

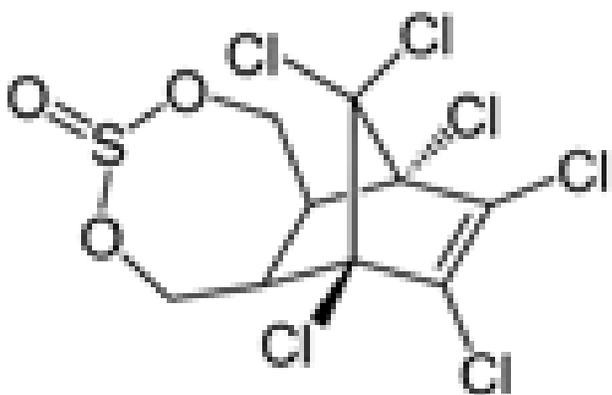
Representatives from 127 Governments meeting in Geneva on 25 - 29 April 2011 at the fifth meeting of the Conference of the Parties to the Stockholm Convention agreed to add endosulfan to the list of POPs to be eliminated worldwide. The action puts the widely-used pesticide on course for elimination from the global market by 2012. The Parties agreed to list endosulfan in Annex A to the Convention, with specific exemptions. When the amendment to the Annex A enters into force in one year, endosulfan will become the 22nd POP to be listed under the Convention. The decision was among more than 30 measures taken by Parties to the Stockholm Convention to boost global action against POPs (<http://chm.pops.int/Convention/COP/Meetings/COP5/tabid/1267/mctl/ViewDetails/EventModID/870/EventID/109/xmid/4351/language/en-GB/Default.aspx>).

Information such as name, trade name, CAS number, structures, properties, impact on human health and environment, standard, persistency, alternatives, and country specific issues related to Endosulfan has been presented below.

|                    |   |
|--------------------|---|
| <b>A. Name</b>     | Endosulfan  |
| <b>Other Names</b> | Benzoepin, Endocel, Parrysulfan, Phaser, Thiodan, Thionex, Tiovel                             |
| <b>IUPAC Name</b>  | 6,7,8,9,10,10-Hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzodioxathiepine-3-oxide |

**B. CAS No** 115-29-7

### C. Structure



### D. Properties

|                                    |                                      |
|------------------------------------|--------------------------------------|
| <b>Molecular formula</b>           | $C_9H_6Cl_6O_3S$                     |
| <b>Molar mass</b>                  | 406.93 g mol <sup>-1</sup>           |
| <b>Melting point, °C</b>           | 70                                   |
| <b>Boiling point, °C</b>           | 106 (0.7 torr)                       |
| <b>Vapor pressure, mmHg</b>        | $1.7 \times 10^{-7}$                 |
| <b>Vapor density (air=1)</b>       | 14.0                                 |
| <b>Solubility in water</b>         | 0.1 mg/L                             |
| <b>Density</b>                     | 1.745 g/cm <sup>3</sup> (20°C)       |
| <b>Partition coefficient, pKow</b> | 3.83                                 |
| <b>Appearance</b>                  | Brown or colorless crystalline solid |
| <b>Odor</b>                        | Pungent                              |
| <b>Stability</b>                   | Nonexplosive                         |

## E. Impact on human health and environment

### ***Environmental impact***

Due to its potential to evaporate and travel long distances in the atmosphere, endosulfan has become one of world's most widespread pollutants. Endosulfan is now found extensively in global water resources, soils, air, rainfall, snow and ice deposits and oceans, including in remote ecosystems such as the Arctic, Antarctic, Great Lakes, Canadian Rockies, Costa Rican rainforests, Alps, and Himalayas.

According to the European Union “endosulfan is very toxic to nearly all kinds of organisms”. Levels in the environment are frequently high enough to impact on wildlife. According to the US EPA, “Monitoring data and incident reports confirm that endosulfan is moving through aquatic and terrestrial food chains and that its use has resulted in adverse effects on the environment adjacent to and distant from its registered use sites”. Endosulfan is detected in the tissues of animals worldwide, including polar bears, antelope, crocodiles, Minke whales, and African vultures (<http://www.ipen.org/ipenweb/documents/poprc%20documents/endosulfan%20fact%20sheet%20pan%20europe.pdf>).

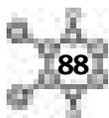
It is, however, considered to be moderately toxic to honey bees, and it is less toxic to bees than organophosphate insecticides.

### ***Human health effects***

Acute endosulfan poisoning can cause convulsions, psychiatric disturbances, epilepsy, paralysis, brain oedema, impaired memory and death. Long term exposure is linked to immunosuppression, neurological disorders, congenital birth defects, chromosomal abnormalities, mental retardation, impaired learning and memory loss. Endosulfan is also a xenoestrogen—a synthetic substance that imitates or enhances the effect of estrogens—and it can act as an endocrine disruptor, causing reproductive and developmental damage in both animals and humans. With regard to consumers intake of endosulfan from residues on food, the Food and Agriculture Organization of United Nations has concluded that long-term exposure from food is unlikely to present a human health concern, but short term exposure can exceed acute reference doses (<http://southasia.oneworld.net/resources/know-endosulfan>).

## F. Standard

US EPA's acute reference dose for dietary exposure to endosulfan is 0.015 mg/kg for adults and 0.0015 mg/kg for children. For chronic dietary exposure, the EPA reference doses are 0.006 mg/(kg·day) and 0.0006 mg/(kg·day) for adults and children, respectively. EPA recommends that the amount of endosulfan in lakes, rivers, and streams should not be more



than 74 micrograms per liter ( $\mu\text{g/L}$ ) or 74 parts per billion (74 ppb). US FDA allows no more than 24 parts per million (24 ppm) of endosulfan on dried tea, and EPA allows no more than 0.1 to 2 ppm endosulfan on other raw agricultural products. US NIOSH recommends that workers should not breathe air that contains more than 0.1 milligram (mg) of endosulfan per cubic meter of air ( $0.1 \text{ mg/m}^3$ ) during a 10-hour workday, 40-hour workweek.

## **G. Persistence**

The estimated half-lives for the combined toxic residues (endosulfan plus endosulfan sulfate) range from roughly 9 months to 6 years.

## **H. Alternative**

Successful replacement of endosulfan has been achieved in all countries where endosulfan is now banned including France, Spain, Greece and Portugal – all major users prior to the EU ban in 2006. Farmers in some non-EU countries have also converted away from endosulfan, including in cotton, soy and coffee production. A 2008 study in Sri Lanka showed that yields of all crops, including rice and tea, have been maintained since a national ban in 1998 (<http://www.ipen.org/ipenweb/documents/poprc%20documents/endosulfan%20fact%20sheet%20pan%20europe.pdf>).

## **I. Country specific issue**

Nepal is preparing to ban in the country.



| Substitute                        | CAS Number | Chemical Class     | Main Use | Aldrin | Chlordane | DDT | Dieldrin | Endrin | HCB | Heptachlor | Mirex | Toxaphene | Nr. of List |
|-----------------------------------|------------|--------------------|----------|--------|-----------|-----|----------|--------|-----|------------|-------|-----------|-------------|
| Phorate                           | 298-02-2   | Organophosphorus   | I        | X      | X         |     |          | X      |     | X          |       |           | 12          |
| Phosalone                         | 2310-17-0  | Organophosphorus   | I        | X      |           | X   |          |        |     |            |       |           | 2           |
| Phosphamidon                      | 13171-21-6 | Organophosphorus   | I        |        |           |     |          | X      |     |            |       |           | 3           |
| Phoxim                            | 14816-18-3 | Organophosphorus   | I        | X      |           |     |          |        |     |            |       |           | 2           |
| Primiphos ethyl                   | 23505-41-1 | Organophosphorus   | I        | X      |           | X   |          |        |     |            |       |           | 1           |
| Primiphos methyl                  | 29232-93-7 | Organophosphorus   | I        | X      |           | X   |          |        |     |            |       |           | 3           |
| Quinalphos                        | 13593-03-8 | Organophosphorus   | I        | X      |           | X   |          |        |     |            |       |           | 3           |
| Tetrachlorvinphos                 | 22248-79-9 | Organophosphorus   | I        |        |           | X   |          | X      |     |            |       |           | 3           |
| Triazophos                        | 24017-47-8 | Organophosphorus   | I        |        |           |     |          | X      |     |            |       |           | 1           |
| Trichloronalc                     | 327-98-0   | Organophosphorus   | I        | X      |           |     |          |        |     |            |       |           | 1           |
| Trichlorfon                       | 52-68-6    | Organophosphorus   | I        | X      |           | X   | X        | X      |     | X          | X     | X         | 5           |
| Monocrotophos                     | 6923-22-4  | Organophosphorus   | I        | X      |           | X   |          | X      |     | X          |       |           | 10          |
| Chlordeconed                      | 143-50-0   | Organochlorine     | I        | X      |           |     | X        |        |     |            |       |           | 1           |
| Endosulfan                        | 115-29-7   | Organochlorine     | I        | X      | X         | X   | X        | X      |     | X          |       |           | 20          |
| Lindane                           | 58-89-9    | Organochlorine     | I        | X      | X         | X   |          | X      |     | X          |       |           | 13          |
| Petroleum oil, unclassified       | 68815-10-1 | Oil - petroleum    | I,Adj.   |        | X         |     |          |        |     |            |       |           | 1           |
| Aldicarb                          | 116-06-3   | N-Methyl Carbamate | I        | X      |           |     |          |        |     | X          |       |           | 2           |
| Bendiocarb                        | 22781-23-3 | N-Methyl Carbamate | I        |        | X         | X   |          |        |     | X          |       |           | 4           |
| Carbaryl                          | 63-25-2    | N-Methyl Carbamate | I        | X      | X         | X   | X        | X      |     | X          | X     |           | 23          |
| Carbofuran                        | 1563-66-2  | N-Methyl Carbamate | I        | X      | X         |     | X        | X      |     | X          |       |           | 30          |
| Carbosulfan                       | 55285-14-8 | N-Methyl Carbamate | I        | X      |           |     |          |        |     | X          |       |           | 7           |
| Isoprocarb                        | 2631-40-5  | N-Methyl Carbamate | I        |        | X         |     |          |        |     |            |       |           | 1           |
| Methoyle                          | 16752-77-5 | N-Methyl Carbamate | I        | X      |           |     |          | X      |     |            |       |           | 2           |
| Propoxur                          | 114-26-1   | N-Methyl Carbamate | I        |        | X         | X   |          |        |     |            |       |           | 3           |
| Avermectin/ abamectin             | 71751-41-2 | Microbiale         | I        |        |           |     |          |        |     |            | X     |           | 1           |
| Bacillus thuringiensis            | 68038-71-1 | Microbial          | I        |        |           | X   |          |        |     |            |       |           | 4           |
| Baculovirus                       |            | Microbial          | I        |        | X         |     |          |        |     |            |       |           | 1           |
| Beauveria bassiana                | 63428-82-0 | Microbialf         | I        |        |           | X   |          |        |     |            |       |           | 1           |
| Agrotis segetumg granulosis Virus |            | Microbial          | I        |        |           |     | X        |        |     |            |       |           | 1           |
| Microsporodians                   |            | Microbialh         | I        |        |           |     | X        |        |     |            |       |           | 1           |
| Sulfluramid                       | 4151-50-2  | Fluorine           | I        |        |           |     |          |        |     |            | X     |           | 2           |
| Trifluralin                       | 1582-09-8  | Dinitro aniline    | H        |        |           |     |          |        |     |            |       | X         | 1           |
| Carboxin                          | 5234-68-4  | Carboxamide        | FST      |        |           |     |          |        | X   |            |       |           | 2           |
| Nicotine                          | 54-11-5    | Botanical          | I        |        |           |     |          | X      |     |            |       |           | 1           |
| Neem                              | 8002-65-1  | Botanical          | I        |        |           | X   | X        |        |     |            |       |           | 2           |
| Fuberidazole                      | 3878-19-1  | Benzimidazole      | F        |        |           |     |          |        | X   |            |       |           | 2           |
| Guazatine                         | 13516-27-3 | Aliphatic nitrogen | F        |        |           |     |          |        | X   |            |       |           | 1           |
| Alachlor                          | 15972-60-8 | Acetanilide        | H        |        |           |     |          |        |     |            |       | X         | 1           |
| Carbon dioxide                    | 124-38-9   |                    | I, F, R  |        | X         |     |          | X      |     |            |       |           | 2           |
| Monoxide                          | 630-08-0   |                    |          |        |           |     |          |        |     |            |       |           | 2           |
| <b>Other substitutes</b>          |            |                    |          |        |           |     |          |        |     |            |       |           |             |
| Anticoagulants                    |            | Not specified      |          |        |           |     |          | X      |     |            |       |           | 2           |
| Insect growth regulators          |            | Not specified      |          |        | X         |     |          |        |     | X          | X     |           | 3           |
| Synthetic pyrethroids             |            | Not specified      |          |        |           | X   |          | X      |     |            |       | X         | 6           |
| Organophosphates                  |            | Not specified      |          |        |           | X   |          |        |     |            |       |           | 2           |

| Substitute   | CAS Number | Chemical Class | Main Use | Aldrin | Chlordane | DDT | Dieldrin | Endrin | HCB | Heptachlor | Mirex | Toxaphene | Nr. of List |
|--|------------|----------------|----------|--------|-----------|-----|----------|--------|-----|------------|-------|-----------|-------------|
| Carbamates   |            | Not specified  |          |        |           | X   |          |        |     |            |       |           | 1           |
| Botanical pesticides   |            | Not specified  |          |        |           | X   | X        | X      |     |            |       |           | 4           |
| Neamtodes  |            | Not specified  |          |        | X         |     |          |        |     |            |       |           | 1           |
| Traps  |            | Not specified  |          |        |           |     |          | X      |     |            |       |           | 1           |
| Netting on the houses and use of mosquito pyrethroid-treated bednets |            | Not specified  |          |        |           | X   |          |        |     |            |       |           | 2           |

- obsolete according to the WHO Table 6: The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification 1998-99, (WHO/PSC/98.21/Rev.1), WHO, Vienne, Switzerland
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- obsolete according to the WHO Table 6: The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification 1998-99, (WHO/PSC/98.21/Rev.1), WHO, Vienne, Switzerland
- Derivate from soil bacterium *Streptomyces avermitilis*, Source: Oregon State University, EXTOXNET, Extension Toxicology Network (1996): Pesticide Information Profiles, Oregon
- entomopathogenic fungi, Source: Bischoff, R. (1998): Untersuchungen zur Wirksamkeit insektenpathogener Pilze gegen die vorratschädlichen Motten *Ephestia kuehniella* und *Plodia interpunctella* (Lepidoptera : Pyralidae), Humboldt University (ed.), Berlin
- common cutworm, turnip moth (german: Saateule --the author), Source: Bourner, T.C. ; Cory, J.S. (1995): Nuclear Polyhedrosis And Granulosis Viruses For The Control Of The Common Cutworm, *Agrotis segetum* (Lepidoptera: Noctuidae), Department of Ecology, Massey University, Palmerston North, New Zealand; Institute of Virology and Environmental Microbiology, Oxford, UK.
- Mau, R.F.L.; Matin, J. L. (1992): *Bactrocera dorsalis* (Hendel), Department of Entomology, Honolulu, Hawaii

## Key Main Use:

| Abbreviation | Description   |
|--------------|---|
| I            | Insecticide   |
| A            | Acaricide   |
| F            | Fungicide   |
| F            | ST Fungicide for seed treatment                                       |
| R            | Rodenticide   |
| H            | Herbicide   |
| I-S          | Insecticide-applied to soil: not used with herbicides or plant growth |
| Adj.         | Adjuvant  |



# GLOSSARY

**Acaricide:** A chemical agent used to kill mites.

**Acute effect:** An effect that develops rapidly after a single or short exposure to a substance at high dose.

**Adjuvant:** An additive that enhances the effectiveness of medical treatment.

**Bioconcentration :** The increase in concentration of a chemical in an organism resulting from tissue absorption levels exceeding the rate of metabolism and excretion.

**Biological half-life:** The time required for a living organism to reduce the steady-state level of a chemical to 50% of its original level once further chemical exposure is discontinued.

**Biomagnification:** The process by which the concentration of substances increases in each successive trophic level in the food chain.

**Break down:** Separate (substances) into constituent elements or parts.

**Carcinogen:** Any substance that produces cancer.

**Chemical Abstract Service (CAS):** Part of the American Chemical Society which maintains a database of chemical compounds and sequences. The CAS database currently contains over 55 million different organic and inorganic chemical compounds. Each CAS entry is identified by their CAS Registry Number, or CAS Number for short.

**Chemical Abstract Service (CAS) number:** Number assigned to a compound as the CAS registers a new compound. CAS Numbers are up to 10 digits long using the format xxxxxx-yy-z. The CAS Number of a compound is a useful way to identify a chemical over its name. The CAS Number can also be used to distinguish between stereoisomers of a compound.

**Chlorobenzene:** An aromatic organic compound with the chemical formula  $C_6H_5Cl$ .

**Chronic effect:** An effect that is due from long term exposure to a substance or that persists for a long time (months, years; it can also refer to a permanent or long term effect that is the result of a short term (acute) exposure.

**Dirty Dozen POPs:** Earlier 12 POPs enlisted under Stockholm Convention.

**Food Chain:** (Ecology) A community of organisms where each member is eaten in turn by another member.

**Genotoxicity:** A deleterious action on a cell's genetic material affecting its integrity.

**Half-life:** The period of time it takes for a substance undergoing decay to decrease by half.

**Henry's Law Constant:** A measure of the solubility of a gas in a liquid solution at a constant temperature and pressure, which is used to predict equilibrium concentrations of a contaminant in a gas/liquid system, and describes the extent of transport across air/water systems.

**Hepatotoxicity:** Chemical-driven liver damage i.e. liver toxicity.

**International Union of Pure and Applied Chemistry (IUPAC):** An international scientific organization not affiliated with any government. The IUPAC strives to advance chemistry, in part by setting global standards for names, symbols, and units. The IUPAC was formed in 1919 by scientists and academicians who recognized a need for standardization in chemistry. IUPAC nomenclature is worldwide the most used chemical nomenclature.

**Isomer:** Compounds that have the same atomic composition (constitution) but differ in their chemical structure.

**Lipophilic:** Having an affinity for lipids.

**Log octanol-water partition coefficient (log K<sub>ow</sub>):** A measure of the equilibrium concentration of a substance between octanol and water that indicates the potential for partitioning into fat or soil organic matter and used in models to estimate bioaccumulation potential.

**Nasty Nine POPs:** New 9 POPs enlisted under Stockholm Convention.

**Organic compound:** Any member of a large class of gaseous, liquid, or solid chemical compounds whose molecules contain carbon.



**Organochloride:** An organic compound containing at least one covalently bonded chlorine atom.

**part per billion (ppb):** A unit of proportion equal to  $10^{-9}$ .

**part per million (ppm):** A unit of proportion equal to  $10^{-6}$ .

**part per quadrillion (ppq):** A unit of proportion equal to  $10^{-15}$ .

**part per trillion (ppt) :** A unit of proportion equal to  $10^{-12}$ .

**Partition coefficient:** The ratio of the concentrations of a substance in two heterogenous phases in equilibrium with each other.

**Persistent Organic Pollutants (POPs):** These are organic chemical substances which possess a particular combination of physical and chemical properties such that, once released into the environment, they remain intact for exceptionally long periods of time (many years); become widely distributed throughout the environment as a result of natural processes involving soil, water and, most notably, air; accumulate in the fatty tissue of living organisms including humans, and are found at higher concentrations at higher levels in the food chain; and are toxic to both humans and wildlife.

**pH:** It is a measure of the acidity or basicity of an aqueous solution. Pure water is said to be neutral, with a pH close to 7.0 at 25°C (77°F). Solutions with a pH less than 7 are said to be acidic and solutions with a pH greater than 7 are basic or alkaline.

**Photodegradation:** Degradation of a photodegradable molecule caused by the absorption of photons, particularly those wavelengths found in sunlight, such as infrared radiation, visible light, and ultraviolet light.

**Photolysis:** A chemical reaction in which a chemical compound is broken down by photons. Also called Photodissociation or photodecomposition.

**Phytoplankton:** Photosynthetic or plant constituent of plankton; mainly unicellular algae.

**Phytotoxicity:** A term used to describe the degree of toxic effect by a compound on plant growth. Such damage may be caused by a wide variety of compounds, including trace metals, pesticides, salinity, phytotoxins or allelopathy.

**Polybrominated biphenyls(PBBs):** Brominated hydrocarbons formed by substituting hydrogen with bromine in biphenyl.

**Preeclampsia:** Medical condition in which hypertension arises in pregnancy (pregnancy-induced hypertension) in association with significant amounts of protein in the urine.

**Protein binding:** Degree to which a chemical binds to the proteins.

**Quantitative structure-activity relationship (QSAR):** It is the process by which chemical structure is quantitatively correlated with a well defined process, such as biological activity or chemical reactivity. Sometimes, quantitative structure-property relationship (QSPR).

**Reference Dose:** United States Environmental Protection Agency's maximum acceptable oral dose of a toxic substance. Reference doses are most commonly determined for pesticides.

**Solubility:** The quality of being soluble and easily dissolved in liquid; the quantity of a particular substance that can dissolve in a particular solvent (yielding a saturated solution).

**Stability:** The quality or attribute of being firm and steadfast; the quality of being enduring and free from change or variation.

**Teratogenic:** Of or relating to substances or agents that can interfere with normal embryonic development.

**Torr:** A non-SI unit of pressure with the ratio of 760 to 1 standard atmosphere, chosen to be roughly equal to the fluid pressure exerted by a millimetre of mercury, i.e., a pressure of 1 Torr is approximately equal to 1 mmHg. It was named after Evangelista Torricelli, an Italian physicist and mathematician who discovered the principle of the barometer in 1644.

**Toxic Equivalent (TEQ):** A quantitative measure of the combined toxicity of a mixture of dioxin-like chemicals.

**Toxic:** Of or relating to or caused by a toxin or poison.

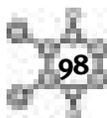
**Viscosity:** Resistance of a liquid to shear forces (and hence to flow).

**Volatility:** The property of changing readily from a solid or liquid to a vapor.

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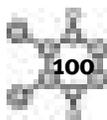
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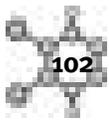
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Fact Sheets of 22 Persistent Organic Pollutants  
(POPs) under Stockholm Convention



# About CEPHED

Center for Public Health and Environmental Development (CEPHED) is an environmental NGO established in the year 2004, by and through the contribution, coordination from a group of activist and experienced people from medical, environment and public health sectors. CEPHED's focus is to serve Nepalese people and communities in the field of public health and environment. CEPHED has adopted the vision of bridging people with the science and technology for healthy living and environmental safety and taken a mission to act as bridging forum between people with science and technology to make access new scientific knowledge, technology and safety measures of environment and public health sector through research, coordination, capacity building and policy dialogue, etc. CEPHED is working with and also willing to work with group and organizations around the country with an understanding that this will help to bring the experience from the ground to the concerned authorities' notice that leads to more meaningful and sustainable solutions. From past six years CEPHED has been engaged mainly on research, awareness raising, capacity building, policy influence especially in the area of chemical management, pesticide, obsolete pesticide, healthcare waste, POPs, heavy metals like mercury, lead and cadmium.

Additionally, CEPHED has been actively engaged in research, production of Information, Education and Communication (IEC) materials both in printed and electronic format widely disseminating all over the country. The research results and findings have been shared with all stakeholders especially government, business communities and general public at large scale thorough all possible means such as meeting, interaction, presentation, newspaper, radio and television programme and also through organizing series of district, regional and national level awareness and capacity building training programmes on these issues.

With its growing interest and engagement with various environmental issues of national and international importance, it became an active participating organization of several global networks working in the area of public health, environment and toxic free future. CEPHED is member organization of Toxic Link, International POPs Elimination Network (IPEN), Global Alliance for Incinerator Alternatives (GAIA), Healthcare Without Harm (HCWH), Collaborative on Health and the Environment (CHE) and Zero Mercury Working Group (ZMWG)/EEB. CEPHED has been doing research, raising awareness and at the same time setting pilot model projects. CEPHED has recently completed the feasibility study and strategy development for mercury free health care services from there pilot projects. The second intervention made by CEPHED towards curbing the release of POPs (Dioxins, Furans) is the development of environmentally sound management of health care waste and promotion of the use of dry welding machine for metal fabricating throughout country as model programme.

CEPHED has been awarded with "2011 Stockholm Convention's PEN Award" in the ceremony hosted by POPs Convention Secretariat because of organization's outstanding work on raising awareness on PCBs, their health effects and ways to prevent their release.



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