# Executive Summary

Samoa signed the Stockholm Convention on Persistent Organic Pollutants (POPs) in 2001 as part of its national and international commitment to the reduction and elimination of persistent organic and toxic substances. Since signing the Convention, Samoa has received an Enabling Activity Funding from the Global Environment Facility to facilitate the development of its National Implementation Plan (NIP) for POPs.

Part of the activities for the development of the NIP includes conducting a National Assessment of POPs produced, imported, used and disposed in Samoa. Furthermore, the National Assessment is to identify the priority chemicals and set objectives for the development of the NIP.

From the various studies undertaken on POPs in Samoa, it has been identified that eight of the 12 POPs chemicals identified in the Convention are either produced or imported into the country. Of the eight chemicals, three are pesticides (aldrin, dieldrin, and DDT) used as insecticides for taro and banana plantations and chlordane and heptachlor are used as termiticides in homes. One industrial chemical (PCB) was imported as part of electric transformers while two chemicals (dioxins and furans) are produced and released unintentionally from incomplete combustion.

An additionally six POPs and persistent toxic substances (TBT, TPH/PAH, lindane, and CCA/PCP) are also present in Samoa. Of all the chemicals currently present in Samoa only dioxin and furans are still being released from unintentional production while the rest are either non-consented for import or alternatives have been found.

All the pesticides and industrial chemicals are no longer imported, with the last known stockpiles disposed by the Agricultural Store in the mid 1990s. Dioxins and furans are still being produced albeit unintentionally from incineration, open burning, energy production, industrial processes and vehicle combustion.

Despite the high number of POPs chemicals produced and used in Samoa, the levels were quite low for all except DDT, dieldrin and aldrin which were widely used by farmers between the 1950s and the 1970s. The low levels and localized uses of most chemicals confirm the results of the assessment in that presence is only in a few sites with low risk to human health and the environment.

The assessment identifies only four sites considered to be hotspots mainly because of the contaminations around the sites from chemical spills. The contaminations are localized and actions have been identified to either avoid future contact with area and/or cleaning up the contamination from the area. Additionally, the few stockpiles from contaminated PCB transformers are being planned for disposal by mid 2004.

Therefore, the main focus of activities for reduction and elimination of POPs in Samoa will be to reduce the production and release of dioxins and furans by installing good air pollution controls systems and public awareness programmes to reduce burning.

# List of Acronyms

**ASC: Agricultural Store Corporation**
**AusAID: Australian Assistance for International Development**
**CCA: copper chromium arsenic**
**DDT: dichlorodiphenyltrichloroethane**
**EPC: Electric Power Corporation**
**GEF: Global Environment Facility**
**HCB: hexachlorobenze**
**IPC: Island Pest Control**
**MNRE: Ministry of Natural Resources and Environment**
**MWH: Montgomery Watson Hagard**
**NTT: National Task Team**
**NEPM: National Environment Protection Measures**
**NIP: National Implementation Plan**
**PAH: Polycyclic aromatic hydrocarbon**
**PCB: polychlorinated biphenyls**
**PCDD:Polychlorinated dibenzo-p-dioxins (dioxins)**
**PCDF: Polychlorinated dibenzo-furans (furans)**
**PCP: Pentachlorophenols**
**PECL: Pacific Environment Consultants**
**PICs Convention : Prior Informed Consent Convention**
**POPs: Persistent Organic Pollutants**
**PTS: Persistent Toxic substances**
**PUMA: Planning and Urban Management Agency**
**SFC: Samoa Forest Corporation**
**SPREP: South Pacific Environment Programme**
**TBT: tri-butyl tin**
**TEQ: Technical Equivalents**
**TPH: Total Petroleum Hydrocarbons**
**UNDP: United Nations Development Programme**
**UNEP: United Nations Environment Programme**
**USEPA: United States Environment Protection Agency**

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# 1. Introduction

Samoa is a party to the Stockholm Convention on Persistent Organic Pollutants (POPs) negotiated and agreed by countries of the world in 2001. Samoa signed the Convention in May 2001 and ratified in early 2002. The Convention obligates Parties to undertake measures to reduce or eliminate releases from production, use, stockpiles and wastes of the twelve chemicals identified as most persistent.

The Convention initially targets a group of twelve chemicals commonly known as the "dirty dozen" for priority actions to reduce and eliminate from production, use, storage and disposal. The dirty dozen are *aldrin, chlordane, dieldrin, DDT, hexachlorobenzene (HCB), heptachlor, mirex, polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins (dioxins), polychlorinated dibenzo-furans (furans), and toxaphene.*

Persistent organic pollutants are organic compounds of natural or anthropogenic origin that resist photolytic, chemical and biological degradation. They are characterized by low water solubility and high lipid solubility, resulting in bio-accumulation in fatty tissues of living organisms. POPs are transported in the environment in low concentrations by movement of fresh and marine waters and they are semi-volatile, enabling them to move long distances in the atmosphere, resulting in wide-spread distribution across the earth, including regions where they have never been used. Thus, both humans and environmental organisms are exposed to POPs around the world in many cases for extended periods of time.

Humans can be exposed to POPs through diet, occupational accidents and the environment (including indoor). Acute or chronic exposure to POPs by humans either can be associated with a wide range of adverse health effects such as cancer, damage to the nervous system, reproductive disorders, and disruption of the immune system in infancy and early childhood.

Animals can be exposed to POPs through foraging, diet and the environment. Studies of POPs impact on the wildlife include endocrine disruption, reproductive and immune dysfunction, neuro-behavioural disorders and cancer.

Over the last twenty years, countries of the world have taken initial steps to reduce POPs chemical production, eliminate the stockpiles, and contamination from the environment. The establishment of the Convention provides an international framework to facilitate a global effort to reduce and eliminate the chemicals from the environment.

The first steps into the reduction and elimination of POPs is to conduct an assessment of the existing stocks, emissions and contamination, which will be used to identify gaps and determine objectives and priority actions for a National Implementation Plan (NIP).

In conclusion, there are eight chemicals of the POPs Convention currently present in Samoa with six imported for past use as pesticides and industrial chemicals. Only two of the POPs chemicals are produced locally albeit unintentionally from burning and industrial processes.

# 2. Background

The Convention under Article 7 provides a mechanism for the Parties to meet the obligations through the development of National Implementation Plans (NIPs*)* to reduce and eliminate releases from production, use, stockpiles and wastes as well improving public awareness on the impacts of such chemicals both on human health and the environment.

To support the development of NIPs, Article 13 of the Convention regarding Financial Mechanisms provides financial opportunities to assist with meeting its obligations. One of such mechanisms is the Global Environment Facility (GEF) Enabling Activity (EA) which is providing assistance to developing countries including Samoa to develop its NIP.

Samoa has been able to access this GEF EA through United Nations Development Programme (UNDP) in 2002 to develop its NIP using the guidelines as articulated in the following process.

A. Establish Enabling Activity Project Coordinating Mechanisms;
B. Capacity Building in Support of Project Implementation;
C. Assess National Infrastructural and Institutional Capacity;
D. Prepare Initial POPs Inventories;
E. Set Objectives and Priorities for POPs and POPs Reduction and Elimination Options;
F. Prepare Draft Implementation Plan for Meeting Samoa's Obligations Under the Stockholm Convention;
G. Review and Finalization of Implementation Plan.

The Assessment of POPs in Samoa report was produced by Pacific Environment Consultants Ltd. (PECL) as part of the Enabling Activity for developing the National Implementation Plan for Samoa, under the Ministry of Natural Resources and Environment (MNRE).

The first actions for the NIP included the establishment of the Multi-sectoral National Task team and building capacity with PUMA as lead agency and other partners to support the project implementation. Once the organizational component was settled, the technical process of conducting the assessment and development of the plan were contracted to PECL to facilitate, while in close consultation with the NTT.

**Electrical Transformers in Asau**


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# 3. Methodology

## 3.1 General Approach

Prior to compiling Samoa's POPs Assessment Report, several initiatives including the "Initial Inventory POPs and PTS in Samoa" were carried out by Montgomery Watson Harza (MWH) New Zealand Ltd. on behalf of Ministry of Natural Resources, UNEP "Regionally Based Assessment on Persistent Toxic Substances in the Pacific, and an Australian Agency for International Development (AusAID) / South Pacific Regional Environment Programme (SPREP) study on "Persistent Organic Pollutants in the Pacific". The PECL carried out comprehensive reviews of the available data on stockpiles, use, disposal sites, and releases for POPs and PTS in Samoa. The studies provided a comprehensive baseline while acknowledging the missing gaps as recommendations for follow up actions to complete the assessment of POPs in Samoa.

The Montgomery Watson Harza (New Zealand) Ltd. (MWH) report established a methodology for the selection of determinands for chemical sampling and identified different environmental media relevant for the types of POPs chemicals found in Samoa.

To complete the POPs assessment, the following steps were taken

- Independent Review of MWH report;
- Review of United Nations Environment Programme (UNEP) and SPREP reports;
- Compilation chemical inventories by the current importing agencies such as Agricultural Store Corporation, Ministry of Health, and the pest control companies;
- Discussions with members of the National Task Team on verification of existing data as well as assistance on obtaining additional information;
- Consultations and collaboration with the Project Coordinator POPs and Ministry of Natural Resources and Environment (MNRE) Planning and Urban Management Agency (PUMA) representatives on additional information and data related to the assessment; and
- Additional sampling and information gathering on gaps identified is noted from previous studies such as
  - Assessment of dioxin and furans,
  - Bio-accumulation in the food chain via pig fat and human breast milk,
  - Additional sampling for organo-chlorine (dieldrin and DDT) pesticides in major banana plantations during the period up to the 1970's before dieldrin and DDT were substituted, and
  - Additional sampling of contaminated sites at Agriculture Store Corporation (ASC), Vaitele for pesticides and Samoa Forest Corporation (SFC), Asau to determine the depth and spread of contamination identified in previous surveys

## 3.2 Environmental Media

To identify at-risk communities in terms of human exposure to contaminants, possible associated human health impacts and potential adverse effects on ecosystems, the selection of appropriate environmental media for sampling and analysis is very important. The environmental media of soil, marine sediments, shellfish, animal fat, water, and breast milk were selected to provide a broad cross-sectional view of the Samoan environment based on the quantitative and qualitative data and previous sampling undertaken by MWH and SPREP. Furthermore, the limited finances and the availability of the dioxin and furan Toolkit meant that any sampling for dioxin and furans were not done during the assessment.

Soil was used to determine the contamination at suspected sites of use and disposal and identify at-risk communities in terms of human exposure to contaminants. Marine sediments, shellfish, animal fat pig, human breast milk and water were assessed to determine possible associated human health, ecosystems, and wildlife impacts.

The assessment for dioxin and furans utilized the UNEP "Standardized Toolkit for the identification and quantification of dioxin and furan releases" where default emission factors were identified for air, land, water, products, fly ash and bottom ash.

### 3.3 Determinands and Sample Selection

Since there is no manufacturing or production of pesticides and PCB in the country, identification and selection of sites for the inventory and sampling was confined to sites associated with the storage, handling, use and disposal of these chemicals. The sites selected for the dioxin and furan assessment are the main areas of production as identified in the Dioxin and Furan Standardized Tool kit. The selected sites were therefore

- Pesticides
    - storage and handling sites: ASC Vaitele, and Island Pest Control (IPC) Vaivase,
    - use sites: Old banana plantations (Samoa College, University of the South Pacific, STEC Mulifanua, William Arp at Moamoa, Marist Brothers Alafua, )
    - disposal sites: MAFFM Nuu Research Station.
- PCB
    - storage and disposal sites: Electric Power Corporation (EPC) in Vaitele, and Samoa Forest Corporation (SFC) in Asau
    - old transformers: EPC Salelologa, Vaitele and Fuluasou, and Puapua quarry
- Dioxin and furans
    - Waste Incineration: Tafaigata Landfill, Motootua and Tuasivi Hospitals.
    - Power Generation and heating:
        - EPC power plants in Tanugamanono and Salelologa;
        - Estimates of firewood used for cooking and natural gas
    - Transportation: estimate through fuel consumption
    - Biomass burning: estimates on domestic burning and accidental house fires
    - Landfill and waste dumps: Tafaigata and Savaii rubbish dumps
    - Miscellaneous: dry cleaning and tobacco smoking
    - Others during and following a Workshop on Estimation of Dioxins/ Furans by Toolkit
- Additional PTS: samples were also taken of other POPs-like PTS that have been used in the past
    - timber treatment storage, use and disposal sites for PCP and CCA: SFC Asau
    - fuel and bitumen storage sites for TPH and PAH: Oil tanks at Sogi
    - marine sediments and water samples for heavy metals: Vaiusu Bay, various streams in greater Apia area (Fagalii to Afega)
    - marine sediments for TBT from anti-fouling at the Apia Wharf

### 3.4 Assessment for Contamination

In determining contaminated sites, the assessment pulled from different national guidelines as none were available at the time for Samoa. These guidelines include

- United States Environmental Protection Agency (USEPA) Region 6 Risk-Based Human Health Screening Values
- National Environmental Protection Measures *(NEPM*) for Assessment of Site Contamination -1999
- Canadian Environmental Quality Guidelines (Canadian Council of Ministers of the Environment – 1999)
- Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand – 1999
- Health and Environmental Guidelines for Selected Timber Treatment Chemicals – 1997
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality – 2000 (ANZECC)
- Draft Samoa Drinking-Water Standards – 1999
- Centre for Food Safety and Applied Nutrition – 1993
- New Zealand Food Safety Authority "Food Standards 2002"

Based on the comparison of analytical results with guidelines, certain sites were identified as being hot spots.

**Soil Sampling at Asau Timber treatment Plant**

# 4. POPs in Samoa

## 4.1 Introduction

Persistent organic pollutants are a set of chemicals that are toxic, persist in the environment for long periods of time, and characterized by low water solubility and high lipid solubility thus bio-accumulate in fatty tissues as they move up the food chain. Because they are semi-volatile, they circulate globally via the atmosphere, oceans, and other pathways, thus those released in one part of the world can travel to regions far from their source of origin.

The persistence of these chemicals in the atmosphere and bioaccumulation in fatty tissues has caused detrimental impacts on human health and the environment throughout the world. Within Samoa, no evidence has been documented linking such environmental and human health issues to contact with any of the POPs released locally.

## 4.2 Background

Of the 12 POPs chemicals identified in the Convention, eight are present in Samoa (Table 1) with the ninth suspected from the presence of its impurities. These include aldrin, chlordane, dieldrin, DDT, and heptachlor as pesticides, PCB primarily as an industrial chemical, and dioxins and furans as unintentional introduction. There is also presence of DDT as an impurity (<0.1%) in Dicofol, but for which available Dicofol usage data indicate that DDT releases to the environment from this source are likely to be small. Hexachlorobenzene (HCB) is present as an impurity in atrazine, lindane, chlorothalonil, picloram, pentachloronitrobenzene (PCNB), pentachlorophenol (PCP), etc

| **Table 1. : The POPs Convention Chemicals found in Samoa** | |
|---|---|
| [1]Pesticide [2]Industrial Chemical [3]Byproduct | |
| aldrin[1] | Hexachlorobenzene (HCB)[1,2,3] |
| dieldrin[1] | polychlorinated biphenyls (PCBs)[2,3] |
| DDT[1] | polychlorinated dibenzo-p-dioxins (Dioxins)[3] |
| heptachlor[1] | polychlorinated dibenzo-furans (Furans)[3] |
| chlordane[1] | |

# 5. Production, Import and Use

## 5.1 Sources

Samoa does not manufacture any of the intentionally released substances such as pesticides and industrial chemical, thus the main sources of entry are through, transportation and handling, storage, use and disposal. As for unintentional releases, the main sources are through uncontrolled combustion of different fires, controlled combustion processes such as incineration, and incomplete combustion of motor engines. Table 2 shows the different sources of POPs entry in the environment in Samoa.

## Table 2: POPs Sources in Samoa

| Chemical | Source Entry into the environment |
|---|---|
| Aldrin/Dieldrin | *Agricultural use*<br>• Young banana sucker soaking,<br>• runoff from agricultural use,<br>• spills at storage and chemical mixing sites |
| Chlordane | *Ants and termite control*<br>• building spraying for termites,<br>• spills at storage site, |
| DDT | *Agricultural Use*<br>• Spraying of banana plantations<br>*Public health*<br>• dengue fever spraying in the 1970's<br>• mosquito coils |
| Heptachlor | *Termite control*<br>• house spraying<br>• Spills from handling and mixing of chemicals for use |
| PCDD/PCDF | *Controlled Combustion Processes*<br>• waste incineration<br>• backyard burning of wastes<br>• power generation<br>• transportation and 2-stoke engines<br>*Uncontrolled combustion Processes*<br>• open burning<br>• domestic heating<br>• forest fires and<br>• dry cleaning,<br>• dying of pandanus for fine mats |
| PCB | Electric transformers<br>• Spills from old electric transformers<br>• Storage sites |

Based on the exposure pathways for chemicals entering the environment, the selected environmental media were identified, of which Table 3 shows the chemicals present in each. The tables confirm the qualitative information collected as part of the assessment in that, no more new chemicals are being released. The more persistent chemicals such as DDT and PCB are present in more than one media, but in smaller quantities than those recorded by the Fryauff (1982) study when most of the chemicals were either still being used or being phased out.

## Table 3. POP and PTS presence in different environmental media in Samoa

| Chemicals | Environmental Media | | | | | | Total |
|---|---|---|---|---|---|---|---|
| | Soil | Marine sediment | Marine organism | Water | Animal fat (pig) | Breast milk | |
| Aldrin | - | - | - | - | - | - | 0 |
| Chlordane | X | - | - | - | - | - | 1 |
| DDT | X | X | X | - | X | X | 5 |
| Dieldrin | X | X | X | - | - | | 3 |
| Heptachlor | X | - | - | - | - | | 1 |
| PCB | X | - | - | - | X | X | 3 |
| PCDD/ PCDF | NA | NA | NA | NA | NA | NA | |
| HCB | - | - | - | - | - | - | 0 |
| **PTS:** | | | | | | | |
| *PAH/* TPH | X | - | - | - | - | - | 1 |
| TBT | - | X | - | - | - | - | 1 |
| CCA | X | - | - | - | - | - | 1 |
| Lindane (g-HCH) | - | - | - | - | - | X* | 1 |
| Other heavy metals | X | X | X! | X | - | - | 4 |

* Breakdown product beta-Hexachloro-CycloHexane (HCH) ! Arsenic in Vaiusu Bay

## 5.2: Production and Use:

### *5.2.1 Intentional introductions: Pesticides and PCB*

Samoa does not manufacture any of the pesticides or PCB identified in the Convention, while its association with some of the agricultural chemicals goes back as early as the 1950's. At this time dieldrin was used to control the leaf hopper for taro plantations, and control borer in banana plantations. (Laufasi Ola Bulletin 1956). Based on the inventories and assessment reports, the POPs and PTS chemicals were imported for the following uses.

- Aldrin and dieldrin which are similar compounds were used for crop protection against various soil dwelling pests as well as for termite infestation, by soaking the young banana saplings in the chemicals before planting. The approach was discontinued in the late 1970's
- DDT was commonly used as one of the mixtures in the puffer for new banana bunches and as health vector spraying for malaria and dengue fever in the 1970's. According to Ministry of Health reports, DDT was last used for dengue fever vector spraying in 1974. A specific brand of mosquito coils was found to contain DDT after DDT had been non-consented under the related Rotterdam Convention for Prior Informed Consent for trade.
- Chlordane was originally used as a pesticide on field crops such as corn and citrus fruits and was later used to control termites in houses and cable phone lines. The last known supplies were with the Agricultural Store and Island Pest Control in the early 1990's
- Heptachlor was once used as a non-agricultural insecticide for ants and termite control
- PCBs were imported into the country as part of electrical transformers. The amount of PCB containing transformers imported could not be obtained as they were not documented in the records of imports
- The presence of chlorothalonil, picloram, pentachlorophenol (PCP), atrazine, and lindane in the ASC list of chemicals (SPREP report, 2002) indicated that HCB may also be present in Samoa although analysis have not shown any traces.
- Lindane is currently imported for pharmaceutical uses for scabies but with alternatives now available, this could be phased out/discontinued.

No records were available to ascertain the quantities imported by the main importers such as the Agicultural Store Corporation (ASC) since the last imports were identified as being prior to the establishment of the office of Register for Pesticides. The recent inventories and surveys did not find any pesticide stockpiles left in country while the only indication of past use was obtained from personal communications with some of the people associated with their use or management and former Department of Agriculture's "Laufasi Ola" journal.

### *5.2.2 Unintentional Introduction: Dioxin and furans*

Dioxins and furans are mainly produced from incomplete combustion processes at the incinerators, and industrial processes with no Air Pollution Control (APC) and open burning processes. According to US EPA, dioxin can be formed through natural combustion, but the contribution of natural combustion to dioxin levels in the environment is probably insignificant. Table 4 shows the Samoa dioxin and furans inventory estimates where the major releases are

- Waste Incinerations: approximately 0.797g Toxic Equivalent (TEQ) /annum is released annually from fly ash and air
- Uncontrolled combustion: approximately 0.425g Toxic Equivalent (TEQ)/annum (a) mainly from open and uncontrolled burning
- Power generation and Heating: approximately 0.009gTEQ/a annually with the majority release from domestic heating and cooking
- Transportation: approximately 0.003gTEQ/a annually mainly from vehicle and 2 stroke engines emissions,
- Miscellaneous: approximately 0.2 TEQ/annum from dry cleaning and tobacco smoking
- Waste disposal, Consumer goods, and metallurgic processes have insignificant releases on an annual basis

**Table 4: Estimated Dioxin and furan releases in Samoa**

| | Source Categories | Annual Releases (g TEQ/a) | | | | |
|---|---|---|---|---|---|---|
| Cat. | | Air | Water | Land | Products | Residue |
| 1 | Waste Incineration | 0.797 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2 | Ferrous and Non-Ferrous Metal Production | 0.000 | 0.000 | 0.000 | 0.000 | 0.0 |
| 3 | Power Generation and Heating | 0.009 | 0.000 | 0.000 | 0.000 | 0.0 |
| 4 | Production of Mineral Products | 0.000 | 0.000 | 0.000 | 0.000 | 0.0 |
| 5 | Transportation | 0.003 | 0.000 | 0.000 | 0.000 | 0.0 |
| 6 | Uncontrolled Combustion Processes | 0.245 | 0.000 | 0.020 | 0.000 | 0.180 |
| 7 | Production of Chemicals and Consumer Goods | 0.000 | 0.000 | 0.000 | 0.000 | 0.0 |
| 8 | Miscellaneous | 0.000 | 0.000 | 0.000 | 0.000 | 0.150 |
| 9 | Disposal/Landfilling | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 10 | Identification of Potential Hot-Spots | | | | | |
| **1-9** | **Total** | **1.1** | **0.0** | **0.0** | **0.0** | **0.3** |

Samoa's annual dioxin and furan releases of about 1.4gTEQ/a which is similar to Brunei Darussalam whose annual dioxin and furan release is 1.401TEQ/annum. Other countries who used the Tool Kit have estimates of annual releases higher than Samoa include Uruguay (28gTEQ/a), Jordan (142.2gTEQ/a), and New Zealand (14-51gTEQ/a for air only). Nevertheless, complacency in reducing dioxins and furans could pose some impacts in the future if appropriate best environmental practices best available technology options are used for waste incineration and transport.

## 5.3 Levels and Trends

### 5.3.1 Intentional releases: Pesticides and PCB

The levels of pesticides releases in Samoa varied throughout the years, with the last major releases of DDT, dieldrin and aldrin in the 1970's. Heptachlor and chlordane were identified as the chemicals last used around the early 1990's, the confined uses for termite spraying limited any possible nation wide contamination. Five PCB contaminated transformers have been identified and confined in secured locations for disposal. Table 5 elaborates on all the POPs and PTSs levels and trends

Since POPs pesticides and PCBs are no longer consented for importation into Samoa, it is expected that there will be no more intentional releases into the environment, except if they are imported illegally. Therefore current levels of contamination which are very confined and localized for soils are expected to decrease over the years, especially if the highly contaminated areas can be cleaned and disposed or sealed from further contact with humans or animals.

**Table 5: POPs and PTS in Samoa**

| Chemicals | Use | Amounts | Current status | Levels | Trends |
|---|---|---|---|---|---|
| Aldrin | Banana plantations | Moderate | Non-consent for import since 1998 | • Widely used in banana plantation up to the 1970's<br>• No known contamination or stockpile | • No new releases into the environment<br>• Soil erosion could result in bio-accumulation in aquatic and marine organisms |
| Chlordane | Termite control | Low | Non-consent for import since 1993 | • Contamination in only two storage sites (ASC Vaitele and ISC Vaivase | • No new releases into the environment<br>• Possible contamination at homes sprayed with chlordane<br>• Localized contamination can be eliminated with clean up |
| DDT | Banana plantation | Widely used in banana plantations | Non-consent for agricultural use since 1993 | • Contamination at ASC Vaitele facility, and some old plantations<br>• low level detection in pig fat, marine organisms tested<br>• Very low levels of DDT in humans possibly from past use or imported food and other products | • Possible increase in food chain bioaccumulation from existing low levels in marine organisms from Vaiusu Bay and domesticated pigs<br>• Decreasing levels of presences in humans due to the absence of any new releases |
| Dieldrin | Banana plantations | Widely used in banana plantations | Non-consent for import since 1998 | • widely used for banana plantations<br>• Confined contamination in two confirmed sites<br>• Presence in marine organisms | • No new releases into the environment<br>• Decrease of bioaccumulation in food chain |
| Heptachlor | Termite control | Low | Non-consent for import since 1994 | • very low and confined use for termite control<br>• contamination only at ASC Vaitele compound and ISC Vaivase | • no new releases into the environment<br>• Possible contamination at homes sprayed with chlordane |
| PCB | Electrical transformers | Low | Importing countries do not produce PCB transformers anymore | • unknown number of imported transformers with PCB<br>• three contaminated sites (EPC Vaitele, Salelologa and TVC Asau) | • no new imported transformers containing PCBs<br>• contaminated sites are sealed and planned for disposal, therefore pose limited risk to the environment and human health |
| PCDD/ PCDF | Produced from combustion processes and burning | Moderate | Produced from combustion processes and burning with low levels from other processes | • emissions are low compared to other countries<br>• highest releases from biomass burning and incinerators | • considerable decrease in future when new incinerators with good APC are installed<br>• implementation of waste management strategy |
| **PTS:** | | | | | |
| TPH/PAH | Oil waste | Low | | • presence at the main bulk storage oil facility | • will be reduced when good oil management plans are installed for waste oil disposal |
| TBT | Anti-fouling for boats | Low | No anti-fouling done in the country | • presence in marine sediments from main Matautu Wharf | • Could continue to be present in the area due to high traffic use of the area, although no anti-fouling is done in country (water blasting hulls?) |
| CCA/PCP | Timber treatment | Moderate | not used anymore | • the TVC site in Asau is the only area that has significant presence which should be a priority contaminated site for clean up | • clean up of SFC site will eliminate future contamination |
| Lindane (g-BHC/ HCH) | For scabies | Low | Non-consent for import for livestock use since 2000 when alternative was identified | • found as degradation product beta-HCH in breast milk samples | • used for medical purposes only |

The current levels of bioaccumulation for DDT, dieldrin, PCB, and beta-HCH in fatty tissues for animal fat, humans and marine sediments are below levels of concerns for human health and the environment. These are expected to continue to decrease over the years as long as no new chemicals are released into the environment.

For PTSs, high concentrations of TBT were found in marine sediments at the Matautu Wharf, possibly from anti fouling used in boats. These releases will possibly continue with the frequent use of the wharf as the main port of entry for ships. To ensure that this contamination is not spread, a possible remedial action can be through an advisory to limit shellfish intake from the site.

### 5.3.2 Unintentional releases: dioxin and furans

The current releases from dioxin and furans are considered low compared to other countries of the world and are at levels that do not pose considerable impacts on the environment and human health. Nevertheless, if actions are not taken to reduce the current levels, the accumulation in soil and water as well as the bioaccumulation in animals could be a concern in the future.

## 5.4 Stockpiles

To date, the only stockpiles of POPs found in Samoa are electric transformers with PCBs, which an exact amount has not been identified due their continued use, although only five transformers have been confirmed to have PCBs above 20 mg/ kg oil. The obsolete transformers and those taken for repairs are tested using the PCB quick test method to determine if they contain PCBs. Transformers with PCB are than placed in the allocated stockpiles at the EPC Vaitele and Salelologa depot.

Buried stockpiles of obsolete chemicals were noted at the Nuu Research station although no confirmation on what chemicals are included. A SPREP report indicates the types of chemicals buried although these were based on the memory of some staff since no documentation were identified. Additionally, the analysis around the buried sites shows only very small levels of heptachlor.

## 5.5 Hot Spots

Of all the sites selected and analysed for the POPs assessment, only four sites are considered hot spots based on the extremely high levels of contamination found within them. Two of the sites are particular to POPs, one is a mixture of POPs and PTS while the fourth and are for PTS only.

The hot spots are very small sites, usually less than 25m square and less than *0*.65m in depth. The main source of contamination are from spillage during unloading and/or mixing of chemicals. The hotspots therefore are;

- the Agricultural Store’s Vaitele compound: the area shows contamination from a mixture of chemicals including chlordane and heptachlor. Chlordane showed the most contamination which is around 10 times above recommended levels for commercial sites. The contamination has reached 0.65m depths and shows to cover around 25m2 around the old docking bay to the store room. The major concerns for the site, is the night watchman’s cooking house is less than 5m from the contaminated area, while his chickens forage over the contaminated site. Immediate actions will be needed to stop access of the area by both humans and animals, while possible plans to dispose of the contamination will be needed.

- The Island Pest Control facility in Vaivase also shows contamination of chlordane, heptachlor, as well as heptachlor epoxide. The levels do not exceed those of a commercial area, but total chlordane is more than 7 times above the recommended levels for residential areas. The concern is due to the close proximity of the contaminated site to family residences. Possible actions will be to seal off the contaminated site while a plan for possible disposal is undertaken.

- The SFC Asau old timber treatment facility showed that Arsenic concentrations exceed the guidelines by up to 30 times the acceptable levels. Copper and chromium III concentrations are also significantly elevated; however the levels of these determinands are either within the guidelines or are not considered a major health risk given the current land use. All samples exceed the acceptance criteria set for agricultural land use purposes, as listed in the New Zealand timber treatment guidelines and free-range livestock which, included cattle, pigs and chickens.

**Vaitele EPC and ASC hotspot sites, respectively**

Other sites were also found to be contaminated but below levels of concern to humans and the environment. Nevertheless, some actions need to be undertaken to ensure that the exposure is eliminated in the future. So actions such as sealing off the areas, as well as public awareness programmes for the sites are needed to prevent future human and animal access to contaminated areas.

- PCB:
    - EPC Vaitele Compound where the current contaminated transformers are stored.
    - SFC Asau's old timber treatment plant, has one contaminated old transformer
- Pesticides
    - William Arp's storage and handling facility in Moamoa shows elevated levels of dieldrin and DDT. The area is now a cooking house for the family. The concern therefore is the continual use exposure of humans and animals to the contamination will need to be removed or have the area sealed off.
- Disposal site:
    - Heptachlor was the only POPs present from only one sample at the Nuu Agricultural Research Station. The site is adequately secured but might need proper sealing from future excavation work.
- Vaiusu Bay and Matautu Wharf:
    - the two sites showed low concentrations of dieldrin, DDT, TBT and some other heavy metals. Nevertheless, due to the limited size of samples collected, the sites will require further investigation to ascertain the extent of bio-accumulation in the food chain.

Additional notice should be made to the public and the surrounding users of the areas to avoid contact or utilization of foods from the areas.

**Table 6: POPs Detection levels (mg/ kg)**

| Sites | Dieldrin | Chlordane | DDT | Heptachlor | PCB | b-HCH | TBT | Copper/chromium/ arsenic: (CCA) |
|---|---|---|---|---|---|---|---|---|
| **Soil:** | | | | | | | | |
| ASC (Vaitele) | - | **2402.381** | 1.145 | **59.4** | | | | |
| EPC (Vaitele) | - | - | - | - | *0*.6 | | | |
| *IPC* (Vaivase) | | **11.619** | | **0.108** | | | | |
| TVC (Asau) | | | | | 1.1 | | | Copper: 6580- 41,200<br>Chromium: 1980- 18,700<br>Arsenic: 4860- 60,200 |
| William Arp (Moamoa) | **0.23** | | 0.04 | | | | | |
| Samoa College Plantation | | 0.857 | | | | | | |
| Nuu Research Station | | 3.033 | | 0.275 | | | | |
| ASC (Apia) | 0.104 | | | | | | | |
| **Sediment:** | | | | | | | | |
| Vaiusu Bay | | | | | | | | |
| Matautu Wharf | | | | | | | | |
| **Animal samples:** | | | | | | | | |
| Pig fat (mg/kg) | | | 0.007-0.121 | | 0.06 | | | |
| Breastmilk (mg/kg) | | | 0.006-0.132 | | 0.001-0.003 | .0004-0.0006 | | |
| Tugane (bivalve) | | | 0.0003 | | | | | |
| Fatuatua (rock oyster) | | | 0.00009 -.00066 | | | | | |
| **Guideline:** | | | | | | | | |
| **NZFSA (animal tissue)** | | | **5** | | | | | |
| **NZFSA (marine sediments)** | | | **0.1** | | | | | |
| **USEPA (residential)** | **0.13** | **1.6** | | **0.053** | | | | |
| **USEPA (commercial)** | | **50** | **20.8** | **0.11** | **50** | | | Copper 47,000<br>Chromium 100,000<br>Arsenic 380 |
| **(Australia) NEPM** | dieldrin **50** | **250** | **1000** | **10** | **1.8** | | | Cu 5000<br>Cr 72,000<br>As 500 |

**Leaked (approximately 2/3) PCB transformer in Asau**

## 6. Information Gaps

Several important data and documents were unavailable or unobtainable to facilitate the compilation of a full inventory on POPs and PTS in Samoa. These include

- Historical inventory records on the quantities of chemicals imported into the country each year. The only information obtained were the chemical inventories for 2003 chemicals from ASC, Farm Supplies Ltd., Scientific Pest Management, and Arco Chemicals
- Full amounts on production and use of dioxin and furan releasing activities
- Absence of records on PCB containing transformers imported into the country
- Air sampling for POPs chemicals concentration in the air, and
- Historical records of plantations which used POPs pesticides

Due to the absence of any toxicology or eco-toxicology studies in Samoa regarding the possible impacts on the environment and human health from POPs releases, the assessment was not able to clearly show any linkages between the current increase in the amount of cancer patients in the country or any wildlife population decreases with POPs.

Furthermore, the lack of an institution or agency that approves and regulates the importation, use and disposal of industrial chemicals denotes that accurate numbers could not be identified.

Additionally, the assessment was also unable to draw comprehensive conclusions for some of the areas due to the limited number of samples collected . This was clearly evident in the bioaccumulation of POPs in animal tissue and marine sediments, where the sample numbers were low. Nevertheless, the intent of the assessment was to identify if there is presence which should then indicate further actions in the NIP.

The most clearly identifiable gap for the POPs assessment is the lack of technical expertise, and technology in-country to provide training on the proper use, handling and disposal of POPs.

**Water sampling at Fugalei Stream**

# 7. Individual Chemical Profiles:

The chemical profiles presented below is a simplified version (Ritter et al., 1995) for local use while more detailed and standardized profiles for the chemicals are presented in the Pacific Island Regional Assessment for PTS and a global profile produced as part of the Convention. The profiles provides descriptions of the chemicals, sources and exposure pathways, human and environmental impacts, presence, effects on the Samoa and environment and some specific recommendations for actions on each chemical.

## 7.1 ALDRIN/DIELDRIN

***Aldrin chemical properties***

**CAS chemical name**:
1,2,3,4,10,10-Hexachloro-1,4,4a,5,8,8a-hexahydro-1,4:5,8-dimethanonaphthalene.

**Synonyms and Trade Names** (partial list): Aldrec, Aldrex, Aldrex 30, Aldrite, Aldrosol, Altox, Compound 118, Drinox, Octalene, Seedrin.
**CAS No**.: 309-00-2; molecular formula: C12H8Cl6; formula weight: 364.92

**Appearance**: White, odourless crystals when pure; technical grades are tan to dark brown with a mild chemical odour.

**Properties**: Melting point: 104 C(pure), 49-60 C(technical); boiling point: 145 C at 2 mm Hg; KH: 4.96 x 10-4 atm m3/mol at 25 C; log KOC: 2.61, 4.69; log KOW: 5.17-7.4; solubility in water: 17-180 µg/L at 25 C; vapour pressure: 2.31 x 10-5 mm Hg at 20 C

***Dieldrin Chemical properties***

**CAS Chemical Name**:
3,4,5,6,9,9-Hexachloro-1a,2,2a,3,6,6a,7,7a-octahydro-2,7:3,6-dimetanonapth[2,3-b]oxirene.

**Synonyms and Trade Names** (partial list):Alvit, Dieldrite, Dieldrix, Illoxol, Panoram D-31, Quintox.

**CAS No**.:60-57-1; molecular formula: C12H8Cl6O; formula weight: 380.91.

**Appearance**: A stereo-isomer of endrin, dieldrin may be present as white crystals or pale tan flakes, odourless to mild chemical odour.

**Properties**: Melting point: 175-176 C; boiling point: decomposes; KH: 5.8 x 10-5 atm·m3/mol at 25 C; log KOC: 4.08-4.55; log KOW: 3.692-6.2; solubility in water: 140 µg/L at 20 C; vapour pressure: 1.78 x 10-7 mm Hg at 20 C.

**Description**

Aldrin and dieldrin are similar compounds which were both used for crop protection against various soil dwelling pests as well as for termite infestation. Both were widely used in Samoa in banana plantations. These chemicals have since been banned for importation by the Pesticides Technical Committee. No confirmation was obtained for the import and current use of these pesticides in Samoa. Dieldrin is a primary degradation product of aldrin. Dieldrin has been detected in three locations, with two being old plantation sites while the third is currently used by a pest control company. Aldrin was not detected but any aldrin detections are much lower and less frequent, since it is converted rapidly to dieldrin through both chemical and biological processes.

**Sources and Sectors**

Known and suspected sources include:

- Contaminated soils from historical applications;
- Atmospheric transport;
- Contaminated building materials from termiticide application; and
- Hazardous waste sites associated with storage, distribution, transfer, or use.

**Exposure and Health Effects**

Humans are exposed to aldrin and dieldrin through water, food and soil. Contaminated fish are a main source of exposure through food. Both aldrin and dieldrin are fat-soluble and will accumulate in the bodies of humans and animals. Aldrin is converted to dieldrin in the human body, which is then slowly excreted. Possible short-term health effects include headache, dizziness, nausea, vomiting, irritability, confusion, ataxia and general malaise. Large doses can cause death. Long-term health effects of both aldrin and dieldrin can include adverse neurological and behavioral effects. In addition, dieldrin is thought to cause reproductive problems and is considered an endocrine disruptor. Both aldrin and dieldrin are probable human carcinogens. Recent studies have linked elevated exposure to dieldrin with breast cancer.

**Environmental Impacts**

Concentrations of dieldrin in surface waters are generally higher than other highly persistent organochlorine pesticides, primarily due to its greater preference for the water phase, relative to other compounds in this class. Aldrin and dieldrin, however, still tend to accumulate in biological tissues and are primarily detected as dieldrin. Dieldrin has been detected in many remote locations, including the Arctic, indicating long range atmospheric transport. Short-term exposures to aldrin have been associated with a variety of behavioural and physical effects, including tremors, convulsions, and seizures. Dieldrin exposure can result in similar effects, including convulsions, ataxia, dyspnea, and immobility. Long-term effects of dieldrin in mammals may include reproductive effects such as reduced litter size, reduced ovulation rate, and increased resorption of pregnancy.

**Effects to Samoa's Environment:**

- The highest concentration of dieldrin was found at the ASC Vaitele hot spot
- There are no current stockpiles of aldrin or dieldrin found in the Samoa.
- Soil sampling show dieldrin to be present at the old banana plantations in Mulifanua and Moamoa, of which the Moamoa residential area is the main concern due to the area currently used as the family cook house

High concentrations were found only at the docking bay for the ASC storage facility in Vaitele. Concern is the current use of the area by the nightwatchman's family as cooking area and foraging for the domesticated animals

Since Aldrin/Dieldrin are not manufactured in Samoa, the only source of contamination was from importation of these chemicals for agricultural uses. These chemicals were widely used in Samoa for the treatment of corms for new banana plantations. The uses of these chemicals in Samoa have ceased. Dieldrin is currently only present around storage and handling sites such as ASC and some of the old banana plantation storage facilities such as William Arp's in Moamoa and STEC's old banana plantation in Mulifanua. With the low levels of dieldrin and aldrin in the environment, this is less of a threat to human health and the environment apart from the contaminated sites which will need remedial actions.

**Recommended Actions**:

1. Possible sampling of more storage and handling facilities for old plantations to determine if aldrin/dieldrin is present so appropriate actions can be undertaken to minimize human or animal contact with the areas or undertake actions for appropriate disposal.

2. Inform the owners of currently contaminated areas, namely ASC and William Arp of the contaminated areas and actions undertaken to seal off the areas from further human or animal contact.

3. Legislate the ban on the importation of aldrin and dieldrin as alternatives have been found and are currently used.

## 7.2 CHLORDANE

**Chlordane chemical properties**

**CAS Chemical Name**:
1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-4,7-methano-1H-indene

**Trade names**: (partial list): 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.

**CAS No**.: 57-74-9; molecular formula: C10H6Cl8; formula weight: 409.78

**Appearance**: colourless to yellowish-brown viscous liquid with an aromatic, pungent odour similar to chlorine;

**Properties**: Melting point: <25 C; boiling point: 165 C at 2 mm Hg; KH: 4.8 x 10-5 atm m3/mol at 25 C; log KOC: 4.58-5.57; log KOW: 6.00; solubility in water: 56 ppb at 25 C; vapour pressure: 10-6 mm Hg at 20 C.

**Description**

Chlordane is a thick, colourless to amber liquid with a mildly irritating smell. Technical chlordane is not a single chemical but a mixture of pure chlordane with more than 140 other related compounds.

Chlordane is a man-made pesticide sometimes referred to as Octachlor® or Velsicol 1068®. Chlordane is very persistent in the environment and poses concerns of human cancer risk, evidence of human exposure and accumulation in body fat, and danger to non-pest wildlife. Chlordane was originally used as a pesticide on field crops such as corn and citrus fruits and was later used to control termites in houses.

### Sources and Sectors

Ongoing sources to the environment are associated with historical applications and releases. The major source of contamination to Samoa's environment is from importation and the lack of laws and regulations to protect the safety use of the chemical in Samoa which have resulted in the main contaminations at the storage and handling sites.

***Known or suspected sources include**:*

- Contaminated building materials from termiticide application;
- Soils to which chlordane was historically applied, spill, etc.;
- Hazardous contaminated sites associated with poor storage, transfer or use;
- Contaminated reservoirs; and
- Illegal importation of chlordane into the country.

### Exposure and Health Effects

A primary exposure route for chlordane is through contaminated food. Humans living in homes that were previously treated with chlordane to control termites may also be exposed. Applicators are high risk exposures if safety precautions are not adhered. Short-term acute exposure to chlordane may cause eye, nose, mouth and throat irritation, nausea, headaches, confusion, weakness, vision problems, diarrhea, abdominal pain, convulsions, unconsciousness and vomiting. Long-term exposure has been associated with liver and kidney damage, cancer and infertility. Chlordane has been classified as a probable human carcinogen based on studies in mice in which liver cancer was observed at concentrations of 30 to 64 mg/kg/day. Chlordane may also cause behavioral disorders in children who are exposed before birth or while being nursed.

Because chlordane was primarily used to control termites in Samoa, concentrations of the chemical are likely to be localised in storage areas and surroundings, and at application sites. Those living or working in these structures today may be at the greatest risk for exposure.

### Environmental Impacts

Chlordane is found in all environmental media including air, soil, water, and sediment. In soils, it binds strongly to particles and is highly persistent, having been shown to remain for over 20 years. It is unlikely to enter groundwater, though it does volatilize from surface soils to some extent. Although the half-life of chlordane in the atmosphere is relatively short, it has been known to travel long distances and has been detected in remote locations such as the Arctic. Chlordane concentrations in air from homes that were previously treated for termite infestation have been found to be 10-1000 times higher than in ambient air, even years after treatment occurred. In aquatic systems chlordane is typically bound to sediments in harbours and bays. The ultimate fate of chlordane in lakes and oceans is in the bottom sediment. Chlordane also bio-accumulates in both marine and freshwater organisms. Chlordane has been demonstrated to be highly toxic to freshwater invertebrates and fish. Chronic exposures to chlordane in the environment have been associated with a shortened lifespan, reproductive impairments, reduced fertility, and changes in the appearance or behaviour of animals and birds. Chlordane has also been identified as an endocrine disruptor and may cause adverse reproductive or developmental effects.

**Effects to Samoa's Environment:**

Chlordane is no longer imported in Samoa as ICON and COOPEX (both synthetic pyrethroids) are now used for termite and ant control for houses

- There are no current stockpiles of chlordane found in the Samoa.
- Soil sampling show chlordane in only two locations,
    - The Island Pest Control site in Vaivase has elevated contamination in relation to USEPA guidelines for residential areas
    - The ASC storage facility in Vaitele show extremely high contamination at the docking and loading area
- One marine sample found chlordane detection that exceeds marine organism guidelines

Since chlordane is not manufactured in Samoa, its source of contamination to Samoa's environment is primarily from the imported chemical use. Tests results confirmed contamination sites as primarily dealers and pest control business in the country. These contaminations were from poor management and the lack of training for the employees involved with handling of the chemical. The scope of chlordane contamination in Samoa is very limited and very manageable if assistance is obtained for the cleanup of two highly contaminated sites.

The presence of chlordane in one marine sample from the Vaiusu Bay area is expected since the area is the main outlet for all the western Apia watersheds and Apia Township. Since chlordane is no longer imported it is expected that the bioaccumulation value will decrease over the years. Nevertheless, more sampling should be done in this area because of the high fishing and shellfish value.

**Recommended Actions**:

1. To continue the ban on importation of chlordane into the country
2. Fence or cementing the contaminated sites at ASC Vaitele and Island Pest Control in Vaivase from further human and animal access, while actions are undertaken to dispose of the contamination
3. Further sampling to be undertaken on marine organisms from the Vaiusu Bay.

## 7.3 DDT

***DDT chemical properties***

**CAS Chemical Name**: 1,1'-(2,2,2-Trichloroethylidene)bis(4-chlorobenzene)

**Synonyms and Trade Names** (partial list): 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.

**CAS No.**: 50-29-3; molecular formula: $C_{14}H_9Cl_5$; formula weight: 354.49.

**Appearance:** Odourless to slightly fragrant colourless crystals or white powder.

**Properties**: Melting point: 108.5 C; boiling point: 185 C at 0.05 mm Hg (decomposes); KH: 1.29 x 10-5 atm·m3/mol at 23 C; log KOC: 5.146-6.26; log KOW: 4.89-6.914; solubility in water: 1.2-5.5 µg/L at 25 C.

**Description**

DDT is a manufactured chemical widely used as a pesticide that does not occur naturally. DDT was one of the most commonly used chemical for controlling insect pests on agricultural crops after 1945. It was also highly effective in controlling insects that carry such diseases as malaria and typhus in the world. DDT was a household name in the 1960s to the late 1970's. It was commonly used to puff into new banana bunches. Technical DDT is primarily composed of three forms: p,p'-DDT (85%), o,p'-DDT (15%), and o,o'-DDT (trace), all of which are white, crystalline, tasteless, and almost odourless solids. DDE and DDD, similar compounds which are also the breakdown products of DDT in the environment, are found in small amounts as contaminants in technical DDT.

No current use of DDT has been identified in Samoa except presence in some of the mosquito coils imported in the mid 1980's, and the public health spraying during a dengue fever outbreak in the 1970's.

**Sources and Sectors**

The primary sources of DDT and metabolites to the environment are from past application and storage sites and from current illegal uses in the country. Numerous hazardous waste sites throughout Samoa associated with past applications, distribution, storage and disposal contain levels of DDT. These sites can result in localized exposure. Further studies are done in pig fat tissues. Considerable DDT concentration in pig fats from only the MWH study although same methodology was undertaken. This poses a concern because pork is major source of food in the Samoan diet.

**Known or suspected sources include**:

- Historical applications;
- Atmospheric transport;
- Hazardous waste sites associated with storage, transfer, or use; and
- Continued use of pesticides containing DDT impurities, such as Dicofol, etc.

**Exposure and Health Effects**

The primary human exposure pathway for DDT is through ingestion of contaminated food or through inhalation. However, small amounts of DDT, still present in soils throughout Samoa as the result of historical applications in banana plantations and mosquito control, may represent an additional exposure pathway. Surprising results of pig fat contaminated with traces of DDT indicated the wide spread of DDT contamination in Samoa and causes concerns in pig farming and free range chickens in Samoa as a potential high risk source of DDT contamination in the local food chain.

Short-term health effects associated with DDT can include headaches, nausea, excitability, tremors, diarrhoea, disturbed gait, seizures and convulsions. Prolonged and repeated exposure can irritate the eyes, skin, nose, and throat. Long-term health effects may include cancer, liver damage, and fertility problems. In the body, DDT is stored in fatty tissue and tends to leave the body very slowly with decreasing exposure. Nursing infants may be exposed to DDT through breast milk. There is limited evidence that correlations may exist between maternal DDT blood levels and miscarriage in humans. However, the confounding effects of other organochlorine compounds make it impossible to positively attribute the effects to DDT. DDT has been classified by the USAEPA as a probable human carcinogen

**Environmental Impacts**

Historically, DDT was released to the environment during agricultural use and disease vector control as an insecticide. DDT is very persistent in the environment. It has an extremely low solubility in water and therefore tends to bind to soils and sediments. Its persistence, combined with wind and water erosion and the resulting long range atmospheric transport, has made the compound virtually ubiquitous in the environment. DDE and DDD are the initial breakdown products of DDT in the soil environment. Both sister compounds are highly persistent and have chemical and physical properties similar to those of DDT. DDT reaches surface waters primarily by runoff or atmospheric transport. The reported half-life for DDT in the water environment ranges from a few days for fast-moving environments (where the compound is at or near the surface of the water) to more than 150 years. The main degradation and loss pathways in the aquatic environment are volatilization, photo-degradation, adsorption to water-borne particulates, and uptake by aquatic organisms, which store DDT and DDT metabolites in their tissues. In the atmosphere, DDT can photo-oxidize to carbon dioxide and hydroxyl radicals. DDT is eventually broken down by sunlight or by micro organisms to form DDE or DDD. The presence of DDT (as opposed to DDE or DDD) in samples from known sources, however, indicates that DDT's photo-degradation is slow under natural conditions. Both wet and dry deposition are significant mechanisms of removal from the air column. Oral exposure to DDT is moderately to slightly toxic to mammals. Animal studies suggest that short-term exposure to DDT in food may have a harmful effect on reproduction. It is believed that the reproductive effects associated with DDT may be the result of a disruption in the endocrine system. Long-term exposure in animals affects liver function, reproduction and behaviour. Initial degradation products in mammalian systems are DDE and DDD, which are very readily stored in fatty tissues. DDT is also highly toxic to, and bioaccumulates in, aquatic organisms.

**Effects in Samoa's Environment**

DDT has not been imported into the country since 1994 in mosquito coils therefore the only presence is from sediments and bioaccumulation. DDT showed the highest absolute concentrations of all the POPs and some samples reaching near the unacceptable limits for the sample type as defined by various international standards

- No stockpiles of DDT are left in Samoa
- The only traces of DDT in soils samples is from the ASC Vaitele's storage facility, which has been sealed-off from human access other than the nightwatchman's family
- 43 percent of the pig fat samples analysed show traces of DDT, with the highest concentration found in the pigs tested at 0.121 mg/kg which does not exceed the safety guideline or 5mg/kg
- Marine sediments at Matautu-tai wharf and Vaiusu bay show low concentrations of DDT

- Total DDT was present in 100% of the human breastmilk tested which is mostly from the high DDE values. The DDT traces in the samples range from 0.006 -0.132mg/kg which are very low level.

DDT was a household name in Samoa in the 1960s. DDT was widely used as a pesticide in Samoa for the control of pests in banana plantations and in mosquito control efforts. Since DDT was widely used in the rural areas for banana plantations, it is not surprising than that it also represents the highest total concentration of the POPs found in Samoa. The wide spread use of mosquito coils in Samoa which in the past were confirmed to have DDT could be attributed to some of the bioaccumulation shown in pig fat and humans. The critical concern is the diversity of its presence having being present in all the environmental media tested accept water samples. Additionally, the concentration in some of the main food sources such as pigs and marine organism shows that it is moving up the food chain. The presence in all the women tested reflect the wide extent on the bioaccumulation in humans.

**Recommendations for Actions:**

1. A possible toxicology study should be undertaken to determine if DDT presence in Samoa is impacting the human health and environment.
2. Additional sampling should be undertaken on animals and marine organisms that are part of Samoan diet to determine how much of the DDT is being passed through the food chain
3. Additional sampling and analysis should be undertaken for old plantation storage sites and ex-workers associated with using DDT to ascertain the extent of possible concentration in the food chain.
4. Ban the import of DDT for agricultural use except if it's needed for malaria vector spraying.

## 7.4 HEPTACHLOR

***Heptachlor chemical properties***

**CAS Chemical Name**: 1,4,5,6,7,8,8-Heptachloro-3a,4,7,7a-tetrahydro-4,7-methanol-1H-indene.

**Synonyms and Trade Names** (partial list): Aahepta, Agroceres, Baskalor, Drinox, Drinox H-34, Heptachlorane, Heptagran, Heptagranox, Heptamak, Heptamul, Heptasol, Heptox, Soleptax, Rhodiachlor, Veliscol 104, Veliscol heptachlor, gold crest H-60

**CAS No**.: 76-44-8; molecular formula: C10H5Cl7; formula weight: 373.32.

**Appearance**: White to light tan, waxy solid or crystals with a camphor-like odour.

**Properties**: Melting point: 95-96 C (pure), 46-74 C (technical); boiling point: 135-145 C at 1-1.5 mm Hg, decomposes at 760 mm Hg; KH; 2.3 x 10 -3 atm·mm3/mol; log KOC: 4.38; log KOW; 4.40-5.5; solubility in water: 180 ppb at 25 C; vapor pressure: 3 x 10-4 mm Hg at 20 C.

**Description:**

Heptachlor is a white to tan waxy organic solid with camphor-like odour. The epoxide is formed from heptachlor in the environment. It was once used as a non-agricultural insecticide. Most uses were for fire ants control in buried electric power transformers and telephone cable boxes.

It is believed to have been used in Samoa for termite control in the past. Heptachlor epoxide is not produced commercially, but rather is formed by the chemical and biological transformation of heptachlor in the environment.

The world's last producer of heptachlor, the U.S.-based Velsicol chemical corporation, announced in 1997 that it would permanently cease production. Limited amounts were imported into the country for pest control mainly for termites in buildings. Importers of heptachlor in the past had ceased importation of this chemical as Lambda-cyhalothrin also known as ICON (registered here; or Karate) is being used as an alternative.

**Sources and Sectors**

Known and suspected sources include:

- Contaminated soils from historical applications;
- Atmospheric transport;
- Contaminated building materials from termiticide application; and
- Hazardous waste sites associated with storage, distribution, transfer, or use.

**Exposure and Health Effects**

Human exposure to heptachlor is mainly through ingestion of food with residues of the compound and through inhalation in homes sprayed with heptachlor as an insecticide. Heptachlor and its epoxide (heptachlor epoxide) cause the following health effects when people are exposed to it at levels above the Maximum Contaminant Level (MCL) for relatively short periods of time: liver and central nervous system damage. Long term effects include extensive liver damage and cancer.

**Effects to Samoa’s Environment:**

Since heptachlor is not manufactured in Samoa, and its limited use in the past, there is no real threat of Heptachlor contamination in Samoa’s environment and to the population. Heptachlor is no longer imported into the country. Contamination sites were confirmed from soil analysis in New Zealand. Two sites with major contamination were confirmed as possible spills from loading, unloading and handling of the chemical. The contamination sites are localized and therefore very manageable for cleanup. No stockpiles of heptachlor exist in Samoa

- three of the sampled sites which are storage and handling sites of the importers and pest controllers had traces of heptachlor, albeit two are above safety guidelines for commercial areas

**Recommended Actions:**

1. Continue the ban on heptachlor importation, by using the existing alternatives for ant and termite controls of Permakil, ICON and COOPEX

2. Advise contaminated sites for actions on clean up or sealing of areas from further access by humans and animals

## 7.5 PCDD/PCDF (Dioxin and Furans)

### *Dioxins chemical properties*

| Congener Group | Molecular weight (g/molecular | Vapour Pressure | Water Solubility (mg/m3) | Log KOW (Pa X 10-3 |
|---|---|---|---|---|
| M1CDD | 218.5 | 73-75 | 295-417 | 4.75-5.00 |
| D2CDD | 253.0 | 2.47-9.24 | 3.75-16.7 | 5.60-5.75 |
| T3CDD | 287.5 | 1.07 | 8.41 | 6.35 |
| T4CDD | 322.0 | 0.00284-0.275 | 0.0193-0.55 | 6.60-7.10 |
| P5CDD | 356.4 | 0.00423 | 0.118 | 7.40 |
| H6CDD | 391.0 | 0.00145 | 0.00442 | 7.80 |
| H7CDD | 425.2 | 0.000177 | 0.0024 | 8.00 |
| O8CDD | 460.0 | 0.000953 | 0.000074 | 8.20 |

### Description:

**Polychlorinated dibenzo-*para*-dioxins (dioxins) and polychlorinated dibenzo-furans (furans)** are two structurally similar families of compounds that include 75 and 135 congeners, respectively. At least seventeen are considered highly toxic. The overall toxicity of a dioxin containing mixture is assumed to be the Toxic Equivalent (TEQ) of a stated amount of pure 2, 3, 7, 8-tetrachloro-dibenzo-p-dioxin (TCDD), the most potent, hazardous and well-studied dioxin. Dioxins and furans have similar effects on human health, and will be referred to collectively as dioxins.

Dioxins are not commercially produced, but are by-products of combustion and industrial processes, including the manufacture of chlorinated chemicals, the incineration of hospital, hazardous and municipal waste, and the bleaching of paper products. Dioxins are stable, persistent compounds that are believed to have a half-life of seven to twenty years in the human body.

Dioxins are known to be toxic at extremely low doses. In most industrialized nations of the world, on average, are exposed to only 1 to 3 picograms per kilogram of body weight (bw) per day, with levels assumed to be somewhat lower in developing countries, where little testing has been done. The World Health Organization recently lowered by more than half its tolerable daily intake from 10 pg, fixed previously in 1990, to 4 pg/kg bw, based on a recognition that subtle effects may already occur in the general population in developed countries at levels of 2 to 6 picograms (World Federation of Public Health Associations, WFPHA, 2000).

### Sources and Sectors

Known sources of dioxin and furan releases in Samoa are

- Waste incineration burning at the Hospitals and Quarantine
- Uncontrolled burning from forest fires, backyard burning and umu

### Effects on Humans

In humans, there is evidence that high-level exposure to dioxins and furans can cause variations in serum lipid level, microsomal enzyme induction, and gastrointestinal alterations. Other studies of high-level occupational exposure have found associations with some types of cancer, and have concluded that in utero and lactational exposures to dioxins and furans are capable of affecting the hypothalamic/pituitary/thyroid regulatory system in human infants.

A single cellular mechanism is thought to be responsible for the wide range of effects dioxins can have. It is believed that dioxins affect organisms by binding to pre-existing cellular receptors designed for hormones, entering the nucleus and manipulating the on or off function of the gene.

The genes affected by an impostor-like dioxin contain codes for proteins, hormones, enzymes and growth factors, which collectively influence tissue development in the human body. This mechanism is the same in both humans and animals, allowing extrapolation from laboratory experiments involving dioxin effects on animals to a parallel human reaction. (WFPHA, 2000).

### Effects on the Environment

There is substantial evidence to indicate that populations of wildlife species high on the food chain are suffering health damage due to reproductive and developmental impairment due to background exposures to dioxins and related compounds.

The U.S. EPA hypothesized that the primary mechanism by which dioxins enter ecological food chains and human diet is via atmospheric deposition. Dioxin and related compounds would enter the atmosphere directly through air emissions and are widely spread in the environment as a result of a number of physical and biological processes. (U.S. EPA, 2000).

## EFFECTS IN SAMOA'S ENVIRONMENT:

Manmade source of dioxins exceeds natural source burning by 100:1. According to US EPA, dioxin can be formed through natural combustion, but the contribution of natural combustion to dioxin levels in the environment is probably insignificant. While some small levels of dioxin may have been evident in soil samples hundreds of years old, the critical point is that levels today are much higher, and that substantial levels did not begin showing up until after the birth of the petrochemical industry in the 1940s.

The main sources of dioxin release into Samoa's environment are limited to incinerators, vehicle combustion, forest fires (about every 7 years during La Nina drought events since 1983, e.g. 2003), and backyard burning. So the major source of dioxin unintentional release to Samoa's environment is by burning organic matter in the presence of chlorine. This source of release is thus significant and must be reduced under the Stockholm Convention.

The high number of diesel vehicles in the country is a positive note since chlorine in diesel fuel (0.61 mg/kg) releases less dioxins (although also other air pollutants) compared with unleaded gasoline (14 mg/kg) and leaded gasoline (63 mg/kg). The latter was phased-out in 1999, while American Samoa uses unleaded petrol with a catalyst with virtually zero dioxins emissions that offers further improvement for the future environment.

Actions to minimize the release of man-made releases such as incinerators, vehicle combustion, and backyard burning should therefore have public awareness as a main focus.

### Best Available Technology and Best Environmental Practice

Dioxin and furans major POPs released into Samoa's environment could continual to increase in the future, is the only area in which BAT/BEP are needed.

Based on the analysis and information on the major releases of dioxin and furans, the following are the BAT and BEP that will need to be addressed

1. Waste incineration: the current Hospital and Quarantine incinerators will need to be converted into one of the three controlled combustions incinerators with a good Air Pollution Control (APC) system.
2. Non-chlorinated firewood for cooking, including traditionally on heated rocks '*umu*' making in Samoa, although it has low emissions is the most common form of

emissions in the country. The best environmental practice to reduce the dioxin and furan emissions would be a public awareness campaign to advise the public against using of chlorinated wood and paper. Firewood should be dry, and removal of bark will reduce minerals including Cl burned.

3. Backyard burning and construction sites burning will need to be phased out along with a strong public awareness campaign to separate the rubbish so as to not burn PVC and chlorinated substances.

4. With the majority of small passenger vehicles running on unleaded petrol, the best environmental practice or best available technology would be having strict emission controls on cars or unleaded petrol with a catalyst as for American Samoa with virtually zero dioxins emissions

**Recommendations for Actions**

To facilitate the reduction in releases from dioxin and furans to the environment, the recommended actions are to introduce the BAT/BEP actions identified.

**7.6 PCBs**

**PCBs chemical properties**

**Trade Names for different mixtures** (partial list): Aroclor, Pyranol, Pyroclor, Phenochlor, Pyralene, Clophen, Elaol, Kanechlor, Santotherm, Fenchlor, Apirolio, Sovol.

**CAS No**.: 1336-36-3

| Congener Group | Molecular weight (g/molecular) | Vapour Pressure (Pa) | Water Solubility (g/m3) | log KOW |
|---|---|---|---|---|
| Monochlorobiphenyl | 188.7 | 0.9-2.5 | 1.21-5.5 | 4.3-4.6 |
| Dichlorobiphenyl | 223.1 | 0.008-0.60 | 0.06-2.0 | 4.9-5.3 |
| Trichlorobiphenyl | 257.5 | 0.003-0.22 | 0.015-0.4 | 5.5-5.9 |
| Tetrachlorobiphenyl | 292.0 | 0.002 | 0.0043-0.010 | 5.6-6.5 |
| Pentachlorobiphenyl | 326.4 | 0.0023-0.051 | 0.004-0.02 | 6.2-6.5 |
| Hexacholorbiphenyl | 360.9 | 0.0007-0.012 | 0.0004-0.0007 | 6.7-7.3 |
| Heptachlorobiphenyl | 395.3 | 0.00025 | 0.000045-0.000 | 6.7-7 |
| Octachlorobiphenyl | 429.8 | 0.0006 | 0.0002-0.0003 | 7.1 |
| Nonachlorobiphenyl | 464.2 | - | 0.00018-0.0012 | 7.2-8.16 |
| Decachlorobiphenyl | 498.7 | 0.00003 | 0.000001-0.000 | 8.26 |

**Description:**

**Polychlorinated biphenyls, (PCBs)** are a group of highly toxic chlorinated industrial chemicals used as dielectrics, coolants and lubricants in electrical transformers and other electrical equipment, and to prolong residual activity of pesticides. PCBs are usually released to the environment as a mixture in which other chemicals are also present. PCBs are fire-resistant, have a low volatility, and are relatively stable and persistent, making them well-suited for industrial use but also problematic in the environment.

PCBs have been in use for more than 25 years when in 1966 attention focused on PCB poisoning birds and people. By the late 1970's, evidence of the extreme persistence and adverse health effects of PCBs had resulted in bans on their manufacture in some countries. Many countries have taken steps to control and restrict the flow of PCBs into the environment.

Although they are no longer manufactured or imported into many countries, there remain sizable quantities in storage. In addition, PCB fluids are present in many older transformers, fluorescent lighting fixtures, and other electrical devices and appliances. These are vulnerable to release into the environment, as older components can leach. Other sources of PCB contamination come from improper disposal or incineration of PCBs and PCB-containing waste sites (WFPHA, World Federation of Public Health Associations, 2000). Planar-PCBs are produced by unintentional burning and to be added to estimation by Toolkit methodology.

**PCBs Chemical Structure and Congeners**

PCBs is a category, or family, of chemical compounds formed by the addition of chlorine (Cl2) to biphenyl (C12H10), which is a dual-ring structure comprising two 6-carbon benzene rings linked by a single carbon-carbon bond. The nature of an "aromatic" (benzene) ring allows a single attachment to each carbon. This means that there are 10 possible positions for chlorine substitution (replacing the hydrogen's in the original biphenyl). Species with a single chlorine subsistent are called "monochlorobiphenyl" (or just "chlorobiphenyl"). Species with two chlorines are called "dichlorobiphenyl", and the those with three through ten chlorines, in order, are called: "tri...", "tetra...", "penta...", "hexa...", "hepta...", "octa...", "nona...", and "decachlorobiphenyl". The positions of the chlorine substituents on the rings are denoted by numbers assigned to each of the carbon atoms, with the carbons supporting the bond between the rings being designated 1 and 1'. Any single, unique, well-defined chemical compound in the PCB category is called a **"congener"**. The name of a congener specifies the total number of chlorine substituents and the position of each chlorine. For example: 4,4'-dichlorobiphenyl is a congener comprising the biphenyl structure with two chlorine substituents, one on each of the two carbons at the "4" (also called "para") positions of the two rings. There are 209 PCB congeners.

**Effects on Humans**

Acute effects of PCB exposure in humans were documented following ingestion of contaminated rice oil in Japan in 1968 and Taiwan in 1979. Long term studies of the more than 2,000 people who were exposed during these events revealed increased mortality due to PCB intake. A positive association was established between PCB dosing and acute liver damage, with liver disease being the cause of death in a significant number of exposed people. Acute exposure to PCBs ash also caused chloracne, a chemically induced acneform eruption. Human fetal exposures of PCBs are associated with neural and developmental changes, lower psychomotor scores, short-term memory and spatial learning effects, and long-term effects on intellectual function. Neurological dysfunction has been associated with perinatal PCB exposure in several Dutch studies**.**

**Effects on the Environment**

PCBs have a long and documented history of adverse effects in wildlife. They have been associated with poor reproductive success and impaired immune function of captive harbour seals in the Arctic. After a major flood in the Saginaw River basin in Michigan in 1986 allowed PCB contaminants to spread through the ecosystem, the following year's hatch rate of Caspian terns in the area dropped by more than 70 percent. Hatching chicks showed developmental deformities, and none survived more than five days, Hatch ability of this Caspian tern colony did not show recovery after three more breeding seasons. (WFPHA, 2000).

In water, PCBs are absorbed in sediments and other organic matter; experimental and monitoring data have shown that PCBs concentration in sediment and suspended matter are higher than those in associated water columns. On the basis of their water solubilities and n-octanol-water partition coefficients, the lower the chlorinated PCB congeners will absorb less strongly than the higher chlorinated isomers. Although absorption can immobilize PCBs for relatively long periods in the aquatic environment, absorption into the water column has been shown to occur by both a-biotic and biotic routes. The substantial quantities of PCBs in aquatic sediments can therefore act as both an environmental sink and a reservoir of PCBs for organisms. Most of the environmental load of PCBs has been estimated to be in aquatic sediment. (WHO, 1993). Even though many countries have controlled both use and release of PCBs and new input into the environment is on a reduced scale compared with the past, the available evidence suggests that the cycling of PCBs is causing a gradual redistribution of some congeners towards the marine environment. (WHO, 1993).

Several factors determine the degree of bioaccumulation in adipose tissues: the duration and level of exposure, the chemical structure of the compound, and the position in pattern of substitution. In general, the higher chlorinated congeners are accumulated more readily. Experimentally determined bio-concentration factors of various PCBs in aquatic species (fish, shrimp, and oyster) range from 200 up to 70 000 or more. In the open ocean, there is bioaccumulation of PCBs in higher trophic levels with an increased proportion of higher chlorinated biphenyls in higher ranking predators.

**Effects to Samoa's Environment:**

A survey by SPREP (Graham in Burns et al., SPREP, 2000) identified significant stockpiles of old transformers and transformer oils throughout Samoa, and some of these were shown to contain PCBs (by rapid Chlor-N-Oil 50 test), with only five confirmed beyond 20 ppm on analysis in New Zealand.

The recent re-survey of Samoa has found PCBs in transformers oil by the quick test . Samples sent to Hills Laboratory, New Zealand confirmed PCBs above 50 mg/litre or parts per million in three, i.e. two from Electric Power Corporation, Vaitele and one from Tui Vaai Corporation, Asau. The latter has only about two-thirds of its oil with slightly PCB oil-contaminated soil near the road.

There is very little contamination of PCB in Samoa's environment therefore there is no real threat to Samoa's environment and the population. The contamination is manageable.

**Recommendations for Actions:**

1. Initiate a ban on the importation of any more electric transformers with PCB.
2. Complete the testing of all electric transformers to ensure the contaminated ones are cleaned as part of the Australian Agency for International Development (AusAID) Sub-*r*egional POPs in PIC project coordinated by SPREP

## 7.7 Hexachlorobenzene (HCB)

***HCB chemical properties***

**CAS Chemical Name**: hexachlorobenzene

**Trade names**: (partial list): Amaticin, Anticarie, Bunt-cure, Bunt-no-more, Co-op hexa, Granox, No bunt, Sanocide, Smut-go, Sniecotox

**CAS No.:** 118-74-1; molecular formula: C6Cl6; formula weight: 284.78;

**Appearance**: White monoclinic crystals or crystalline solid

**Properties**: Melting point: 227-230 C; boiling point: 323-326 C (sublimes); KH: 7.1 x 10-3 atm m3/mol at 20 C; log KOC: 2.56-4.54; log KOW: 3.03-6.42; Solubility in water: 40 µg/L at 20 C; vapour pressure: 1.089 x 10-5 mm Hg at 20 C.

***Description:***

**Hexachlorobenzene (HCB)** has been used as both a pesticide and as industrial chemical. While intentional production has declined, HCB is also still produced as a by product during the manufacture of several chlorinated chemicals, it has been detected in the flue gas and the fly ash of municipal incinerators and other thermal processes.

The presence of chlorothalonil, picloram, pentachlorophenol (PCP), atrazine, lindane in the *ASC* list of chemicals (SPREP report, 2002) indicated that HCB may also be present in Samoa as impurities of those chemicals, but the risk to the health and the environment may be of no significance.

**Effects on Humans**

Acute high dose exposure to HCB is associated with porphyria cutanea tarda due to its liver toxicity. HCB is also associated with enlarged thyroid glands, scarring, and arthritis exhibited in offspring of accidentally exposed women. Children born to mothers known to have ingested HCB-tainted food during pregnancy experienced acute illnesses and rashes. These children were additionally exposed through breast milk.

**Effects on the Environment**

Organisms generally accumulate HCB from water and from food, although benthic organisms may also accumulate HCB directly from sediment. The bio-availability of sediment-bound HCB is inversely correlated to sediment organic carbon content, and varies with the feeding habits of the organisms. Fields studies indicate that exposure via food is important for organisms at higher trophic levels, as significant bio-magnification has been observed in several studies in natural aquatic ecosystems. (EHC, Environmental Health Criteria 195, WHO, 1997).

**Recommendations for Actions**

Since there is no known data on the importation of HCB, nevertheless some impurities of HCB have been identified, in the sampling analysis, possible actions should be to

- Ensure future applications for importation of products with HCB are not allowed while those with its impurities are assessed on the economic and social benefits and costs before action is taken if they are allowed.

## 7.8 Other POPs and PTS chemicals

The POPs assessment report provided an opportunity for a small island developing country like to Samoa to utilize the opportunity for conducting assessment on other POPs like chemicals of concern which could also be added to the Convention, as well as analysing other persistent toxic substances known to have been imported and used in Samoa.

The following chemicals were reviewed and analysed as part of the Initial Inventory on POPs and PTS in Samoa by MWH.

**7.8.1 Pesticides:**

Of the PTS identified for the survey, only lindane and endosulfan were noted.

- *Lindane* was last imported in 1997 for pharmaceutical use but has since been non-consented for agricultural use due to availability of alternatives. No existing stockpiles or contamination were found in the assessment.
- *Endosulfan* was found in the Fryauff (1982) study to be present in the several of the samples analysed including vegetables and domesticated animals. The latest analysis by MHW and PECL both did not reveal any traces of endosulfan in the samples. However, 0.8 litre Thiodan 35 (endosulfan) has been listed for disposal under the POPs in PICs project.

**7.8.2 CCA/PCP:**

The two timber treatment sites assessed were the Samoa Forest Corporation site at Asau, Savaii, and the Samoa Land Corporation site (currently occupied by Bluebird Transport) at Vaitele, are widely different in the extent of contamination and thus in the environmental risk issues posed and the extent of management and remediation required.

The Asau site is heavily contaminated, with three specific contaminants; i.e. copper, chromium and arsenic, all showing extremely elevated concentrations. Copper and arsenic levels were well above the relevant guideline values. A management regime is therefore suggested, while the first requirement is to prevent unauthorised access of persons and stock to the site.

The levels of pentachlorophenols (PCPs) detected at the Asau site, while barely detectable, still that an exact delineation of the area for PCP application to timber at the site should be attempted, with an associated more detailed investigation to follow. This is given added importance by the association of dioxins as an historical by-product contaminant of PCP manufacture.

The SLC, Vaitele site has limited residual CCA contamination which at present is contained (covered) and is thus managed. Any changes in site use and related re-development would require reconsideration of associated risks.

**7.8.3 TPH/PAH**

The three sites investigated with respect to petroleum hydrocarbon and associated polycyclic aromatic hydrocarbon (PAH) contamination all revealed different contamination scenarios, with a dominant common theme of unsatisfactory past (and present) management of stored/used hazardous substances. The relevant individual sites each need to urgently address the ongoing issue of waste oil pollution leaving the site via drains in an apparently uncontrolled manner.

Adverse ecological effects from petroleum hydrocarbon contamination may be more of a concern. These can be as simple as preventing vegetation growth, reducing the natural fertility of the soil, contaminating groundwater, or destroying habitats utilised by sub-surface organisms, e.g. worms. Specific ecological assessments for each site would be required to establish if sensitive ecosystems are being affected.

### 7.8.4 Heavy Metal Concentrations:

The sediment samples taken in Apia Harbour and Vaiusu Bay each consistently reveal concentrations of chromium and nickel which are significantly above guideline levels for the protection of aquatic habitats. In Apia Harbour tri-butyl tin (TBT) concentrations are also elevated above guidelines in some sediment samples and this is a cause for concern.

The single Vaitele sediment sample, from the inlet adjacent to the old timber treatment site, shows (possibly expected) elevated levels of chromium, and also of nickel and zinc. However, the background soil sample (see *GOS, 2003* Section 4.27) showed similarly high chromium, nickel and zinc concentrations.

Salelologa and Mulifanua Harbour sediment samples are only elevated above aquatic protection guidelines in nickel concentrations. The remaining heavy metal determinand concentrations are relatively low.

Concentrations of arsenic in shellfish samples from both Apia Harbour and Vaiusu Bay are in some samples significantly above guideline levels for the protection of aquatic habitats, and must be considered a cause for concern although the reason for the consistently elevated concentrations of this determinand is unclear. In the meantime, health authorities and/or the Ministry of Natural Resources and Environment may need to consider establishing signs informing people of the issues that have been identified.

# 8. Prioritisation and Objective Setting

To conduct the prioritisation of chemicals for actions within the National Implementation Plan for Persistent Organic Pollutants (POPs) in Samoa, outcomes of the POPs assessment and the Institutional and Capacity Assessment reports were to be completed which identified the chemicals produced, used or disposed in the country. The Assessment reports were also needed to identify the extent of these chemicals and other PTS with POPs-like nature which needed to be addressed for reduction and elimination in the future.

From the assessment reports, it was found that eight of the current POPs Convention chemicals are present in Samoa, and an additional seven PTS chemicals have been used or disposed locally.

Furthermore, the assessment report also noted that all the imported chemicals are no longer used except lindane. Therefore the only priority issues will on avoiding dispersal of chemicals from contaminated sites and ensuring the bioaccumulation in fatty tissues of chemicals does not reach levels where they become a risk to the environment and to human health.

## 8.1 Chemical Prioritisation

The proposed prioritisation of chemicals in Table 7 follows the approach taken in the regional and global assessments of PTS while incorporating issues relevant to Samoa and was undertaken through a consultative process at the National Workshop on the development of the National Implementation Plan.

The main issues for prioritizing of chemicals for Samoa were:
1. the impacts of the chemical on human health;
2. impacts of the chemical on the environment;
3. levels of past and present use of the chemical in the country;
4. degree of persistence of the chemical;
5. availability of alternatives at economical costs; and
6. information gaps on the chemical for actions.

These were then graded according to each chemical to obtain the following priorities:
- Top priorities: DDT, dioxins and furans; dieldrin,
- Secondary priorities: PCB, TBT, CCA; chlordane and heptachlor
- Low priorities: aldrin, atrazine, PAH, lindane; HCB, endosulfan,

It should be noted that due to the current status of the POPs chemicals in the country, whereby all the pesticides and PCB are already banned, the main issues for the future management are therefore seen as:

1. effective control on any future importation of these chemicals;
2. elimination of the existing stockpiles;
3. disposal on clean up of contaminated sites to eliminate future spread of the contamination; and
4. monitoring the chemical bioaccumulation and breakdown on animals to avoid reaching levels detrimental to human health and the environment.

For dioxin and furan which will continue to be produced, the main issues are therefore:

1. reducing the releases from some of the processes for which alternatives or technologies are available; and
2. improving the public awareness of the consequences of some of their actions so they are able to reduce releases at source

**Table 7. Chemical Prioritisation**

| **Chemicals** | **Human health impacts (scale 1-5)** | **Impacts on the environment (scale 1-5)** | **Degree of persistence in relation to environmental presences** | **Produce/ Use (scale 1-3)** | **Alternative BAT/BEP** | **Total** |
|---|---|---|---|---|---|---|
| *POPs* | | | | | | |
| **Aldrin** | 1 | 1 | 1 | 1 | 1 | 5 |
| **Chlordane** | 1 | 2 | 1 | 1 | 1 | 6 |
| **DDT** | 2 | 1 | 2 | 3 | 1 | **9** |
| **Dieldrin** | 1 | 2 | 2 | 2 | 1 | **8** |
| **Heptachlor** | 1 | 2 | 1 | 1 | 1 | 6 |
| **PCB** | 2 | 1 | 2 | 1 | 1 | **7** |
| **Dioxin & furans** | 1 | 1 | 2 | 3 | 2 | **9** |
| **HCB** | 1 | 1 | 1 | 2 | 1 | 6 |
| *Other POPS and PTS* | | | | | | |
| **PAH/TPH** | 1 | 2 | 1 | 1 | 1 | 6 |
| **CCA/PCP** | 1 | 2 | 1 | 2 | 1 | 7 |
| **TBT** | 2 | 2 | 1 | 1 | 1 | **7** |
| **Endosulfan** | 0 | 0 | 1 | 1 | 1 | 3 |
| **Lindane** | 2 | 1 | 1 | 2 | 1 | **7** |
| **Atrazine** | 0 | 0 | 1 | 2 | 2 | 5 |

*Note:* there is insufficient information on all the chemicals

## 8.2 Objective Setting

To identify the possible objectives for the National Implementation Plan, the recommendations from the POPs Assessment and Institutional Capacity Assessment reports were used as the baseline. Additionally, the articles of the Convention articulate obligations for Parties to meet to ensure the reduction and elimination of POPs. These are tabulated in Table 8.

This list of possible objectives were discussed at the national workshop where they were refined to produce the following objectives and actions.

***Objectives:***

- Elimination of contamination from intentional releases of POPs to undetected levels by 2010
- Contaminated sites identified and cleaned up by 2010
- Dioxin and furans releases reduced to 50% of 2003 levels by 2015 …
- Institutional mechanisms in place by 2010 to protect Samoa from future importation of POPs pesticides and PCB
- Information clearinghouse mechanism established for chemicals management developed by 2006

From the Objectives, specific Action Plans were discussed to form the basis of the National Implementation Plan. These are:

- Strategy for elimination of intentionally introduced POPs;
- Strategy for reduction and elimination of unintentionally introduced POPs;
- Strategy for elimination of contaminated sites, and stockpiles;
- Action Plan for registration of exemption;
- Action Plan for public awareness,
- Information management and research;
- Strengthening national coordination
- Action Plan for capacity building and education

**Participants at the Objective Setting and NIP workshop**

**Table 8: Objective Setting**

| Objectives | Priority Setting |
|---|---|
| To eliminate the intentional release of POPs chemicals by 2010 | – Strengthen appropriate legislative frameworks and institutions to ban POPs pesticides and regulate importation of industrial chemicals |
| | – Install relevant procotols to facilitate the disclosure of active ingredients with products and imported chemicals |
| | - strengthen national capacity to regulate importation of chemicals with traces of POPs through the development of national analysis capability and national food and safety minimum standards |
| • Registration of exemption | – Register with the Convention an exemption for possible future importation of DDT for malaria spraying if and when a malaria outbreak occurs before the international DDT task force develop an alternative |
| • Reduce and eliminate releases from unintentional production by 2010 to 50% of 2003 levels. | – Strengthen national Regulatory frameworks to reduce dioxin and furan releases from vehicles, power generation engines, and other incomplete combustion engines |
| | – Install proper air pollution control systems for all major incinerators |
| | – Implement Waste Management Strategy components enabling waste separation at source and disposal at relevant disposal sites |
| | - Continued assessment and monitoring of dioxin and furans releases |
| • Reduce and eliminate releases from stockpiles and chemical wastes by 200… | – Public awareness programmes for communities around contaminated areas. |
| | – Conduct programme for cleaning up stockpiles and contamination from hot spots |
| | – Initiate capacity building programmes for clean up and management of contaminated sites |
| • Information management and research | – Develop a database to monitor the movement and status of POPs levels. |
| | – Initiate programs of continued monitoring of potential contaminated sites and stockpiles. |
| | – Initiate a study to determine the full extent and possible impacts of the current POPs bio-accumulation in animal tissue and humans |
| Strengthening National Coordination | - Strengthen the functions and roles of the National Task team for POPs to facilitate information exchange and implementation of NIP |
| | - Establish mechanisms for the transfer of knowledge gained internationally for use in local implementation |
| | - Continue to play an active role in the implementation of the Convention, including utilizing and contributing to the development of appropriate measures for the reduction and elimination of POPs |
| Capacity building and education | – Strengthen local capacity for border control, POPs and PTS management, and monitoring and research. |
| Public awareness | – Public awareness programmes on impacts of open burning of biomass in the release of dioxin and furans.<br>– National Chemical Awareness Day programmes themes to reflect the main concerns identified in the NIP<br>– Conduct Public awareness campaigns on POPs for rural communities and schools |

# 9. Recommendations

Samoa has taken some considerable steps in the right direction on reducing and eliminating POPs production, use and elimination from within the country. These include the ban on the importation of POPs pesticides, the installation of effective waste management programmes such as the establishment of the main incinerator at the main landfill for hazardous body parts only, collection and appropriate disposal of waste associated with release of POPs, and with the POPs in PICs project, the transport of POPs chemicals for disposal away from Samoa.

In spite of the current efforts, several issues need to be addressed not only to ensure human and environmental safety from POPs contaminated areas, but most importantly, the reduction in the production of dioxin and furans releases, which are the main sources of POPs in the country.
To ensure the safety of humans and the ecosystem from further contamination for existing areas, priority actions will be

- Confinement of contaminated sites and chemicals in areas away from the public and foraging animals;
- Technical training of personnel associated with the cleaning and disposal of POPs; and
- Identification and actioning of appropriate disposal and clean up plans on contaminated sites

Due to the still unsubstantiated data on the extent of the bioaccumulation of POPs in the food chain, priority actions should therefore focus on

- Conducting more extensive analysis on the main local food supplies such as pig fat, marine organisms, and more human breast milk possibly including dioxins/ furans

According to the assessment, the DDT has the highest total score of all the pesticides, along with dieldrin due to their extensive use in the rural and agricultural areas, as well as being the ones to which people were most exposed, it will be important actions to

- Conduct further analysis on the presence of DDT in pig fat, to determine the extent of bioaccumulation and if it is from local sources (or imported feeds); and
- Conduct study of marine sediments at the Vaiusu Bay to ascertain the extent of DDT bioaccumulation in bivalves and possibly other marine organisms

Since dioxin and furans are the only POPs produced in the country and the fact that most of the emissions come from open burning and cooking which are the main activities of rural Samoa, to reduce the emissions over the next ten years as identified in the Convention, priority actions will need to include:

- Public awareness campaigns for the separation of waste especially POPs releasing chemicals to be collected for reuse or incineration at the proposed incinerator at the Tafaigata Landfill;
- Install appropriate policy and regulations to reduce emissions of pollutants from cars; and
- Installation of appropriate air pollution control systems for all incinerators;

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