Hong Kong Special Administrative Region
Implementation Plan for the Stockholm Convention on Persistent Organic Pollutants (POP)

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Environmental Protection Department
The Government of the Hong Kong Special Administrative Region

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Abbreviations and Acronyms

AFCD	Agriculture, Fisheries and Conservation Department
AFFF	Aqueous fire fighting foam
BDL	Below detection limit
bw	Body weight (kg)
C-octaBDE	Hexabromodiphenyl ether and heptabromodiphenyl ether
C-pentaBDE	Tetrabromodiphenyl ether and pentabromodiphenyl ether
CEDD	Civil Engineering and Development Department
CFS	Centre for Food Safety
CityU	City University of Hong Kong
COP	Conference of the Parties
CPG	Central People's Government of the People's Republic of China
CUHK	Chinese University of Hong Kong
CWTC	Chemical Waste Treatment Centre
DDT	Dichlorodiphenyltrichloroethane
DL	Detection limit
dw	Dry weight
DH	Department of Health
EEA	European Environment Agency
EPD	Environmental Protection Department
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FEHD	Food and Environmental Hygiene Department
GL	Government Laboratory
HBB	Hexabromobiphenyl
HBCD	Hexabromocyclododecane
HCB	Hexachlorobenzene
HCCO	Hazardous Chemicals Control Ordinance
HCH	Hexachlorocyclohexanes
HKBU	Hong Kong Baptist University
HKSARIP	HKSAR Implementation Plan
HKU	University of Hong Kong
HOKLAS	Hong Kong Laboratory Accreditation Scheme
HW	High Technology Hazardous Waste
HQ	Hazard quotient
I-TEF	International Toxicity Equivalency Factor

I-TEQ	International Toxic Equivalents
LRTAP	Long-range Transboundary Air Pollution
lw	Lipid weight
NIP	National Implementation Plan
OCPs	Organochlorine pesticides
PBDE	Polybrominated diphenyl ethers
PCB	Polychlorinated biphenyls
PCDD	Polychlorinated dibenzo-p-dioxins
PCDF	Polychlorinated dibenzofurans
PeCB	Pentachlorobenzene
PFOS	Perfluorooctane sulfonic acid
PFOSF	Perfluorooctane sulfonyl fluoride
POPs	Persistent Organic Pollutants
PRC	People's Republic of China
UNEP	United Nations Environment Programme
UNECE	United Nations Economic Commission for Europe
US EPA	United States Environmental Protection Agency
WHO	World Health Organization
WSD	Water Supplies Department
ww	Wet weight
α-HCH	Alpha hexachlorocyclohexane
β-HCH	Beta hexachlorocylohexane
γ-HCH	Lindane

EXECUTIVE SUMMARY

The Stockholm Convention is a global treaty to protect human health and the environment from the potentially harmful effects of persistent organic pollutants (POPs). In implementing the Convention, Parties will need to take measures to control/restrict the trade, domestic production and use of intentionally produced POPs and, where possible, to reduce and to ultimately eliminate the production and release of unintentionally produced POPs by-products.

The Stockholm Convention became effective to the People's Republic of China (PRC), including the Hong Kong Special Administrative Region (HKSAR), on 11 November 2004. In accordance with the Convention requirements, the PRC submitted a National Implementation Plan (NIP), which includes the HKSAR Implementation Plan (HKSARIP), to the Conference of the Parties of the Stockholm Convention in 2007.

The fourth and fifth meetings of the Conference of Parties (COP) to the Convention held in 2009 and 2011 adopted amendments to Annexes A, B and C to the Convention to list 10 new POPs in the respective Annexes. The amendment entered into force for PRC, including the HKSAR, on 26 March 2014. In accordance with the Convention, the PRC will submit an updated National Implementation Plan (NIP) which includes the updated HKSARIP for the new POPs to the COP within two years of the date on which these amendments enter into force (i.e. by 26 March 2016).

In updating the HKSARIP, we have reviewed the existing control framework for POPs in Hong Kong. The POPs pesticides are controlled under the Pesticides Ordinance (Cap. 133) and the Import and Export Ordinance (Cap. 60). A number of environmental ordinances are also in place to impose "downstream" control of air and water pollution and waste disposal. Since the inception of the first HKSARIP, the Hazardous Chemicals Control Ordinance (HCCO) has been enacted specifically for regulating the import, export, manufacture and use of non-pesticide POPs through an activity-based permit system.

After a review of the control framework, an inventory on the current status of POPs in Hong Kong was updated. This inventory provided a scientific basis for assessing the environmental and human health impacts of POPs and was fundamental to the prioritization of the proposed action items in the HKSARIP to reduce or eliminate POPs.

The POPs inventory framework was updated in accordance with relevant UNEP guidance documents. Existing data on emission sources, environmental contamination levels, dietary exposure and human body burden of the 23 Convention POPs in Hong Kong from all available sources (relevant government databases, local academia and open literature) were collated and assembled. Data screening and quality assurance checks were conducted at initial information retrieval and all data entries were cross-checked during data compilation.

All 15 Convention POPs pesticides (i.e., aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, HCB, mirex, toxaphene, α-HCH, β-HCH, chlordecone, γ-HCH, PeCB and endosulfan) were either never registered or had been banned from all uses and purposes in the HKSAR for many years. The 2011-2013 non-pesticide POPs inventory indicated only a very small quantity of PCB in electrical transformers and PFOS/PFOSF in aqueous fire fighting foam in import/use/stockpile.

Dioxins (PCDD) and furans (PCDF) are unintentional by-products of industrial and combustion processes. In 2012, there was an annual emission of 46.5 g TEQ dioxins/furans to the local environment via all vectors (air, water, land, product and residues). The major route of release was "residues", responsible for 84.3% of the total, followed by "air" (10.7%) and "land" (4.0%). On a "per capita" basis, the 2012 annual dioxin/furan release in Hong Kong was generally similar to those of Switzerland and the US, and comparable with the EU countries.

The level of POPs contamination in the local environment (ambient air and surface soil) was generally comparable to the range reported in most other urban locations in Asia, Europe and Africa. Assessment based on available data indicated that overall, there was unlikely to be any unacceptable ecological risk of toxicological significance associated with exposure of the local marine life to the current level of POPs contamination in the marine environment of Hong Kong.

Total monthly exposure of local residents to dioxins/furans was estimated to be 21.9 pg TEQ/kg bw/month (based on the total daily exposure estimate of 0.73 pg TEQ/kg bw/day for the Hong Kong population and 30 days per month), a value falling at the lower end of the tolerable monthly intake of 70 pg TEQ/kg bw/month set by the Joint FAO/WHO Expert Committee on Food Additives. Dietary intake was the major route, accounting for 98.6% of total exposure of local residents to dioxins/furans. Results of human health risk assessment indicated that there was no unacceptable inhalation nor dietary chronic/carcinogenic risk of toxicological concern associated with a lifetime exposure of local residents to the current levels of POPs contamination in the local environment and locally consumed foods. Levels of POPs in the local marine biota were found to be well below national/overseas Food Safety Standards/Action Levels of Mainland China, the US and the EC.

Review of the HKSAR's current control framework and POPs inventories was performed to identify areas that need to be continuously followed up or enhanced to ensure proper implementation of the Stockholm Convention. Strategies and action plans were developed to reflect local priorities. The key issues to be pursued are as follows:

- Update relevant ordinances as and when necessary – to update the Pesticides Ordinance and HCCO to ensure that all amendments to Annexes to the Convention are properly incorporated;

- Characterize local dioxin/furan emission sources – to validate annual production activities and estimate emission levels;

- Continue with our systematic monitoring of all currently and potentially listed POPs in the environmental media, locally consumed foods and human breast milk;

- Continue to implement control measures to reduce emission of unintentional POPs to the local environment;

- Continue to enhance public awareness;

- Continue to enhance regional collaboration with the Mainland – to harmonize POPs monitoring and analytical protocols, and to facilitate information exchange and knowledge sharing; and

- Capacity building – to promote best available techniques (BAT) / best environmental practices (BEP), and to enhance local POPs analytical capabilities.

It is envisaged that the second HKSARIP will provide useful data for updating and refining the POPs inventories which are instrumental to a science-based re-assessment of the local POPs situation and evaluation of the effectiveness of the HKSARIP in reducing dioxin/furan emissions.

1. INTRODUCTION

Persistent organic pollutants (POPs) are organochlorine compounds that persist in the environment, bio-accumulate and bio-magnify through the food chain. Their movement within environmental compartments and long-range transport often result in serious threat to the environment and human population around, and also distant from their original point of release. The United Nations Environment Programme (UNEP) has identified an initial set of 12 POPs for global restriction of production/use and, where possible, ultimate elimination under the Stockholm Convention (the Convention).

The Stockholm Convention was adopted on 22 May 2001 in Stockholm, Sweden and entered into force on 17 May 2004. The Convention became effective to the People's Republic of China (PRC), including the Hong Kong Special Administrative Region (HKSAR), on 11 November 2004. The HKSAR has developed a HKSAR Implementation Plan (HKSARIP) in accordance with the Convention which formed part of the PRC's National Implementation Plan (NIP) submitted to the Conference of the Parties (COP) of the Stockholm Convention in April 2007.

The fourth and fifth meetings of the COP to the Convention held in 2009 and 2011 adopted amendments to Annexes A, B and C of the Convention to list 10 new POPs in the respective Annexes. The amendment entered into force for PRC, including HKSAR, on 26 March 2014. In accordance with the Convention, the PRC has to submit an updated NIP which includes the updated HKSARIP for the new POPs to the COP within two years of the date on which these amendments enter into force (i.e. 26 March 2016).

At the sixth and seventh meetings of COP to the Convention held in 2013 and 2015 respectively, the COP agreed to list hexabromocyclododecane (HBCD) in Annex A, polychlorinated naphthalenes (PCN) in Annexes A and C, hexachlorobutadiene (HCBD) in Annex A, pentachlorophenol and its salts and esters (PCP) in Annex A to the Convention. Opportunity is taken to include also these new POPs into the present updated HKSARIP.

The following **Table 1** summarizes the types of use of the 12 initial POPs and 14 new POPs identified by the UNEP under the Convention.

Table 1: POPs listed in the Stockholm Convention

POPs	Year of Listing	Type of POPs		
		Pesticide	Industrial Chemicals	By-product
Aldrin	2001	✓		
Chlordane		✓		
DDT		✓		
Dieldrin		✓		
Endrin		✓		
Heptachlor		✓		
Hexachlorobenzene (HCB)		✓		✓
Mirex		✓		
Toxaphene		✓		
Polychlorinated biphenyls (PCB)			✓	✓
Polychlorinated dibenzo-p-dioxins (PCDD)				✓
Polychlorinated dibenzofurans (PCDF)				✓
Alpha hexachlorocyclohexane (α-HCH)	2009	✓		✓
Beta hexachlorocylohexane (β-HCH)		✓		✓
Chlordecone		✓		
Hexabromobiphenyl (HBB)			✓	
Lindane (γ-HCH)		✓		
Pentachlorobenzene (PeCB)		✓	✓	✓
Perfluorooctane sulfonic acid (PFOS), its salts and perfluorooctane sulfonyl fluoride (PFOSF)			✓	
Hexabromodiphenyl ether and heptabromodiphenyl ether (C-octaBDE)			✓	
Tetrabromodiphenyl ether and pentabromodiphenyl ether (C-pentaBDE)			✓	
Technical endosulfan and its related isomers (Endosulfan)	2011	✓		
Hexabromocyclododecane (HBCD)	2013		✓	
Polychlorinated naphthalenes (PCN)	2015		✓	✓
Hexachlorobutadiene (HCBD)		✓		
Pentachlorophenol and its salts and esters (PCP)			✓	

The POPs Unit of the Environmental Protection Department (EPD) of the Government of the HKSAR (HKSARG) is responsible for preparing and updating the HKSARIP, working on new legislation and its amendment to regulate non-pesticide hazardous chemicals, and coordinating matters relating to the implementation of the Convention in the HKSAR. The pesticide POPs are controlled by the Agriculture, Fisheries and Conservation Department of the HKSARG. Stakeholder consultation is an important process in the preparation of the 2nd HKSARIP. A stakeholder consultation workshop was convened on 23 March 2015 to seek views from relevant stakeholders on the POPs-related issues in Hong Kong

2. THE HKSAR BASELINE

2.1 The HKSAR Basic Profile

The HKSAR is situated in the Pearl River Delta (PRD) at the south-eastern tip of Mainland China. It has a total area of 1,104 km^2, comprising Hong Kong Island, the Kowloon Peninsula, the New Territories and 262 outlying islands. Hong Kong's climate is sub-tropical.

Hong Kong has one of the finest deep-water ports in the world and is a well established international financial, trading and business hub. It is widely recognized as the world's freest economy (Heritage Foundation's 2015 Index of Economic Freedom) and one of the most competitive economies in the world (ranked 4th by International Institute for Management Development in its World Competitiveness Yearbook 2014). Over the past few decades, there has been a structural transformation of the Hong Kong economy from manufacturing to service orientation. The local industrial activities have shrunk to a substantial extent in both variety and size as manufacturing enterprises have progressively relocated their production lines to the Mainland. On the other hand, trading and logistics, finance and banking, tourism, and a wide range of business services are becoming more important.

With a population of 7.2 million, Hong Kong is one of the world's most densely populated cities (6,520 persons per km^2 according to the 2014 data of the Census and Statistics Department). Over the years, Hong Kong has developed an efficient wholesale and retail network to cater for the growing consumption needs of a more affluent population.

The dense population coupled with a high level of dynamic economic activities has exerted intense pressure on Hong Kong's environment. This is further compounded by the effects of immense economic growth in the PRD, one of the fastest developing regions in the world. Since the 1980s, the HKSARG has been implementing various plans and programmes to meet the local environmental challenges. Pollution by toxic substances including POPs is an area of focus in Hong Kong, but one that has received increased attention in recent years. Programmes and researches for monitoring air, water, soil, sediment toxic pollutants have been established to assess background pollution and to better safeguard the environment and human health.

2.2 Environmental Policies and Legislative Framework for POPs Control and Management

2.2.1 Legislative Framework on POPs Control

In implementing the Stockholm Convention, Parties will take measures to control/restrict the import, export, domestic production and use of intentionally produced POPs (pesticides and industrial chemicals), to reduce and where possible to ultimately eliminate the production and release of unintentional POPs (dioxins/furans) from anthropogenic sources to the environment, and to impose proper handling and disposal of POPs-containing wastes.

2.2.1.1 Pesticides

The pesticides are controlled under the Pesticides Ordinance (Cap 133) administered by the Agriculture, Fisheries and Conservation Department (AFCD) under the Food and Health Bureau (FHB). The import, manufacture, supply and retail of pesticides in Hong Kong are regulated by a licensing/permit system. In addition, all pesticides entering/leaving Hong Kong are required to be covered by an import/export licence issued under the Import and Export Ordinance (Cap 60) which, however, does not apply to pesticides that are in air transhipment cargoes and pesticides in transit.

The Pesticides Ordinance, Cap 133, was amended in 2013 to include new provisions to ensure full compliance with the requirements of the Stockholm Convention on the control of POPs pesticides and the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (the Rotterdam Convention). The amended legislation came into operation on 27 January 2014.

On 17 January 2014, the Office of the Commissioner of the Ministry of Foreign Affairs of PRC notified the Government of HKSAR that ratification for inclusion of the six pesticides ((i) alpha hexachlorocyclohexane, (ii) beta hexachlorocyclohexane, (iii) chlordecone, (iv) lindane, (v) pentachlorobenzene, and (vi) technical endosulfan and its related isomers) added to Stockholm Convention in 2009 and 2011 was completed and would take effect from 26 March 2014. PRC has also confirmed that the ratification would apply to HKSAR and enter into force on the same effective date. To such end, AFCD has completed legislative amendment exercise to add the six pesticides to Cap 133. The amendment commenced operation on 1 June 2014.

2.2.1.2 Hazardous Chemicals

Control of hazardous chemicals is within the ambit of environmental policies administered by the Environmental Protection Department (EPD) under the Environment Bureau (ENB). Legislation and licensing are the major regulatory instruments. A number of environmental ordinances are also in place to deal with the control of air and water pollution and waste handling and disposal. They cover a wide range of chemicals which include hazardous chemicals. Relevant key environmental legislation includes:

- Hazardous Chemicals Control Ordinance (Cap 595)
- Air Pollution Control Ordinance (Cap 311)
- Water Pollution Control Ordinance (Cap 358)

- Waste Disposal Ordinance (Cap 354)
- Environmental Impact Assessment Ordinance (Cap 499)

2.2.1.2.1 Hazardous Chemicals Control Ordinance (HCCO)

The HCCO (Cap 595) came into operation on 1 April 2008 to regulate, through an activity-based permit system, the import, export, manufacture and use of non-pesticide POPs that have potentially harmful or adverse effects on human health or the environment. At present, the non-pesticide hazardous chemicals under the HCCO include such chemicals that are subject to regulation of the Stockholm Convention or the Rotterdam Convention.

In view of the amendment in May 2009 to list 5 new non-pesticide POPs ((i) hexabromobiphenyl, (ii) hexabromodiphenyl ether and heptabromodiphenyl ether, (iii) pentachlorobenzene, (iv) tetrabromodiphenyl ether and pentabromodiphenyl ether and (v) perfluorooctane sulfonic acid, its salts and perfluorooctane sulfonyl fluoride), EPD amended the Schedules to the HCCO and the amendment order has come into operation since 1 January 2015.

2.2.1.2.2 Air Pollution Control Ordinance (APCO)

The APCO (Cap 311) enacted in 1983 is the principal law for managing air quality. The Ordinance provides a statutory framework for controlling air pollution from stationary and mobile sources and enables the promulgation of subsidiary regulations to deal with specific air pollution problems.

A number of subsidiary regulations targeted at major industrial sources, combustion processes and vehicle emissions could contribute to the reduction in emission of unintentionally produced POPs to the atmosphere are in place to control pollution from combustion sources. These include:

- Air Pollution Control (Specified Processes) Regulations (Cap 311F)
- Air Pollution Control (Furnaces, Oven and Chimneys) (Installation and Alteration) Regulations (Cap 311A)
- Air Pollution Control (Smoke) Regulations (Cap 311C)
- Air Pollution Control (Open Burning) Regulation (Cap 311O)
- Air Pollution Control (Motor Vehicle Fuel) Regulation (Cap 311L)
- Air Pollution Control (Vehicle Design Standards) (Emission) Regulations (Cap 311J)
- Air Pollution Control (Emission Reduction Devices for Vehicles) Regulation (Cap 311U)

2.2.1.2.3 Water Pollution Control Ordinance (WPCO)

The WPCO (Cap 358) enacted in 1980 is the principal law for managing water quality. The Ordinance provides for the establishment of Water Quality Objectives (WQOs) in relation to the beneficial uses of water bodies and defines Water Control Zones (WCZs) for the entirety of Hong Kong waters within which discharges of effluent are subject to licensing control.

The WQOs set for all WCZs specify that toxic substances in the water should not attain such levels as to produce significant toxic, mutagenic, carcinogenic or teratogenic effects in humans, fish or any other aquatic organisms, with due regard to biologically cumulative effects in food chains and to interactions of toxic substances with each other.

The standards for effluent discharged into the various WCZs are specified in the *Technical Memorandum on Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters* (TM). The TM prohibits the discharge of toxic substances (including fumigants, pesticides, polychlorinated biphenyls (PCB), polyaromatic hydrocarbons (PAHs), chlorinated hydrocarbons, flammable or toxic solvents, petroleum oil or tar and calcium carbide) to foul sewers, inland and coastal waters. It also specifies numerical discharge limits for total suspended solids, Biochemical Oxygen Demand (BOD), oil and grease, toxic metals and chemical compounds such as cyanide, phenol, sulphide, total residual chlorine and surfactants.

2.2.1.2.4 Waste Disposal Ordinance (WDO)

The WDO (Cap 354) enacted in 1980 is the principal law for environmentally sound management of waste collection and disposal. The Ordinance provides control over the handling and disposal of livestock waste and chemical waste, the import and export of wastes (including implementation of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal) and the licensing of waste collection services and waste disposal facilities. Its subsidiary legislation, the *Waste Disposal (Chemical Waste) (General) Regulation (Cap 354C),* provides for the control, through licensing requirements, of packaging, labeling, storage, collection and disposal (including treatment, reprocessing and recycling) of chemical waste, and the registration of chemical waste producers. Chemical waste is defined under the regulation in a schedule of specific substances and chemicals based on their potential risk to human health and/or pollution to the environment. Disposal of chemical wastes containing PCB and unintentionally produced POPs is controlled under the WDO.

2.2.1.2.5 Environmental Impact Assessment Ordinance (EIAO)

The EIAO (Cap 499) enacted in 1997 provides a legal instrument for assessing potential environmental impacts of designated projects at the planning stage and for the protection of the environment. The Ordinance contains provisions to avoid, minimize and control adverse impacts to the local environment of designated projects through an environmental permit and environmental monitoring and audit system. The Technical Memorandum for Environmental Impact Assessment

Ordinance (EIAO-TM) sets out the technical requirements for the EIA process and the criteria for determining the environmental acceptability of designated projects, stipulating that any adverse environmental effects should be avoided to the maximum practicable extent and minimized to within acceptable levels.

2.2.2 Roles and Responsibilities of Relevant Government Bureaux/Departments

Table 2 summarizes the roles and responsibilities of Government bureaux/departments in protecting the environment and human health against the potential harmful effects of hazardous chemicals including POPs.

Table 2: Roles and Responsibilities of Relevant Bureaux/Departments in the HKSARG in Environmental and Human Health Protection

Bureaux/Departments	Relevant Roles and Responsibilities	Legislative Instruments
Development Bureau		
Drainage Services Department	• Provide an effective system for sewage collection, treatment and disposal in an environmentally responsible manner to ensure public safety and health • Maintain a database on effluent/sludge production in sewage treatment works	• Sewage Services Ordinance (Cap 463)
Water Supplies Department	• Provide quality water services and ensure public health and safety through routine monitoring of toxic chemicals in drinking water	
Environment Bureau		
Environmental Protection Department	• Regulate the import, export, manufacture and use of non-pesticide POPs through an activity-based permit system • Impose "downstream" control on air emission, effluent discharge and waste disposal (including chemical waste) of environmental toxic pollutants • Conduct environmental monitoring to assess compliance and provide a basis for the planning of pollution control strategies • Set out technical requirements for the environmental impact assessment (EIA) processes at the planning stage, to avoid, minimize and control	• Hazardous Chemicals Control Ordinance (Cap 595) • Air Pollution Control Ordinance (Cap 311) • Water Pollution Control Ordinance (Cap 358) • Waste Disposal Ordinance (Cap 354) • Environmental Impact Assessment Ordinance (Cap 499)

Financial Services and Treasury Bureau		
Census and Statistics Department	• Maintain a database of vital statistics to facilitate research, planning and decision–making within the Government and in the community	
Food and Health Bureau		
Agriculture, Fisheries and Conservation Department	• Control the manufacture, import, supply, storage, and retail sale of pesticides in Hong Kong • Administer the import and export licensing control system of pesticides in Hong Kong	• Pesticides Ordinance (Cap 133) • Import and Export Ordinance (Cap 60)
Department of Health	• Execute health care policies and statutory functions and safeguard the health of the community through promotive, preventive, curative and rehabilitative services	
Food and Environmental Hygiene Department	• Ensure food safety through food surveillance and certification, conduct dietary risk assessment and risk communication and advice on food safety standards	• Public Health and Municipal Services Ordinance (Cap 132)
Government Laboratory	• Provide laboratory analytical services to Government departments on samples of various matrices to meet client departments' respective responsibilities for environmental protection, public health and safety	
Labour and Welfare Bureau		
Labour Department	• Control the manufacture, process or work involving certain specified hazardous chemicals (such as carcinogenic substances) to protect workers' safety	• Factories and Industrial Undertakings Ordinance (Cap 59) • Occupational Safety and Health Ordinance (Cap 509)
Security Bureau		
Customs and Excise Department	• Control the import and export of commodities and certain prohibited articles by air, land and sea.	• Import and Export Ordinance (Cap 60)
Fire Services Department	• Control the manufacture, labelling, packaging, storage, transport (on land and at sea) and use of dangerous goods (including corrosive, flammable and poisonous substances, etc)	• Dangerous Goods Ordinance (Cap 295)
Transport and Housing Bureau		
Marine Department	• Prevent, mitigate and repair pollution of and damage to the waters of Hong Kong arising from oil spillage, and from contamination of the sea by hazardous substances discharged from ships	• Merchant Shipping (Prevention and Control of Pollution) Ordinance (Cap413) • Merchant Shipping (Safety) Ordinance (Cap 369)

2.2.3 Obligations under Other Related Environmental Conventions Applicable to the HKSAR

2.2.3.1 The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal

The Basel Convention aims to protect the environment and human health from the harmful effects of hazardous waste. The Convention defines the global means to: (a) minimize hazardous waste at source; (b) strictly control the transboundary movement of hazardous waste; and (c) ensure that the hazardous wastes are disposed of in an environmentally sound manner. The Convention requires that a prior informed consent system be put in place to control and monitor the transboundary movement of hazardous waste among the Parties to the Convention.

The Convention was adopted by the Conference of Plenipotentiaries in Basel in 1989 and entered into force in May 1992. The Central People's Government (CPG) of PRC deposited its instrument of ratification with the Secretary-General of the United Nations on 17 December 1991. The Convention is also applicable to the HKSAR.

The Ministry of Environmental Protection (MEP) is the National Focal Point of the PRC for the Convention and EPD is the designated Competent Authority of the HKSAR for implementing the Convention in Hong Kong. Transboundary movement of hazardous waste as specified in the 7th Schedule to the WDO is subject to import/export control provided for in that Ordinance. EPD has established an information exchange network with both local and oversea control authorities to monitor waste shipment activities and to collect intelligence of dubious waste shipment for joint enforcement action to effectively combat illegal shipment of hazardous waste in the region.

2.2.3.2 The Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade

The Rotterdam Convention aims to promote shared responsibility and cooperative efforts among the contracting parties in the international trade of certain hazardous chemicals and pesticides in order to protect human health and the environment from potential harm. The Convention has introduced a mandatory prior informed consent procedure (PIC procedure) to monitor and control the import and export of certain hazardous chemicals and disseminate national importing decisions to the contracting parties. The Rotterdam PIC procedure applies to 33 pesticides, (including 3 severely hazardous pesticide formulations) and 14 industrial chemicals.

The Convention was adopted at the Diplomatic Conference held in Rotterdam on 10 September 1998 and entered into force on 24 February 2004. The Convention became applicable to the PRC and the HKSAR on 20 June 2005 and 26 August 2008 respectively. AFCD is responsible for the control of PIC pesticides while EPD is responsible for the control of PIC industrial chemicals by enforcing the Pesticides Ordinance and the Hazardous Chemicals Control Ordinance respectively.

2.3 Overview of the Current POPs Issue in the HKSAR

2.3.1 Source Inventories of POPs

2.3.1.1 Trade, Production and Use of Intentional POPs

2.3.1.1.1 Pesticides

Nine pesticides (aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, HCB, mirex and toxaphene), five pesticides (α-hexachlorocyclohexane (α-HCH), β-hexachlorocyclohexane (β-HCH), chlordecone, lindane (γ-HCH), PeCB) and one pesticide (endosulfan) have been identified as intentionally produced POPs by the Convention and its amendments approved by PRC, targeted for elimination or restriction on production and use. In Hong Kong, these pesticides were either never registered or had their registration status cancelled for many years due to toxicological or environmental concern.

Initial POPs								
Aldrin	Chlordane	DDT	Dieldrin	Endrin	Heptachlor	HCB	Mirex	Toxaphene
1988*	1991*	1988*	1988*	NR	NR	NR	1997*	1984*

New POPs					
α-HCH	β-HCH	Chlordecone	γ-HCH	PeCB	Endosulfan
NR	1991*	NR	1991*	NR	2013*

*: The year in which all use and trade activities prohibited unless under a pesticide permit granted in exceptional

NR: Never registered

Source: AFCD, 2014

Except for the import of 1,000 kg of endosulfan for local consumption in 2011, there was no import, export, manufacture, use, stockpiling, nor transshipment of the other 14 pesticide POPs in Hong Kong for the past 3 years (2011–2013). These 14 pesticide POPs include aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, HCB, mirex, toxaphene, α-HCH, β-HCH, chlordecone, γ-HCH and PeCB.

2.3.1.1.2 Industrial Chemicals

To identify the trade, use and manufacture of the 10 industrial POPs listed in the Stockholm Convention, a comprehensive survey was conducted in 2014 with the relevant trade and industries of Hong Kong. The use of POPs in laboratories is not controlled under the Convention. This specific use is however included in the survey to show the usage of these chemicals in HKSAR.

Polychlorinated biphenyls (PCB)

In total, 25 stakeholders in Hong Kong have a stockpile of 1.9 x 10^{-2} kg of PCB and all these PCB are stored as the reference standard in laboratory testing. On the other hand, a stakeholder stored and used 1.6 x 10^{3} kg of electrical transformers that contains PCB for the purpose of welding power supply during the years from 2011 to 2013.

For the usage of chemicals, during the years from 2011 to 2013, there were about 1.7 x 10^{-3} kg of PCB consumed for the purpose of reference standard in laboratory testing. Within the same period, the purpose of importing and exporting PCB was to re-sell to local and overseas laboratories, and the total quantities of PCB imported and exported were around 3.0 x 10^{-2} kg and 1.5 x 10^{-2} kg, respectively.

Hexabromobiphenyl (HBB)

18 stakeholders in Hong Kong have a stockpile of 3.3 x 10^{-3} kg of HBB and all these HBB are stored as the reference standard in laboratory testing.

For the usage of chemicals, during the years from 2011 to 2013, there were about 1.8 x 10^{-3} kg of HBB consumed for the purpose of reference standard in laboratory testing. Within the same period, the purpose of importing and exporting HBB was to re-sell to local and overseas laboratories, and the total quantities of HBB imported and exported were around 6.0 x 10^{-2} kg and 1.5 x 10^{-2} kg, respectively.

Tetrabromodiphenyl ether and pentabromodiphenyl ether (C-pentaBDE)

16 stakeholders in Hong Kong have a stockpile of 2.4 x 10^{-3} kg of C-pentaBDE and all these chemicals are stored as the reference standard for laboratory testing.

For the usage of chemicals, during the years from 2011 to 2013, there were about 1.4 x 10^{-1} kg of C-pentaBDE consumed for the purpose of reference standard in laboratory testing. Within the same period, the purpose of importing and exporting C-pentaBDE was to re-sell to local and overseas laboratories, and the total quantities of C-pentaBDE imported and exported were around 1.1 x 10^{-1} kg and 1.5 x 10^{-2} kg, respectively.

Hexabromodiphenyl ether and heptabromodiphenyl ether (C-octaBDE)

14 stakeholders in Hong Kong have a stockpile of 2.4 x 10^{-3} kg of C-octaBDE and all these chemicals are stored as the reference standard in laboratory testing.

For the usage of chemicals, during the years from 2011 to 2013, there were about 2.9 x 10^{-2} kg of C-octaBDE consumed for the purpose of reference standard in laboratory testing. Within the same period, the purpose of importing and exporting C-octaBDE was to re-sell to local and overseas' laboratories, and the total quantities of C-octaBDE imported and exported were around 1.1×10^{-1} kg and 1.5×10^{-2} kg, respectively.

Pentachlorobenzene (PeCB)

12 stakeholders in Hong Kong have a stockpile of 2.4×10^{-2} kg of PeCB and all these chemicals are stored as the reference standard in laboratory testing.

For the usage of chemicals, during the years from 2011 to 2013, there were about 4.2×10^{-3} kg of PeCB consumed for the purpose of reference standard in the laboratory testing. Within the same period, the purpose of importing and exporting PeCB is to re-sell to local and overseas laboratories, and the total quantities of PeCB imported and exported were around 9.3×10^{-2} kg and 3.0×10^{-3} kg, respectively.

Perfluorooctane sulfonic acid (PFOS), its salts and perfluorooctane sulfonyl fluoride (PFOSF)

15 stakeholders in Hong Kong have a stockpile of 1.5×10^{-1} kg of PFOS/PFOSF and all these chemicals are stored as the reference standard in laboratory testing. On the other hand, one of Government Departments (Fire Services Department) imported (1.2×10^{4} L), used (5.9×10^{3} L) and stored (7.8×10^{4} L) the aqueous film forming foam that may contain PFOS/PFOSF for the firefighting purpose during the years from 2011 to 2013[1].

For the usage of chemicals, during the years from 2011 to 2013, there were about 5.3×10^{-3} kg of PFOS/PFOSF consumed for the purpose of reference standard in the laboratory testing. Within the same period, the purpose of importing and exporting PFOS was to re-sell to local laboratories, and the total quantities of imported PFOS/PFOSF was around 1.5×10^{-1} kg and there was no export on chemicals containing PFOS/PFOSF from Hong Kong.

Hexabromocyclododecane (HBCD)

9 stakeholders in Hong Kong have a stockpile of 1.0×10^{-1} kg of HBCD and all these chemicals are stored as the reference standard in laboratory testing.

During the years from 2011 to 2013, there was no either import or export on chemicals containing HBCD in Hong Kong.

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[1] China has applied for using PFOS/PFOSF in fire-fighting foam as an acceptable purpose in accordance with Annex B of the Convention. As required under Article 6 of the Convention, the stock of PFOS/PFOSF and its waste should be managed and disposed of in an environmentally sound manner. HKSAR has taken measures in accordance with Articles 6 of the Convention to achieve proper management of PFOS/PFOSF containing aqueous film-forming foam fire extinguishing agent (see page 55, Action item No. 8).

Chlorinated naphthalenes

3 Industry Groups (HOKLAS Certified Laboratories, Government Departments and Other HCCO Permit Holders) involved in import, storage and/or use of chlorinated naphthalenes. These Industry Groups include 5 stakeholders. In total, relevant stakeholders in Hong Kong have a stockpile of 2.4×10^{-4} kg of chlorinated naphthalenes and all these chemicals are stored as the reference standard in laboratory testing.

For the usage of chemicals, during the years from 2011 to 2013, there were about 2.0×10^{-5} kg of chlorinated naphthalenes consumed for the purpose of reference standard in the laboratory testing. Within the same period, the purpose of importing chlorinated naphthalenes was to re-sell to local laboratories, and the total quantities of imported chlorinated naphthalenes was around 9.0×10^{-5} kg and there was no export on chemicals containing chlorinated naphthalenes from Hong Kong.

Hexachlorobutadiene (HCBD)

4 Industry Groups (Academic, HOKLAS Certified Laboratories, Government Departments and Other HCCO Permit Holders) involved in import, storage and/or use of hexachlorobutadiene. These Industry Groups include 8 stakeholders. In total, relevant stakeholders in Hong Kong have a stockpile of 1.3×10^{-1} kg chemicals of hexachlorobutadiene and all these chemicals are stored as the reference standard in laboratory testing.

For the usage of chemicals, during the years from 2011 to 2013, there were about 9.5×10^{-3} kg of hexachlorobutadiene consumed for the purpose of reference standard in laboratory testing. Within the same period, the purpose of importing hexachlorobutadiene was to re-sell to local laboratories, and the total quantities of imported hexachlorobutadiene was around 9.0×10^{-2} kg and there was no export on chemicals containing hexachlorobutadiene from Hong Kong.

Pentachlorophenol and its salts and esters (PCP)

4 Industry Groups (Academic, HOKLAS Certified Laboratories, Government Departments and Other HCCO Permit Holders) involved in import, export, storage and/or use of pentachlorophenol and its salts and esters. These Industry Groups include 17 stakeholders. In total, relevant stakeholders in Hong Kong have a stockpile of 5.7×10^{-1} kg chemicals of pentachlorophenol and its salts and esters and all these chemicals are stored as the reference standard in laboratory testing.

For the usage of chemicals, during the years from 2011 to 2013, there were about 6.5×10^{-3} kg of pentachlorophenol and its salts and esters consumed for the purpose of reference standard in laboratory testing. Within the same period, the purpose of importing pentachlorophenol and its salts and esters was to re-sell to local laboratories, and the total quantities of pentachlorophenol and its salts and esters imported and exported were around 1.5×10^{-1} kg and 3.0×10^{-3} kg, respectively.

Short-chained chlorinated paraffins (proposed POPs to be listed)

2 Industry Groups (HOKLAS Certified Laboratories and Other HCCO Permit Holders) involved in import, export, storage and/or use of short-chained chlorinated paraffins. These Industry Groups include 10 stakeholders. In total, relevant stakeholders in Hong Kong have a stockpile of 1.3 x 10^{-3} kg chemicals of short-chained chlorinated paraffins and all these chemicals are stored as the reference standard in laboratory testing.

For the usage of chemicals, during the years from 2011 to 2013, there were about 1.4 kg of short-chained chlorinated paraffins consumed for the purpose of reference standard in laboratory testing. Within the same period, the purpose of importing and exporting short-chained chlorinated paraffins is to re-sell to local laboratories, and the total quantities of short-chained chlorinated paraffins imported and exported were around 1.5 x 10^{-1} kg and 2.0 x 10^{-3} kg, respectively.

2.3.1.2 Release of Unintentional POPs as by-Products

2.3.1.2.1 PCDD (Dioxins) and PCDF (Furans)

Dioxins (PCDD) and furans (PCDF) are unintentional by-products of industrial and combustion processes. The source inventory of PCDD/PCDF in the HKSARIP 2006 was prepared according to the “Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases, Edition 2.1” which was established in 2005. Subsequently, the new “Toolkit for Identification and Quantification of Releases of Dioxins, Furans and Other Unintentional POPs” was published in January 2013 by the UNEP. This new toolkit is used to update the local Source Groups and categories of the local emission inventory for 2012. The number and order of the proposed source inventory for 2012 are intentionally kept according to the “Guidance for Developing a National Implementation Plan for the Stockholm Convention on Persistent Organic Pollutants (updated in 2012 to include the POPs listed in 2009 and 2011)”.

Regarding the 9 source categories identified for the source inventory of PCDD/PCDF in Hong Kong, EPD has provided the latest environmental monitoring result of the 9 sources and estimated the annual releasing quantity from these sources through air, water, land, product and residue in the year of 2012. The TEQ of the unintentionally released PCDD/PCDF from each of 9 identified source categories and through 5 emission routes (i.e. air, water, land, product and residue) is shown in **Table 3**.

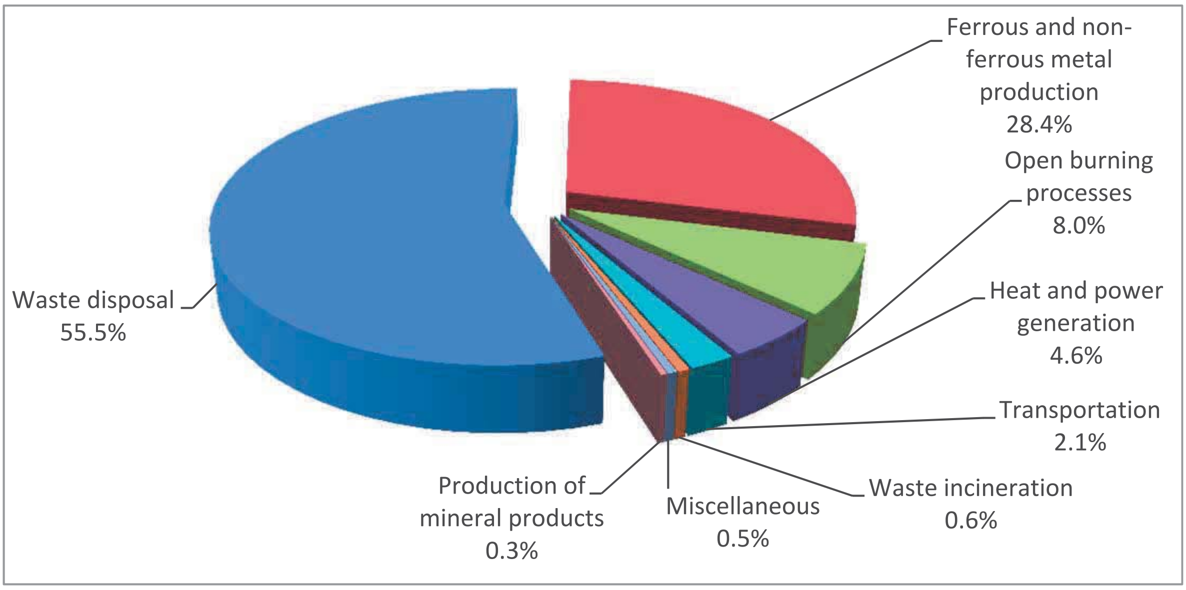
Table 3: Summary of Annual PCDD/PCDF Emission Inventory in Hong Kong for the Year 2012

Group	Source Categories	Annual Release (g TEQ/a)					All Routes (g TEQ/a)
		Air	Water	Land	Product	Residue	
1	Waste incineration	0.0010	0.0000	0.0000	0.0000	0.2549	**0.2559**
2	Ferrous and non-ferrous metal production	0.0003	0.0000	0.0000	0.0000	13.2052	**13.2055**
3	Heat and power generation	1.9092	0.0000	0.0000	0.0000	0.2465	**2.1557**
4	Production of mineral products	0.0895	0.0000	0.0000	0.0000	0.0495	**0.1390**
5	Transportation	0.9898	0.0000	0.0000	0.0000	0.0000	**0.9898**
6	Open burning processes	1.8746	0.0000	1.8510	0.0000	0.0000	**3.7256**
7	Production of chemicals and consumer goods	0.0000	0.0000	0.0000	0.0000	0.0000	**0.0000**
8	Waste disposal	0.0000	0.4686	0.0000	0.0040	25.3386	**25.8112**
9	Miscellaneous	0.1121	0.0000	0.0000	0.0000	0.0987	**0.2108**
Total (g TEQ/a)		***4.9765***	***0.4686***	***1.8510***	***0.0040***	***39.1934***	**46.4935**

Source: EPD 2014

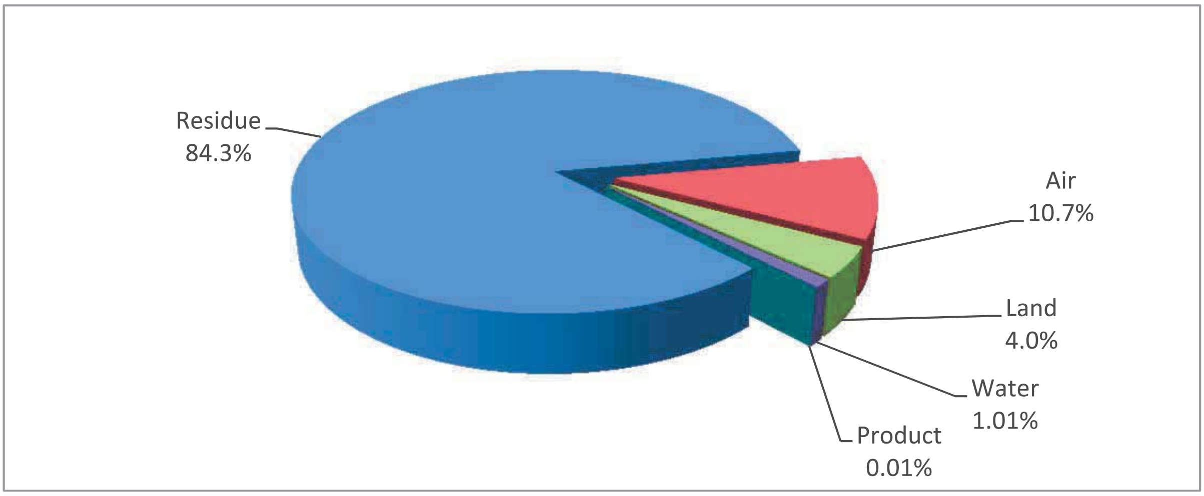
In 2012, there was an annual release of 46.5 g TEQ dioxins/furans to the environment via all vectors. Relative contributions of different categories are shown in **Figure 1**. The top 3 contributing categories of dioxin/furan emission were "Waste disposal" (55.5%), "Ferrous and Non-Ferrous Metal Production" (28.4%) and "Open Burning Process" (8.0%). Together, they represented 91.9% of the total. A "zero" emission value was assigned to Category 7 "Production of Chemicals and Consumer Goods" due to a general lack of local data on the contamination level of dioxins/furans in consumer goods.

Figure 1 – Contribution of Various Emission Source Categories to Annual Dioxin/Furan Emission



On a vector basis (**Figure 2**), the major route of release was "residues", responsible for 84.3% of the total, followed by "air" (10.7%) and "land" (4.0%). The "water" and "products" together contributed to only 1.01% of the total annual release. It was observed that for the "land", "water" and "products" vectors, a "blank" release value was assigned to many classes of potential emission sources due to a general lack of data on emission factors.

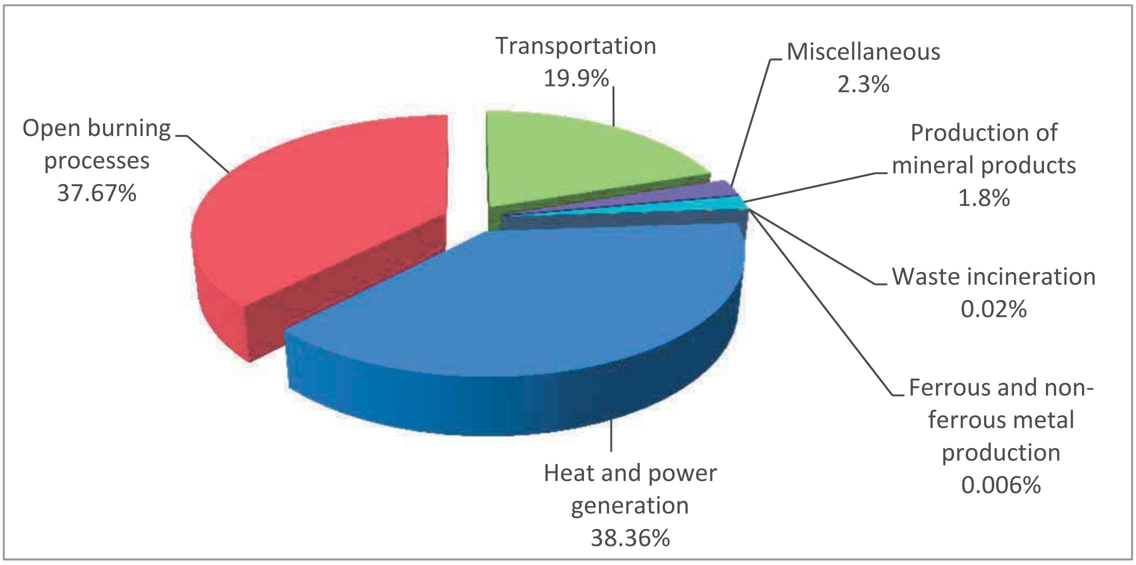
Figure 2 – Percentage of Dioxin/Furan Emission on a Vector Basis



Release of Dioxins/Furans to Air

The 2012 annual dioxin/furan release to the atmosphere was 5.0 g TEQ. The relative contributions of different source categories to air emission are presented in **Figure 3**. A further breakdown of the nine categories of emission sources revealed that the top 3 contributing classes of local processes were: "Heat and Power Generation" (38.4%), "Open Burning Processes" (37.7%) and "Transportation" (19.9%). These three classes of processes together accounted for 96% of the total annual air emission while the others were responsible for the remaining percentage.

Figure 3 – Contribution of Different Source Categories to Annual Dioxin/Furan Emission to Air



Release of Dioxins/Furans to Water

The 2012 annual dioxin/furan release to the local marine environment was 0.47 g TEQ, contributed solely by the "Waste Disposal" category. Sewage treatment and landfill leachate contributed to the total annual release of dioxin/furan to water.

Release of Dioxins/Furans to Land

For release "to land", the only category with an EF available was "Open Burning Processes", which amounted to 1.85 g TEQ. Burning of biomass and accidental fires contributed to the total annual release of dioxin/furan to land. There was a general lack of local information on other potential sources of dioxin/furan release to land.

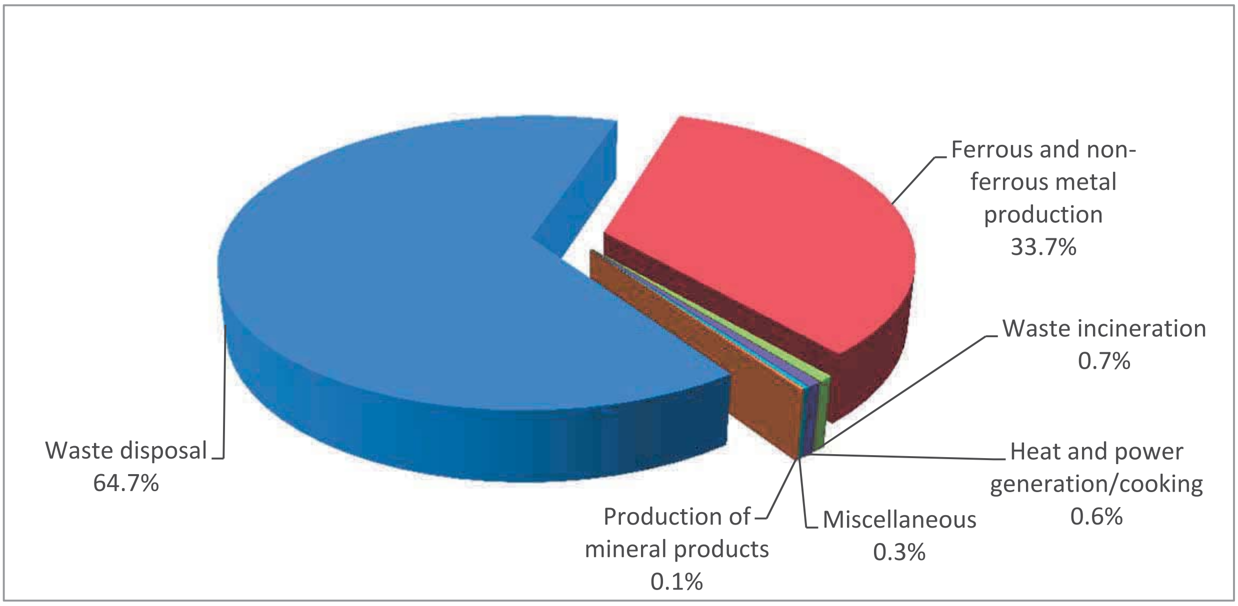
Release of Dioxins/Furans in Products

The 2012 annual dioxin/furan release "in products" was 0.004 g TEQ, from the "Waste Disposal" category. Within this category, the sole contributing class of emission sources was "composting". Release from composting was estimated using an UNEP generic EF for composting of organic wastes separated at source or green material. The compost was used as product for landscaping and horticulture work. There was a general lack of local information on other potential sources of dioxin/furan release in products.

Release of Dioxins/Furans in Residues

The 2012 annual dioxin/furan release "in residues" was 39.19 g TEQ. The relative contributions of different source categories to emission in residues are presented in **Figure 4**. A further breakdown of the nine categories of release sources revealed that the top three contributing categories of local processes were: "Waste Disposal" (64.7%), "Ferrous and Non-Ferrous Metal Production" (33.7%), and "Waste Incineration" (0.7%). These three classes of processes together accounted for 99.1% of the total annual dioxin/furan release in residues.

Figure 4 – Contribution of Different Source Categories to Annual Dioxin/Furan Emission to Residues



2.3.1.2.2 Hexachlorobenzene (HCB)

Among the 7 types of unintentionally produced POPs, PCDD/PCDF have never been intentionally produced for any reason but unintentionally produced, and PCB, HCB and PeCBs are also unintentionally formed, usually from the same sources that produce PCDD/PCDF. However, unlike PCDD/PCDF, PCB, HCB and PeCBs have also been manufactured and used for specific purposes, their intentional production and use being higher than the unintentional formation and release. HCB has been widely used as a pesticide to protect the seeds of onions and sorghum, wheat and other grains against fungus. It has also been used to make fireworks, ammunition and synthetic rubber. It is also used as a solvent in the production of pesticide.

HCB can be unintentionally produced as a by-product or waste material in the production of several types of organic pesticides, such as tetrachloroethylene, trichloroethylene, carbon tetrachloride, chlorine, dimethyl tetrachloroterephthalate, vinyl chloride, atrazine, propazine, simazine, pentachloronitrobenzene, and mirex. It is also a contaminant in several pesticides including dimethyl tetrachlorophthalate and pentachloronitrobenzene.

By reviewing the "Toolkit for Identification and Quantification of Releases of Dioxins, Furans and Other Unintentional POPs" updated in January 2013, there is incomprehensive estimation for all emission source of HCB as a by-product in the toolkit. Among the 10 Source Groups provided by the toolkit for the identifying and estimating the release source of PCDD/PCDF, there are 5 Source Groups including 12 Source Categories and 45 Source Classes being available for estimating the emission factors of unintentionally released HCB.

However, there is limited information on the comprehensive release of HCB as an unintentionally produced POP from combustion and/or as an intermediate during industrial processes in Hong Kong. HCB is a raw material for the production of many agricultural chemicals such as pentachlorophenol (PCP), quintozene (PCNB), chlorthal-dimethyl (TCTP), chlorothalonil and picloram, and remains as an impurity in these products. Apart from PCP, all other four agricultural chemicals are registered pesticides in Hong Kong. Records of their trading for the period 2011 – 2013 revealed that PCNB and chlorothalonil had been imported for local use. In the absence of information on the actual percentage of HCB as impurity in any of these pesticides, the potential annual release of HCB as an unintentional by-product to the local environmental due to their domestic applications could not be estimated. However, the relative contribution was likely to be insignificant.

2.3.1.2.3 Polychlorinated biphenyls (PCB)

PCB are a class of synthetic organic chemicals. Since 1930, PCB were used for a variety of industrial uses (mainly as dielectric fluids in capacitors and transformers but also as flame retardants, ink solvents, plasticizers, etc.) because of their chemical stability. PCB have been used as coolants and lubricants in transformers, capacitors and other electrical equipment because they do not burn easily and are good insulators. Among other things, products that may contain PCB include old fluorescent lighting fixtures and electrical devices containing PCB capacitors. PCB are also fire resistant, have a low electrical conductivity, high resistance to thermal breakdown and a high resistance to oxidants and other chemicals.

By reviewing the "Toolkit for Identification and Quantification of Releases of Dioxins, Furans and Other Unintentional POPs" updated in January 2013, there is still incomprehensive estimation for all emission source of PCB as by-products in the updated version of toolkit. Among the 10 Source Groups provided by the toolkit for identifying and estimating the release source of PCDD/PCDF, there are 5 Source Groups including 15 Source Categories and 59 Source Classes being available for estimating the emission factors of unintentionally released PCB.

Similarly with HCB, there is also limited information on the comprehensive release of PCB as unintentionally produced POPs in Hong Kong. PCB are known to be produced as unintentional combustion by-products of incineration and combustion processes. The Annexes of the "Toolkit for Identification and Quantification of Releases of Dioxins, Furans and Other Unintentional POPs" from UNEP contained emission factors and sources for PCB. Local information on the release of PCB from known emission sources is scarce. PCB emission factors to air have been determined in a measurement campaign in France (Delepine et al. 2011). For high technology MSW incinerators, emission factors in the range of 0.004 – 0.017 µg TEQ/ton of MSW incinerated are calculated for dioxin-like PCB, and between 2 and 64 µg/ton of MSW incinerated for indicator PCB. For high technology hazardous waste (HW) incinerators, emission factors in the range of 0.0004-0.237 µg TEQ/ton of HW incinerated are calculated for dioxin-like PCB, and between 6 - 154 µg/ton of HW incinerated for indicator PCB. Lastly, for high technology sewage sludge incinerators, emission factors in the range of 0.001 - 0.004 μg TEQ/ton of sewage sludge are calculated for dioxin-like PCB, and between 12 – 28 μg/t of sewage sludge incinerated for indicator PCB.

2.3.1.2.4 alpha-Hexachlorocyclohexane (α-HCH) and beta-Hexachlorocylohexane (β-HCH)

α-HCH and β-HCH are unintentionally produced as by-products in the production of the insecticide lindane, which has been ceased to produce in Hong Kong. Furthermore, HCHs were banned (deregistered) in Hong Kong in 1991 by the Pesticides Ordinance. The relative contribution, therefore, was likely to be insignificant. There are currently no standardized toolkits available for identifying and estimating the release sources of α-HCH and β-HCH.

2.3.1.2.5 Pentachlorobenzene (PeCB)

PeCB is produced unintentionally during combustion, thermal and industrial processes. There was comparatively little local information on the release of PeCB as an unintentionally produced POP from combustion, thermal and industrial processes in Hong Kong. There are currently no standardized toolkits available for identifying and estimating the release sources of PeCBs.

2.3.1.3 Contaminated Sites

Three local dioxin-contaminated historical activity sites were identified and documented by EPD during 2000-2004. The Choy Lee Shipyard site (located at Penny's Bay in Lantau Island) was the major contaminated site, contributing to 98.6% of the estimated total dioxin stockpile due to historical improper open burning of waste materials on-site. Decontamination of the Choy Lee Shipyard site and incineration of all dioxin-residue recovered from the contaminated soil at the Chemical Waste Treatment Centre (CWTC) was completed in March 2005. The other two minor contaminated sites were phased-out incineration plants at Kwai Chung, the New Territories and Kennedy Town, Hong Kong Island. Together, they were responsible for only 1.4% of the estimated total dioxin stockpile. The remediation of dioxin-contaminated soil or removal of dioxins containing materials for these sites has been completed. There were no known existing sites with major PCB or POPs pesticides contamination in Hong Kong. In addition, the landfills and the confined contaminated mud disposal facility at East Sha Chau would represent potential sinks of POPs, not posing immediate threats to the environment or human health.

2.3.2 Environmental Levels of POPs

2.3.2.1 Contamination Levels of POPs in Environmental Media

The aim of this section is to present the quantities of the POPs contaminating the surrounding through environmental media (e.g. ambient air, water, soil, sediment, vegetation). The EPD initiated a Toxic Substances Monitoring Programme in 2004. The purpose is to monitor and assess the extent of toxic substances pollution in the Hong Kong marine environment, including marine water, sediment and biota, and potential land-based pollution sources, such as sewage effluent as well as river water and storm runoff. The recent monitoring data about most of the initial and new POPs were collected in 2010 to 2012 from 10 sampling stations in 7 coastal locations (Deep Bay, North Western, Southern, Victoria Harbour, Junk Bay, Mirs Bay and Tolo Harbour).

Regarding the updated contamination levels of the 10 new POPs of ambient air, river water, soil and marine sediment, except for HBCD, EPD conducted a consultancy study "Investigation on the Use of PFOS in Aqueous Fire Fighting Foam and the Environmental Levels of New POPs Listed under the Stockholm Convention" in 2013 (EPD Investigation Study 2013) that tested the levels of PFOS and PFOSF in aqueous firefighting foam (AFFF) found in major AFFF users, and the environmental levels of 10 new POPs in ambient air, water, soil and sediment.

A summary of the contamination levels of POPs in the representative environmental media including ambient air, surface water, surface sediment, surface soil and vegetation is presented in **Table 4**.

2.3.2.1.1 *Ambient Air*

For inventory of period 2002 to 2004, contamination level of ambient air was mainly compiled based on government's monitoring studies. Ambient levels of total PCB and dioxins/furans (PCDD/PCDF) have been routinely monitored at two urban locations (Tsuen Wan and Central & Western District) in Hong Kong since mid-1997. In addition, dioxin data collected from a year-long dioxin-monitoring project (2000-2004) that targeted suspected local emission source at Tsing Yi (where Chemical Waste Treatment Centre (CWTC) is located) and from an ad hoc study conducted at Tai Mo Shan (2000-2001) were included in the calculation of the mean ambient air dioxin/furan concentration. Furthermore, ambient levels of aldrin, chlordane, DDT, dieldrin, endrin, HCB, heptachlor, mirex, PCB, toxaphene were monitored on a project basis at Tap Mun, Yuen Long and Tsuen Wan in 2004 by EPD. The results of this study are contained in the "First Regional Monitoring Report for Asia – Pacific Region (Dec. 2008)".

The recent ambient air contamination levels of POPs monitored by EPD during 2011 to 2013 covered 19 out of the 23 concerned POPs including all 12 initial POPs and 7 newly listed POPs, except 3 newly listed POPs (HBB, C-octaBDE and C-pentaBDE) as well as the proposed POP, HBCD.

EPD Investigation Study 2013 covered ambient air contamination levels of 10 newly listed POPs, except for HBCD, which included HBB, C-octaBDE and C-pentaBDE that were not covered by the EPD monitoring programme of POPs.

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A recent academic study conducted by Wang, W. et al. from HKBU in 2014 also covered the levels of PBDE which can represent the levels of C-octaBDE and C-pentaBDE.

In addition, the environmental level of HBCD in the ambient air is lack of local academic research or published data between 2006 and 2014.

Initial POPs

Only 9 initial POPs were reported with ambient air contamination levels in the HKSARIP 2006, while chlordane, mirex and toxaphene were not reported. However, all 12 initial POPs (the Dirty Dozen) were reported in the EPD monitoring programme of POPs (during 2013). Covered by the EPD monitoring programme of POPs (during 2013), all contamination levels of the 9 initial POPs, including aldrin, DDT, dieldrin, endrin, heptachlor, HCB, PCB, PCDD and PCDF, in the ambient air can now be renewed.

The recent contamination levels of 6 initial POPs including DDT (12.19 pg/m^3), heptachlor (2.39 pg/m^3), HCB (44.88 pg/m^3), PCB (dioxin-like PCBs: 0.003 pg WHO-TEQ /$m^3$and marker PCBs: 19.1 pg/m^3) and PCDD/PCDF (0.044 pg I-TEQ/m^3) were detected to have a lower value than the contamination levels reported in the HKSARIP 2006 (DDT: 0.05 ng/m^3, Heptachlor: 0.03 ng/m^3, HCB: 0.16 ng/m^3, PCBs: 0.48 ng/m^3 and PCDD/PCDF: 0.06 pg I-TEQ/m^3). Regular monitoring of dioxin-like PCB (PCB with TEFs (12 congeners: 77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, and 189) from January 2010 was commenced as well as marker PCB (7 congeners: 28, 52, 101, 118, 138, 153, and 180) to replace total PCB monitoring from May 2010.

The contamination levels of 3 other initial POPs (aldrin, dieldrin and endrin) were detected to be lower than the detection limit (0.02 ng/m^3) in the HKSARIP 2006. Due to recent technological advances, the latest EPD monitoring programme had reported the contamination levels of these 3 initial POPs using lower detection limits. Therefore, by adopting different detection limits, the 2006 and current ambient air contamination levels of aldrin, dieldrin and endrin are not directly comparable.

Another 3 initial POPs, including chlordane, mirex and toxaphene, were newly measured in the EPD monitoring programme of POPs (during 2013) and were detected at values of 4.61 pg/m^3, 5.3 pg/m^3, and below the detection limit (0.3 pg/m^3), respectively.

Newly Listed POPs

The EPD Investigation Study 2013 that also measured the contamination levels of 10 newly listed POPs in ambient air, except for HBCD, but concentrations of all the air samples were found to be below the detection limits. The more recent EPD monitoring programme of POPs (during 2013) covered 7 out of the 11 newly listed POPs including α-HCH (2.22 pg/m^3), β-HCH (2.33 pg/m^3), Chlordecone (BDL), γ-HCH (3.32 pg/m^3), PeCB (4.88 pg/m^3), PFOS/PFOSF (4.12 pg/m^3) and endosulfan (143.53 pg/m^3) by adopting lower detection limits than the previous limits in the EPD Investigation Study 2013. Only the EPD Investigation Study 2013 found contamination levels of C-octaBDE and C-pentaBDE in ambient air. Wang, W. et al. from HKBU published a study report in 2014 on the contamination levels of PBDE in residential air particulate phase (Total PBDE: 43.8 pg/m^3, BDE-99/pent-BDE: 17.3 pg/m^3).

No references, including official monitoring data and published academic studies, could be found on the contamination level of HBCD in the ambient air.

2.3.2.1.2 Marine Water

The major information sources of contamination levels of surface water were government studies, while data from local academia was very limited. In HKSARIP 2006's report, only marine water was included in the measurement of surface water for the contamination levels of all 12 initial POPs. In which, only PCDD/PCDF could be detected with a value above the detection limits, while the other 10 initial POPs were identified to be below the detection limits.

Initial POPs

Among the 12 initial POPs, an academic research on levels of chlordane, DDT and PCB in the marine water in Hong Kong was conducted by Wurl, O., et al. from CityU in 2006, which could be used to update the contamination levels of these 3 initial POPs in the HKSARIP 2006.

Provided by this local academic research, contamination levels of chlordane, DDT and PCB in marine water were reported at 0.0418, 1.908 and 0.356 ng/L respectively. As the reported values were lower than the previous detection limits (DDT: 15 ng/L, PCB: 100 ng/L & chlordane: 10 ng/L) adopted in the HKSARIP 2006, the equivalent concentrations between HKSARIP 2006 and local academic research are not directly comparable.

According to the Toxic Substances Monitoring Programme conducted by EPD since 2004, the latest sampling data on marine water covered levels of all 12 initial POPs. In which, except for PCDD/PCDF (average: 0.003 pg WHO-TEQ/L) and dioxin-like PCB (0.00003 pg WHO-TEQ/L), the other 9 initial POPs were below detection limits.

All 12 initial POPs can be updated by the contribution from the local academic research and the latest EPD Toxic Substances Monitoring Programme including chlordane, DDT, PCB and PCDD/PCDF that are above detection limits in the local marine water and the other 10 POPs comprising of aldrin, dieldrin, endrin, heptachlor, HCB, mirex and toxaphene, chlordecone, HBB and PeCB that are below detection limits.

Newly Listed POPs

Among the 10 newly listed POPs, the Wurl, O., et al. also measured the levels of α-HCH, β-HCH, γ-HCH and endosulfan in local marine water. Another local academic research on the contamination level of PFOS in Hong Kong coastal water was conducted by So, M.K., et al. also from CityU in 2004.

These two local academic studies contributed in identifying the contamination levels of 5 newly listed POPs including α-HCH (0.119 ng/L), β-HCH (0.246 ng/L), γ-HCH (0.215 ng/L), endosulfan (0.0485 ng/L) and PFOS (0.02-12 ng/L) in the local marine water environment.

The latest sampling data from the Toxic Substances Monitoring Programme on marine water also covered levels of 8 newly listed POPs except for endosulfan, PFOS/PFOSF and HBCD. Among these 9 tested new POPs, except for C-octaBDE (0.041 ng/L) and C-pentaBDE (0.232 ng/L), the other 6 new POPs were below detection limits. In addition, there is not recent data for PFOS/PFOSF under the Toxic Substances Monitoring Programme on marine water.

Provided by local academic studies and the Toxic Substances Monitoring Programme, the figure for HBCD could not be found by the desktop research.

2.3.2.1.3 Fresh Water

As the contamination levels of POPs in the surface fresh water is a newly added media in the environment levels in the 2nd HKSARIP, which was not provided in the original HKSARIP, therefore, there is no recorded figure can be compared on the contamination levels of POPs in local surface fresh water.

The sampling data from the Toxic Substances Monitoring Programme on river water covered levels of all 12 initial POPs and 9 newly listed POPs except for endosulfan and HBCD. The latest sampling data were collected from 2 locations from local rivers (Shing Mun River and River Indus) in 2012. The EPD 2013 Investigation Study also covered 3 types of newly listed POPs, namely, PFOS/PFOSF, PeCB and endosulfan, for their contamination levels in local river surface water.

Initial POPs

According to the latest Toxic Substances Monitoring Programme conducted by EPD in 2012 on river water, among the 12 tested initial POPs, 9 POPs were below detection limits except PCDD/PCDF (0.025 pg WHO-TEQ/L) and dioxin-like PCB (0.0003 pg WHO-TEQ/L).

Newly Listed POPs

The latest sampling data from the Toxic Substances Monitoring Programme on river water also covered levels of 9 newly listed POPs except endosulfan and HBCD. Among these 9 tested new POPs, except for PFOS (1.75 ng/L), C-octaBDE (0.055 ng/L) and C-pentaBDE (0.15 ng/L), the other 6 new POPs were below detection limits.

The EPD 2013 Investigation Study also covered 3 types of newly listed POPs, namely, PFOS/PFOSF, PeCB and endosulfan, for their contamination levels in local river surface water. The results showed that 2 of the 3 measured POPs, PeCB and endosulfan were below their detection limits and the other measured POP, namely PFOS, was detected with a contamination value of 5.81 ng/L in the local river surface water.

Data of river water is based on the Toxic Substances Monitoring Programme and the EPD 2013 Investigation Study, and there are no local academic studies on the contamination levels of either initial or newly listed POPs in fresh water that could be found.

2.3.2.1.4 Marine Sediment

Contamination of local marine sediment by toxic chemical pollutants has been relatively well documented. The inventory for the period between 2002 to 2004 was compiled based primarily on data generated from major consultancy studies on local toxic substances pollution reported in 2003, EPD's routine and *ad hoc* marine monitoring programmes (2003-2004) and study reports published by local academia.

Initial POPs

The contamination levels in local marine sediment of all 12 initial POPs were measured and summarised in the HKSARIP 2006. For the updating period between 2005 to 2012, results of several local academic research studies, a government-funded consultancy study examining the environmental levels of 10 new POPs (2011-2012) except for HBCD, and a consultancy monitoring report focusing on mud pits' sediment contamination (2008) contributed to the updated data on the environmental levels of 4 initial POPs – DDT, PCB, PCDD and PCDF in marine sediment. Comparing to the equivalent data collected from 2002 to 2004, the recent contamination level of PCB generally decreased (from 24.1 to 18.36µg/kg dw) , while that of DDT increased (from 6.81 to 17.4µg/kg dw).

According to the Toxic Substances Monitoring Programme conducted by EPD, the latest sampling data on marine sediment covered levels of all 12 initial POPs from 2010 to 2011. In which, except for toxaphene that was below the detection limit, the other 11 initial POPs were detected from local marine sediments. Among these detected levels of 11 initial POPs during 2010 and 2011, 10 values (aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, HCB, PCB, PCDD and PCDF) are lower than the measurements reported in HKSARIP 2006 except for mirex (2006: BDL; 2010/11: 0.471 µg/kg dw). However, the detection limit of mirex adopted in HKSARIP 2006 was 10 µg/kg dw, which is higher than the detected value of Mirex (0.471 µg/kg dw) in the latest Toxic Substances Monitoring Programme, the comparison of contamination levels of mirex in marine sediment between 2006 and 2010/11 could not be concluded.

Provided by the latest Toxic Substances Monitoring Programme and academic researches, the levels for all 12 initial POPs in the marine sediment are updated from the HKSARIP 2006.

Newly Listed POPs

Among the 11 newly listed POPs, the EPD Investigation Study 2013 measured 3 newly listed POPs including PeCB, PFOS/PFOSF and endosulfan with values of 0.122 µg/kg dw, below detection limit and 7.08 µg/kg dw respectively.

The latest sampling data from the Toxic Substances Monitoring Programme on marine sediment also covered levels of 8 newly listed POPs except PeCB, endosulfan and HBCD conducted by EPD in 2010/11 from 10 sampling stations in 7 costal locations (Deep Bay, North Western, Southern, Victoria Harbour, Junk Bay, Mirs Bay and Tolo Harbour).

Among these 8 tested new POPs, chlordecone and PFOS were below the detection limit and the other 6 new POPs (α-HCH: 0.035 μg/kg dw, β-HCH: 0.021 μg/kg dw, HBB: 0.002 μg/kg dw, γ-HCH: 0.064 μg/kg dw, C-octaBDE: 0.089 μg/kg dw and C-pentaBDE: 0.077 μg/kg dw) were detected with contamination levels in the marine sediments.

However, there is still a lack of published information about the contamination level of the proposed HBCD in the marine sediment.

2.3.2.1.5 *River Sediment*

Only 2 initial POPs, namely DDT and PCB, were reported with contamination levels in the river sediment in the HKSARIP 2006.

Initial POPs

According to the Toxic Substances Monitoring Programme conducted by EPD, the latest sampling data on river sediment covered levels of all 12 initial POPs collected from Shing Mun River, Lam Tsuen River and River Indus in 2012. In which, 4 initial POPs (aldrin, endrin, heptachlor and toxaphene) were below detection limits and the other 8 initial POPs were detected in the river sediments (chlordane: 0.86 μg/kg dw, DDT: 1.2 μg/kg dw, dieldrin: 0.79 μg/kg dw, HCB: 0.59 μg/kg dw, mirex: 1.89 μg/kg dw, and total PCB: 3.17 μg/kg dw, dioxin-like PCB: 0.54 pg WHO-TEQ/kg and PCDD/PCDF: 3.12 pg WHO-TEQ/kg). Comparing with the values reported in the HKSARIP 2006, the more recent values of DDT and PCB are significantly lower.

Newly Listed POPs

For the newly listed POPs, Zhao, Y.G., et al. from HKBU conducted a study in 2012 on the environmental contamination of PFOS in Asian countries and revealed that the concentration of PFOS in fresh water sediment (or river sediment) was not significantly different from marine water sediment in Asian countries.

The latest sampling data in 2012 from the Toxic Substances Monitoring Programme on river sediment also covered levels of 9 newly listed POPs except endosulfan and HBCD. Among the tested 9 newly listed POPs, 3 of them were below detection limits including chlordecone, PeCB and PFOS. The other 6 POPs (HBB, α-HCH, β-HCH, γ-HCH, C-octaBDE and C-pentaBDE) were detected with contamination levels of 0.006 μg/kg dw, 0.07 μg/kg dw, 0.02 μg/kg dw, 0.19 μg/kg dw, 0.66 μg/kg dw and 1.29 μg/kg dw respectively from the 3 sampling locations.

However, there is still a lack of published information about the contamination levels of endosulfan and HBCD in the river sediment.

2.3.2.1.6 Surface Soil

Contamination levels of 6 initial POPs including DDT, endrin, HCB, PCB, PCDD and PCDF in the local surface soil for the period 2002 to 2004 was summarised primarily on an *ad hoc* territory-wide background monitoring of surface soil in 46 locations in Hong Kong's rural area by the HKSARIP 2006.

Initial POPS

A local academic study conducted by HKBU in 2007 by Zhang , H.B., et al. reported the updated value of PCB (2.45 μg/kg dw) in the rural area of Hong Kong, which showed an increased value of PCB in the background surface soil measured in the period between 2002 and 2004.

More recent data on the contamination levels of the other 11 initial POPs in natural surface soil could not be found from officially published data or academic research results. Therefore, the levels for those 5 initial POPs (DDT, endrin, HCB, PCDD and PCDF) in the surface soil that were summarised in the HKSARIP 2006 are kept for the updated environmental levels, while the level of PCB can be updated according the local academic study conducted in 2007.

Newly Listed POPs

The EPD 2013 Investigation Study also covered the concentrations of 10 newly listed POPs in the rural surface soil, except for HBCD. The contamination levels of these 10 newly listed POPs in the local soil were generally very low, in which, 7 of them, namely α-HCH, chlordecone, HBB, PeCB, C-octaBDE, C-pentaBDE and endosulfan, were identified below the detection limit. For the concentrations of the other detected POPs, namely, β-HCH, γ-HCH and PFOS, the values were 0.876 μg/kg dw, 1.15 μg/kg dw and 0.197 μg/kg dw, respectively.

2.3.2.1.7 Vegetation

The initial inventory of contamination level of vegetation was compiled by government consultancy studies conducted between 2001 and 2002 that targeted suspected local dioxin emission sources. 40 samples of ground vegetation and 10 samples of tree barks were taken at five locations near landfills, CWTC or livestock waste composting sites. No data on initial POPs in local vegetation were available. Moreover, more recent data on the local published result on Ground Vegetation and Tree Bark could not be found between 2005 and 2014. Therefore, the inventory of PCDD and PCDF published by HKSARIP 2006 for the concentrations in vegetation are kept in the updated environmental levels.

Table 4: Mean Levels of POPs Contamination in the Environment of Hong Kong for the Period 2002 – 2013 [a]

Chemical	Ambient Air [b] (pg/m^3)	Surface Water (ng/L)		Surface Sediment (µg/kg dw)		Surface Soil [e] (µg/kg dw)	Vegetation (µg/kg dw)	
		Marine Water [c]	Fresh Water [d]	Marine Sediment [c]	River Sediment [d]		Ground Vegetation	Tree Bark
Aldrin	1 (0.65-4.8)	BDL	BDL	0.164 (BDL – 2.49)	BDL			
Chlordane	4.61 (3.2-9.9)	0.0418 (0.039- 0.048)	BDL	0.135 (BDL – 1.44)	0.86 (BDL – 1.58)			
DDT	12.19 (4.95-25.85)	1.908 (0.78 - 5.58)	BDL	1.671 (0.15 – 4.51)	1.20 (0.417 – 2.82)	0.52 # (<0.004-6.00)		
Dieldrin	5.21 (0.60-23)	BDL	BDL	0.254 (BDL – 2.52)	0.79 (BDL – 2.2)			
Endrin	0.6 (0.55-0.60)	BDL	BDL	0.014 (BDL – 0.54)	BDL	0.01 # (<0.004-0.10)		
Heptachlor	2.38 (1.95-6.7)	BDL	BDL	0.148 (BDL – 0.41)	BDL			
HCB	44.88 (1.05-138)	BDL	BDL	0.041 (BDL - 0.28)	0.59 (0.25 - 1.21)	0.01 # (<0.001-0.30)		
Mirex	5.3 (0.50-48)	BDL	BDL	0.471 (BDL – 12.9)	1.89 (BDL – 4.88)			
Toxaphene	BDL	BDL	BDL	BDL	BDL			
PCBs*	Dioxin-like PCB: 0.003 (0.002-0.008) Marker PCB: 19.1 (7.2-42.8)	Dioxin-like PCB†: 0.00003 (BDL - 0.0002) Total PCB‡: 0.356 (0.27 - 0.43)	Dioxin-like PCB:0.0003 (BDL - 0.001) Total PCB: BDL	Dioxin-like PCB†: 0.071 (0.0003 – 0.763) Total PCB†: 0.15 (BDL - 4) Total PCB‡:18.36 (18-45)	Dioxin-like PCB: 0.54 (0.01 – 1.05) Total PCB: 3.17 (BDL - 7)	2.45 (0.04-9.87)		
PCDD* PCDF*	0.044 (0.008-0-182)	0.003 (BDL - 0.021)	0.025 (0.007 – 0.039)	PCDD/F†: 2.931 (0.65 – 10.24) PCDD‡: 4.33 (2.4-6) PCDF‡: 1.34 (0.071- 0.3)	3.12 (0.49 – 8.45)	5.33 # (0.35-32.8)	2.13 # (0.29-14.1)	1.47 # (0.49-3.57)
α-HCH	2.22 (0.85-6.6)	0.119 (0.071- 0.23)	BDL	0.035 (BDL – 0.24)	0.07 (BDL – 0.135)	BDL		
β-HCH	2.33 (0.60-21)	0.246 (0.11- 0.34)	BDL	0.021 (BDL – 0.18)	0.02 (BDL – 0.059)	0.876 (<1-3.69)		
Chlordecone	BDL	BDL	BDL	BDL	BDL	BDL		
HBB	BDL	BDL	BDL	0.002 (BDL – 0.071)	0.006 (BDL – 0.012)	BDL		
γ-HCH	3.32 (0.65-13)	0.215 (0.149-0.282)	BDL	0.064 (BDL – 0.4)	0.19 (0.114 – 0.225)	1.15 (<1-5.54)		
PeCB	4.88 (1-20.3)	BDL	BDL	0.122 (0.1-0.381)	BDL	BDL		
PFOS, PFOSF	4.12 (1.2-8.6)	PFOS: 0.02 -12	PFOS†: 1.75 (BDL – 7) PFOS‡: 5.81 (5- 11.9) PFOSF‡: BDL	PFOS: BDL PFOSF: BDL	BDL	PFOS: 0.197 (<0.3-0.624) PFOSF: BDL		
C-octaBDE	Total PBDE:43.8 (0.25-160) BDE-99: 17.3 (0.25 - 139)	0.041 (BDL - 236)	0.055 (0.016 – 0.096)	0.089 (BDL – 1.431)	0.66 (0.336 – 3.013)	BDL		
C-pentaBDE		0.232 (0.066 - 638)	0.15 (0.033 – 0.318)	0.077 (0.012 – 0.333)	1.29 (0.331 – 1.037)	BDL		
Endosulfan	143.53 (16.6-426)	0.0485 (0.046- 0.055)	BDL	7.08 (7.2-14.7)		BDL		
HBCD								

a: Results are expressed as mean (minimum, maximum) values

b: The mean levels of POPs contamination in ambient air of Hong Kong (except HBB and PBDE) are based on the 2013 data of the EPD monitoring programme on POPs; "BDL" indicates values were below detection limits; Detection limits of toxaphene, chlordecone and HBB in ambient air = 0.3 pg/m^3, 0.6 pg/m^3 and 0.016 ng/m^3, respectively; dioxin-like PCB in ambient air was detected by PCB with TEFs (12 congeners: 77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, and 189); marker PCB in ambient air was detected by 7 congeners: 28, 52, 101, 118, 138, 153, and 180; PBDE levels in ambient air measured by Wang, W., et. al. 2014 from Hong Kong Baptist University are "PBDE in particle phase"; HBB levels are based on the EPD Investigation Study 2013.

c: "BDL" indicates values were below detection limits; Detection limits of C-octaBDE, C-pentaBDE, DDT, HBB, PCDD/PCDF, toxaphene and chlordane in marine water = 0.005, 0.01, 2, 0.1, 0.00025, 200, and 200 ng/L, respectively; Detection limits of all POPs except PCDD/PCDF, dioxin-like PCB, DDT, HBB, C-octaBDE, C-pentaBDE, PCDD/PCDF toxaphene and chlordane in marine water = 10 ng/L; Detection limits of aldrin, chlordane, dieldrin, endrin, heptachlor, mirex, toxaphene, HCB, α-HCH, β-HCH, γ-HCH, HBB, chlordecone and C-octaBDE in marine sediment = 0.2, 0.2, 0.2, 0.5, 0.2, 0.2, 2, 0.1, 0.05, 0.05, 0.05, 0.01, 1, and 0.01 μg/kg dw respectively; Detection limits of PFOS and PFOSF in marine sediment = 0.3 and 10 μg/kg dw, respectively.

d: "BDL" indicates values were below detection limits; Detection limits of DDT, toxaphene, C-octaBDE and HBB in fresh water = 2, 150, 30 and 0.1 ng/L, respectively; Detection limit of all POPs except PCDD/PCDF, dioxin-like PCB, DDT, toxaphene, C-octaBDE and HBB in fresh water = 10 ng/L. Detection limits of aldrin, chlordane, dieldrin, endrin, heptachlor, mirex, toxaphene, HCB, α-HCH, β-HCH, γ-HCH, HBB, chlordecone and C-octaBDE in river sediment = 0.2, 0.2, 0.2, 0.5, 0.2, 0.2, 2, 0.05, 0.05, 0.05, 0.01, 1, and 0.01 μg/kg dw; Detection limits of PFOS and PFOSF in river sediment = 0.3 and 10 μg/kg dw, respectively.

e: "BDL" indicates values were below detection limits; Detection limits of α-HCH, chlordecone, HBB, PeCB, C-octaBDE, C-pentaBDE and endosulfan in surface soil = 1, 0.1, 1, 0.1, 0.5, 1 and 7 μg/kg dw, respectively;

*: Unit of PCDD/PCDF and dioxin-like PCB in ambient air = pg I-TEQ/m^3; Unit of PCDD/PCDF and dioxin-like PCB in marine/fresh water = pg WHO-TEQ/L;

#: Values from HKSARIP 2006;

†: Values from the Toxic Substances Monitoring Programme; and

‡: Values from the EPD 2013 Investigation Study.

2.3.2.2 Contamination Levels of POPs in Aquatic Biota

The inventory of the contamination levels of POPs in aquatic biota, including freshwater fish, marine fish and shellfish, water bird eggs and marine mammals, is mainly based on local academia research studies and government-funded consultancy studies. It is found that most local academia focused their research on contamination levels of 3 POPs in aquatic biota, including DDT, HCH and PBDE, probably because the contamination of these POPs would be more influential to the chance of survival or reproduction of aquatic biota. Studies of other types of POPs on aquatic biota are scarce, and mainly rely on comprehensive monitoring studies conducted by EPD.

The Toxic Substances Monitoring Programme also measured the contamination levels of all 12 initial POPs and 9 newly listed POPs except endosulfan and HBCD from 3 species of marine fish (Belanger's croaker) and shellfish (Mantis shrimp and Jinga shrimp) caught from 3 local marine areas (Deep Bay, North Western and Southern) in 2010/11.

It was found that the contamination levels of POPs in marine fish, shellfish, water bird eggs and marine mammals were measured and presented on various weight basis, including μg per kg wet weight, dry weight and lipid weight in different research studies. There is no proper conversion method among these different measuring units due to the markedly varying water and lipid content between individuals and tissues, which are also largely affected by how samples are handled and stored but these information are not mentioned in the monitoring studies. Hence, the original units of the research are reported in this section.

A summary of contamination levels of POPs in aquatic biota including freshwater fish, marine fish, marine shellfish, water bird eggs and marine mammals is presented in **Table 5**.

2.3.2.2.1 Freshwater Fish

There is a general paucity of information on POPs in freshwater biota. Studies conducted by local academia contributed to all the data compiled in this section of the inventory. For the period between 2002 and 2004, 4 freshwater fishes from one to three sampling sites were examined for the contamination levels of aldrin, chlordane, DDT, endrin and heptachlor, while another study measured the levels of PCB in one fish species from two locations. DDT and PCB were the only POPs measured above the detection limits in the HKSARIP 2006.

Initial POPs

A recent study on the residual levels of DDT in freshwater fish from Hong Kong markets was conducted by Cheung, K.C., et al from HKBU in 2007 and the available data can be used to update the contamination level of DDT in aquatic biota. 10 freshwater fish species with 30 fish samples were taken from local wet markets for chemical analysis. Comparing to the equivalent data collected summarised in the HKSARIP 2006, the contamination level of DDT in freshwater fish increased from 6.78 to 29.3μg/kg ww.

No recent data on the contamination levels of the other 11 initial POPs in freshwater fish can be found from officially published data or academic research results. Therefore, the levels for the other 5 initial POPs (aldrin, dieldrin, endrin, heptachlor and PCB) that were measured in the HKSARIP 2006 are kept for the updated environmental levels.

Newly Listed POPs

A local academic study conducted by Zhao, Y.G., et al. from HKBU in 2011 that studied the concentration of PFOS in the freshwater fish showed that an average concentration of 1.03 μg/kg ww was summarized from 8 marine fish species investigated from the local wet market.

2 recent local academic studies both conducted by HKBU in 2008 (Cheung, K.C., et al.) and in 2011 (Wang, H.S., et al.) respectively measured the contamination levels of PBDE in freshwater fish, and an average value of 9.25 μg/kg ww could be summarised for 10 species of freshwater fish investigated from local markets. However, no recent data could be found for the contamination levels of the remaining 8 newly listed POPs in freshwater fish.

2.3.2.2.2 Marine Fish

Compared with freshwater fish, more information on POPs in local marine fish were available. For the initial inventory summarised by HKSARIP 2006, data were retrieved primarily from four studies, including two toxic substances consultancy studies reported in 2003, an *ad hoc* baseline survey on trace toxics in Hong Kong marine biota conducted by EPD in 2003, and a monitoring report of contaminated mud pit at East Sha Chau conducted in 2004 by CEDD.

The Toxic Substances Monitoring Programme also measured the contamination levels of all 12 initial POPs and 9 newly listed POPs except endosulfan and HBCD from 1 species of marine fish (Belanger's croaker) caught from 2 local water control zones (Deep Bay and North Western) in 2010/11.

Initial POPs

All 12 initial POPs were measured and summarized by HKSARIP 2006 with the contamination levels in marine fish. Within the initial POPs, the same academic study on the contamination level of DDT in freshwater fish (Cheung, K.C., et al., 2007) also reported the level of DDT in marine fish in 2007. Comparing with the figures given by HKSARIP 2006, the updated contamination level of DDT in marine fish increased from 27.6 to 112.3 µg/kg ww.

Including the updated measurement on DDT in marine fish conducted by local academic, the levels for all the 12 initial POPs were also covered by the latest Toxic Substances Monitoring Programme conducted by EPD in 2010/11. In which, 3 initial POPs (heptachlor, HCB and toxaphene) were below detection limits and the other 9 initial POPs (aldrin: 0.06 µg/kg ww, chlordane: 0.26 µg/kg ww, DDT: 4.12 µg/kg ww, dieldrin: 0.04 µg/kg ww, endrin: 0.06 µg/kg ww, mirex: 0.72 µg/kg ww, dioxin-like PCB: 0.08 pg WHO-TEQ/kg ww and PCDD/PCDF:0.03 pg WHO-TEQ/kg ww) were detected from samples of local marine fish species.

Newly Listed POPs

The same local academic study conducted by Zhao, Y.G., et al., from HKBU in 2011 that studied the concentration of PFOS in the freshwater fish also investigated the contamination level of PFOS in the marine fish, and an average concentration of 0.71 µg/kg ww was summarized from 7 marine fish species investigated from the local wet market.

The Toxic Substances Monitoring Programme also measured the contamination levels of 9 newly listed POPs in local marine species except endosulfan and HBCD. 3 out of 9 tested new POPs (HBB, PeCB and PFOS) were identified to be below detection limits through the monitoring programme and the other 6 POPs were detected with values from marine fish samples, including α-HCH (0.08 µg/kg ww), β-HCH (0.04 µg/kg ww), γ-HCH (0.08 µg/kg ww), chlordecone (2.1 µg/kg ww). C-octaBDE (0.13 µg/kg ww) and C-pentaBDE (0.38 µg/kg ww).

However, there is still a lack of published information about the contamination levels of endosulfan and HBCD in the marine fish species.

2.3.2.2.3 Marine Shellfish

All 12 initial POPs were summarised with contamination levels in the marine shellfish by the HKSARIP 2006. The latest sampling data of the Toxic Substances Monitoring Programme included all 12 initial POPs and 9 newly listed POPs only except endosulfan and HBCD. The measurements conducted on 2 local marine shellfish species (Mantis shrimp and Jinga shrimp) caught from the North Western and Southern water control zones in 2010/11.

Initial POPs

Among the contamination levels of all the 12 initial POPs in local marine shellfish tested by the Toxic Substances Monitoring Programme in 2010/11, there were 4 POPs (endrin, heptachlor, HCB and toxaphene) below detection limits, while endrin, heptachlor, HCB were reported with detected values in the HKSARIP 2006 and toxaphene was also below the detection limit as reported in the HKSARIP 2006. The other 8 initial POPs, namely, aldrin, chlordane, DDT, dieldrin, mirex PCB, PCDD and PCDF were detected with values of 0.11μg/kg ww, 0.21 μg/kg ww, 3.27 μg/kg ww, 0.09 μg/kg ww, 0.86 μg/kg ww, 0.13 ng WHO-TEQ/kg ww (dioxin-like PCB) and 0.17 ng WHO-TEQ/kg ww (PCDD/PCDF).

Comparing with the values reported in the HKSARIP 2006, 8 initial POPs including chlordane, DDT, dieldrin, endrin, heptachlor, HCB, PCDD and PCDF were recorded with a lower contamination level in the more recent measurement. Another 3 initial POPs, namely, aldrin, mirex and toxaphene were below detection limits in the HKSARIP 2006, and could not be compared with the updated values due to the different detection limits adopted before 2006. Regular monitoring of dioxin-like PCB (PCB with TEFs (12 congeners: 77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, and 189) from January 2010 was commenced as well as marker PCB (7 congeners: 28, 52, 101, 118, 138, 153, and 180) to replace total PCB monitoring from May 2010. The available contamination level of PCB was tested by dioxin-like PCB in the recent data in the Toxic Substances Monitoring Programme, which were incomparable to the previous value of PCB reported as total PCB in the HKSARIP 2006.

Newly Listed POPs

Among the newly listed POPs, a local study with the results of a 6-year (1998-2003) survey of trace toxics in the intertidal mussel *Perna viridis* published by EPD in 2005 (Liu, J.H. and Kueh, C.S., 2005) revealed that local mussels were contaminated with 2 newly listed POPs, namely C-octaBDE and C-pentaBDE, with concentrations of 16.85 and 14.43 μg/kg dw respectively.

The Toxic Substances Monitoring Programme also measured the contamination levels of 9 newly listed POPs in local marine species except endosulfan and HBCD. 4 out of 9 tested new POPs (β-HCH, HBB, PeCB and PFOS) were identified to be below detection limits through the monitoring programme and the other 5 POPs were detected with values from marine shellfish samples, including α-HCH (0.11 μg/kg ww), γ-HCH (0.05 μg/kg ww), chlordecone (0.8 μg/kg ww). C-octaBDE (0.07 μg/kg ww) and C-pentaBDE (0.57 μg/kg ww).

However, there is still a lack of published information about the contamination levels of endosulfan and HBCD in the marine shellfish species.

2.3.2.2.4 *Water Bird Eggs*

Studies conducted by local academia contributed to all the data compiled in this section of the inventory. For the initial inventory from 2002 to 2004, data were retrieved primarily from a local study on the body burden of chlordane, DDT and PCB in eggs of two species of water birds sampled at two locations in the New Territories.

Initial POPs

Among the 12 initial POPs, 4 of them, namely chlordane, DDT, PCDD and PCDF, were reported with contamination levels in the water bird eggs in the HKSARIP 2006. Two recent academic studies on the contamination levels of all 12 initial POPs in water bird eggs were conducted by Wang, Y., et al., from CityU in 2011 and in 2012 respectively. According to the results from these 2 academic studies, the reported values of chlordane, DDT, PCDD and PCDF in the HKSARIP 2006 can be updated to 158-975, 2,490-16,100, 484-520 and 80.1-167 μg/kg lw respectively. However, the units of the updated levels were reported in lipid weight by the recent academic studies, which is different to the previously reported units (wet weight), hence, the contamination levels of these 4 initial POPs between previous levels summarised in HKSARIP 2006 and recent levels measured by recent studies cannot be directly compared.

In addition, the other 8 initial POPs that were not reported by the HKSARIP 2006 were identified with contamination levels in the water bird eggs by Wang, Y., et al., from CityU in 2011 (aldrin: 0.492-8.41 μg/kg lw, dieldrin: 8.36-114 μg/kg lw, endrin: 9.32-31.3 μg/kg lw, heptachlor: 7.81-99.8μg/kg lw, HCB: 40.2-241μg/kg lw, mirex: 84.2-255μg/kg lw, toxaphene: 36.1-395μg/kg lw and PCB: 881-4,310μg/kg lw).

Newly Listed POPs

The topic of PFOS contamination levels in water bird eggs was also conducted by Wang, Y., et al., from CityU in 2008 in another academic study. An average of 65.2 μg/kg ww of PFOS could be concluded from the 19 samples of water bird eggs measured by this study.

Another academic study reported by Connell, D.W., et al., in 2003 detected the total levels of HCH in the water bird eggs (19 μg/kg lw), which can represent the contamination levels of 3 newly listed POPs including α-HCH, β-HCH and γ-HCH. No other recent data on the contamination levels of the other newly listed POPS in water bird eggs could be found from officially published data or academic research results.

2.3.2.2.5 *Marine Mammals*

Studies conducted by local academia contributed to all the data compiled in this section of the inventory but research data was scarce for monitoring the trend. The initial inventory was compiled based on three studies of stranded cetaceans, the Indo-Pacific humpback dolphin (*Sousa chinensis*) and finless porpoise (*Neophocaena phocaenoides*), published in the literatures (1995-2000, 2000-2001 and 2003-2011). They provided baseline data for contamination levels of DDT, mirex, toxaphene, PBDE and PCB in marine mammals.

Initial POPs

Among the 12 initial POPs, 4 of them were reported with contamination levels in the marine mammals in the HKSARIP 2006. Provided by a local academic study conducted by Ramu, K., et al. in 2005 on 2 local cetaceans species, namely finless porpoise and Indo-Pacific humpack dolphin, an average concentration level of 134.5 μg/kg lw of DDT was found in the marine mammals.

Despite the updated concentration of DDT in the marine mammals, no recent data after 2006 could be found on the contamination levels of the other 11 initial POPS in marine mammals from officially published data or academic research results. Therefore, the summarised levels for 3 initial POPs, namely mirex, toxaphene and PCB in the marine mammals reported in the HKSARIP 2006 are kept as the updated environmental levels.

Newly Listed POPs

The study conducted by Ramu, K., et al. in 2005 also measured the contamination of HCH in the 2 investigated cetacean species, namely finless porpoise and Indo-Pacific humpback dolphin, and an average concentration of 0.455 μg/kg lw could be identified, which can represent the contamination levels of 3 newly listed POPs including α-HCH, β-HCH and γ-HCH.

Another local academic study conducted by Lam, J.C.W., et al., from CityU in 2009 analysed the concentrations of PBDE and HBCD in the same 2 cetacean species. The results of PBDE (1,955.2 μg/kg lw) can be used to represent the total contamination levels of C-octaBDE and C-pentaBDE in the marine mammals. The contamination level of HBCD (93.4 μg/kg lw) summarised by the study is the only available contamination data of HBCD for all environmental medias and aquatic biotas. The results of PBDE levels in marine mammals in the latest published study by Zhu, B.Q., et. al. from CityU in 2014 fell within the range of the study conducted by Lam, J.C.W., et al., from CityU in 2009.

Table 5: Levels of POPs Contamination in the Aquatic Biota of Hong Kong for the Period 2002 – 2014[a]

Chemical	Freshwater Fish [b] (µg/kg ww)	Marine Fish [c] (µg/kg ww)	Marine Shellfish [c] (µg/kg)	Water Bird Eggs [d] (µg/kg)	Marine Mammals [e] (µg/kg)
Aldrin	BDL #	0.06 (BDL – 0.24)	0.11 (BDL – 0.15)	0.492-8.41	
Chlordane		0.26 (BDL – 0.54)	0.21 (BDL – 0.48)	158-975	
DDT	29.3 (1.1 to 127)	4.12† (0.92 – 6.73) 112.3‡ (2.3-1,018)	3.27 (BDL – 8.66)	2,490-16,100	134.5 (9.9-470)
Dieldrin	BDL #	0.04 (BDL – 0.08)	0.09 (BDL – 0.2)	8.36-114	
Endrin	BDL #	0.06 (BDL – 0.12)	BDL	9.32-31.3	
Heptachlor	BDL #	BDL	BDL	7.81-99.8	
HCB		BDL	BDL	40.2-241	
Mirex		0.72 (0.56 – 0.88)	0.86 (BDL – 1.94)	84.2-255	178 # (70.5-286)
Toxaphene		BDL	BDL	36.1-395	32.0 # (19.7-44.2)
PCB*	57.8 #	Dioxin-like PCB: 0.08 (0.004 – 0.15)	Dioxin-like PCB: 0.13 (0.04 – 0.21)	881-4,310	8,190 #
PCDD*		PCDD/F: 0.03 (0.019 – 0.041)	PCDD/F: 0.17 (0.02 – 0.47)	484-520	
PCDF*				80.1-167	
α-HCH		0.08 (BDL – 0.16)	0.11 (BDL – 0.23)	HCH: 19 (8.4-30)	HCH: 0.455 (0.032 - 2.2)
β-HCH		0.04 (BDL – 0.085)	BDL		
γ-HCH		0.08 (BDL – 0.16)	0.05 (BDL – 0.1)		
Chlordecone		2.1 (BDL – 4.16)	0.8 (BDL – 1.6)		
HBB		BDL	BDL		
PeCB		BDL	BDL		
PFOS, PFOSF	1.03 (0.27-4.5)	0.71 (0.27-1.5)	BDL	65.2 (14.1-34.3)	
C-octaBDE	PBDE: 9.25 (0.53-130)	0.13 (0.08 – 0.17)	0.07† (BDL – 0.15) 16.85‡ (2.31 - 31.46)		PBDE: 1,955.2 (103-51,100)
C-pentaBDE		0.38 (0.22 – 0.53)	0.57† (0.03 – 1.3) 14.43‡ (5.69-33.1)		
Endosulfan					
HBCD					93.4 (4.1-519)

a: Results are expressed as mean (minimum, maximum) values

b:"BDL" indicates values were below detection limit; Detection limit of pesticides in freshwater fish = 0.10 µg/kg ww;

c: "BDL" indicates values were below detection limit; Detection limit of aldrin, mirex, DDT, chlordane, dieldrin, heptachlor, PeCB, PFOS and HCB in marine fish/shellfish = 0.1 µg/kg ww; Detection limit of HBB, endrin and toxaphene in marine fish/shellfish = 0.01, 0.2 and 2 µg/kg ww; Detection limit of α-HCH, β-HCH and γ-HCH in marine fish/shellfish = 0.05 µg/kg ww; Unit of C-octaBDE and C-pentaBDE in marine shellfish = µg/kg dw; Units of other POPs except C-octaBDE, C-pentaBDE and PCDD/PCDF in marine shellfish = µg/kg ww.

d: Unit of PFOS/PFOSF in water bird eggs = µg/kg ww; Units of other POPs except PCDD/PCDF in water bird eggs = µg/kg lw;

e: Units of mirex, toxaphen, PCB in marine mammals = µg/kg ww; Units of other POPs in marine mammals = µg/kg lw;

*: Units of PCDD/PCDF and dioxin-like PCB = ng WHO-TEQ/kg ww

#: Values from HKSARIP 2006

†: Unit of value = μg/kg ww

‡: Unit of value = μg/kg dw

2.3.3 Dietary Exposure to POPs

In 2011, the Centre for Food Safety (CFS) of the Food and Environmental Hygiene Department (FEHD) conducted The First Hong Kong Total Diet Study on dioxins and dioxin-like polychlorinated biphenyls (PCB) to obtain the contamination level of 142 composite samples involving 71 common food items of Hong Kong citizens. In 2014, the CFS also conducted a study on organochlorine pesticide (OCP) residues to obtain the contamination level of 14 OCPs in 600 composite samples involving 150 common food items of Hong Kong citizens. The numbers of composite samples with detectable levels of one or more of the 14 OCPs and dioxin and dioxin-like PCB in the 15 food groups are summarised in **Table 6 and Table 7**. Furthermore, in 2012, CFS published "The first Hong Kong Total Diet Study: Polybrominated diphenyl ethers (PBDE)" to include the dietary exposure levels of PBDE found in 71 food items involving 142 composite samples.

Human exposure to POPs through dietary intake was estimated based on measurements of contamination levels of POPs in various types of foods and information on daily diets of the local population. In general, the inventory of the dietary exposure to POPs is well-documented for both 12 initial POPs (aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, HCB, mirex, toxaphene, PCB, PCDD and PCDF) and 7 new POPs (α-HCH, β-HCH, γ-HCH, PeCB, C-octaBDE, C-pentaBDE and endosulfan). A summary of POPs contamination in foods and estimated daily exposure is presented in **Table 8**.

Due to the lack of local data before 2005, the HKSARIP 2006 report adopted food consumption patterns of Far East Countries (including China) published by WHO (2003) for the estimation of daily dietary exposure of Hong Kong citizens. In view of this information gap, the CFS conducted a Hong Kong Population-Based Food Consumption Survey in 2005-2007 to obtain food consumption habits of local Hong Kong citizens. Therefore, a better estimation of daily dietary exposure could be made by adopting the food consumption data fitting the local context. As the methodology of calculating the estimated daily dietary exposure in the HKSARIP 2006 report is different from the new study conducted by the CFS, in which the data presented in this report is considered to be a better estimation, the equivalent data collected in 2003 presented in the 2006's report would not be compared for analysing the trend of estimated daily dietary exposure of Hong Kong citizens. CFS has published the contamination levels and dietary exposure levels of some important POPs in each food item analysed in the relevant reports of The First Hong Kong Total Diet Study.

Table 6: Numbers of Composite Samples in Total Diet Study Food Groups

Food group	No. composite samples analysed	No. composite samples with detectable level of OCPs													
		Aldrin	Dieldrin	Chlordane	DDT	Dicofol	Endosulfan	Endrin	Heptachlor	HCB	HCH(α,β,γ and δ)	-Lindane (γ-HCH)	Mirex	Pentachlorobenzene	Toxaphene
Cereals and their products	76	0	1	0	24	6	11	8	0	26	1	1	1	21	0
Vegetables and their products	140	0	1	1	7	3	59	0	0	10	3	3	0	9	0
Legumes, nuts and seeds and their products	24	0	2	0	8	1	6	0	2	6	7	1	0	1	3
Fruits	68	0	0	0	3	1	10	0	0	1	1	1	0	0	0
Meat, poultry and game and their products	48	1	1	0	44	1	1	0	0	46	6	0	2	1	0
Egg and their products	12	0	0	0	11	0	0	0	0	11	1	0	0	4	0
Fish, seafood and their products	76	0	2	24	67	0	25	0	1	46	12	0	8	16	4
Dairy products	20	0	2	0	9	0	0	0	0	3	0	0	0	0	0
Fats and oils	8	0	0	0	5	0	0	0	0	4	1	0	0	0	0
Beverages, alcoholic	8	Not detected in any samples													
Beverages, non-alcoholic	40	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Mixed dishes	48	0	0	0	10	0	20	0	0	27	8	1	0	6	0
Snack foods	4	0	0	2	0	0	0	0	1	1	1	0	0	0	0
Sugars and confectionery	8	0	0	0	2	0	0	0	0	1	0	0	0	0	0
Condiments, sauces and herbs	20	0	0	0	4	0	0	0	0	0	0	0	0	0	0
Total:	600	1	10	27	194	12	132	8	4	182	41	7	11	58	7
%:	100	<1	2	5	32	2	22	1	1	30	7	1	2	10	1

-Chlordecone was not detected in any sample.

Table 7: Dioxin and Dioxin-like PCB Contents in TDS Foods of the 1st HKTDS

TDS Food Item	Number of composite samples	% of test results < LOD	Mean (pg TEQ/g)	[range]#
Cereals and their products	24	45	0.021	[0.007- 0.058]
Meat, poultry and game and their products	24	23	0.091	[0.012 – 0.257]
Eggs and their products:	6	16	0.137	[0.020 – 0.302]
Fish and seafood and their products	38	20	0.44	[0.009 – 1.270]
Dairy products	10	57	0.021	[0.007- 0.072]
Fats and oils	4	33	0.094	[0.011 – 0.282]
Beverages, non-alcoholic	6	58	0.011	[0.007 – 0.015]
Mixed dishes	22	40	0.018	[0.007 – 0.039]
Others	8	53	0.013	[0.008 – 0.030]
Total	142	34		

Notes:

As less than 60% of results are below limits of detection (LODs), half of LOD is used for all results less than LOD in calculating the concentrations.

Table 8: Ranges (lower bound and upper bound) of dietary exposure estimates to the OCPs for the average and high consumers of the Hong Kong population in year 2011- 2014

OCPs	Dietary exposure estimate (µg/kg bw/day) * #	
	Average	High consumer
Aldrin+Dieldrin	0.0003-0.0059	0.0012-0.0096
Chlordane	0.0002-0.0142	0.0010-0.0230
DDT	0.0238-0.0399	0.0912-0.1099
Endosulfan	0.0085-0.0166	0.0258-0.0359
Endrin	0.0010-0.0091	0.0021-0.0145
Heptachlor	0-0.0084	0-0.0136
HCB	0.0024-0.0048	0.0052-0.0084
HCH (α,β,γ and δ)	0.0008-0.0120	0.0023-0.0195
Lindane (γ-HCH)	0.0001-0.0029	0.0002-0.0046
Mirex	0-0.0028	0.0001-0.0045
PeCB	0.0003-0.0030	0.0008-0.0049
Toxaphene	0.0002-0.0171	0.0011-0.0276
Dioxins and Dioxin-like PCB (pg TEQ/kg bw/day)	0.7307	1.9983
PBDE	0.00134	0.0029

* Figures for dietary exposure estimates were rounded to four and one decimal places, respectively; the daily dietary exposure of dioxin and dioxin-like PCB was calculated from the monthly dietary exposure with an assumption of 30 days per month.

Values of “0” denote < 0.00005 µg/kg bw/day for dietary exposure estimates.

Note: Chlordecone was not detected in any sample so dietary exposure estimation was not conducted.

2.3.4 Human Body Burden of POPs

2.3.4.1 Human Breast Milk

POPs in the environment can enter the food chain, bio-accumulate and bio-magnify as they move up the trophic levels and ultimately end up in the human body. It is expected that POPs will continue to accumulate in the body fat and their average concentration will increase with age. Levels of POPs in human blood/serum and breast milk are good indicators of their body burden. As human breast milk could be obtained by non-intrusive method, it is a more common and acceptable method for testing human body burden of chemicals compared to the other two types of indicators. A summary of POPs contamination in breast milk of Hong Kong mothers is presented in **Table 9**.

Initial POPs

4 academic studies conducted by HKBU (Tsang, H. L., et al., 2011), HKU (Hedley, A.J., et al., 2010) and CUHK (Wong, T.W., et al., 2010 and 2013) covered all the 12 initial POPs with the concentration levels in human milk. The data from Wong, T.W., et al. (2010 and 2013) of CUHK were originally a government-funded research study. This government-funded research study was reference to WHO/UNEP (2007) Guidelines for Developing a National Protocol of Fourth WHO – Coordinated Survey of Human Milk for POPs in Cooperation with UNEP, in which lactating mothers were selected based on several requirements, such as (a) age, (b) primiparae, (c) healthy, (d) exclusively breastfeeding one child (i.e. no twins), and (e) residing length in Hong Kong. Jointly provided from the 2 studies from CUHK and HKBU, the ranges of the contamination levels of DDT and PCB in human milk were 129.9 – 4,507 μg/kg lw and BDL – 93 μg/kg lw respectively. The most recent value of dioxin-like PCB (3.79 pg TEQ/g lw) was measured by CUHK (Wong, T.W., et al.,) in 2013, which recorded a decreased value compared with the previous value (4.67 pg TEQ/g lw) in the HKSARIP 2006. A similar decrease can be also found in the recent data for PCDD/PCDF (7.48 pg TEQ/g lw) in the human milk reported in the CUHK studies in 2013 while comparing with the previous reported level (8.25 pg TEQ/g lw).

The 8 other types of initial POPs that were not covered in the HKSARIP 2006 were also studied in these 4 recent academic studies, and except for aldrin, heptachlor, and endrin which were all below the detection limits, chlordane, dieldrin, HCB, mirex and toxaphene could be detected in the human milk with a contamination level range of 2.4 – 9.4, 0.5 – 3.04, 9.53 – 136.77, 0.52 – 6.85 and 0 – 2.5 μg/kg lw respectively.

Newly Listed POPs

7 out of the 11 newly listed POPs, except chlordecone, HBB and PFOS as well as HBCD, were also identified with contamination levels in human milk by these academic studies. In which, the contamination levels of endosulfan investigated by Wong, T.W., et al., in 2010 and 2013 respectively

were both below detection limits, while the detected ranges of α-HCH, β-HCH, γ-HCH, PeCB and PBDE were 0.2 – 8.38, 45 – 1,380, BDL - 2, 0.49 – 1.3 and 1.7 – 4.2 μg/kg lw respectively.

2.3.4.2 Human Blood Plasma

Contamination levels of the concerned POPs in human blood were not studied in the HKSARIP 2006 as a human body burden of POPs. For recent studies, two local academic studies both conducted by HKBU in 2011 and 2013 respectively (Qin, Y.Y., et al., 2011 and Wong H. S., et al., 2013) on 5 of the concerned POPs, including DDT (1,120 μg/kg lw), HCB (1.5-49.5 μg/kg lw), PCB (110 μg/kg lw), α-HCH (206 μg/kg lw) and PBDE (5.56 μg/kg lw) showed a similar figure that was identified on POPs in the human breast milk. A summary of POPs contamination in blood plasma of Hong Kong citizens is presented in **Table 10**.

Table 9: Levels of POPs Contamination in Breast Milk of Hong Kong Citizens reported in the Period 2009-2013

Chemical	Human Breast Milk Concentration [a] (μg/kg lw)	Reference
Aldrin	BDL (age: mean 27.2; range 20 – 29)	Wong, T.W., et al., 2010
Chlordane	4.9 (2.4-9.4) (age: mean not given; range 17 – 42)	Hedley, A. J., et al., 2010
DDT	53.6 (129.9 – 1,847.7) (age: mean 27.2; range 20 – 29)	Wong, T.W., et al., 2010
	3,099 (2,098 – 4,507) (age: mean 33.8; range 25 – 44)	Tsang, H.L., et al., 2011
Dieldrin	1.27 (0.5 – 3.04) (age: mean 27.2; range 20 – 29)	Wong, T.W., et al., 2010
	1.36 (0.7 – 2) (age: mean not given; range 17 – 42)	Hedley, A. J., et al., 2010
Endrin	BDL (BDL – 0.14) (age: mean 27.2; range 20 – 29)	Wong, T.W., et al., 2010
	BDL (age: mean not given; range 17 – 42)	Hedley, A. J., et al., 2010
Heptachlor	BDL (age: mean 27.2; range 20 – 29)	Wong, T.W., et al., 2010
	0.9 (0.8 – 1) (age: mean not given; range 17 – 42)	Hedley, A. J., et al., 2010
HCB	22.34 (9.53 – 136.77) (age: mean 27.2; range 20 – 29)	Wong, T.W., et al., 2010
	20.84 (17 – 27) (age: mean not given; range 17 – 42)	Hedley, A. J., et al., 2010
Mirex	1.71 (0.52 – 6.85) (age: mean 27.2; range 20 – 29)	Wong, T.W., et al., 2010
	1.3 (no range provided) (age: mean not given; range 17 – 42)	Hedley, A. J., et al., 2010

Chemical	Human Breast Milk Concentration [a] (µg/kg lw)	Reference
Toxaphene	1.6 (no range provided) (age: mean 27.2; range 20 – 29)	Wong, T.W., et al., 2010
	0.74 (0 – 2.5) (age: mean not given; range 17 – 42)	Hedley, A. J., et al., 2010
PCB*	PCB: 24.1 (no range provided) Dioxin-like PCB: 3.28 (no range provided) (age: mean 27.2; range 20 – 29)	Wong, T.W., et al., 2010
	PCB: 49 (BDL – 93) (age: mean 33.8; range 25 – 44)	Tsang, H.L., et al., 2011
	Dioxin-like PCB: 3.79 (2.93 – 5.07) (age: mean 29.6; range 25 – 37)	Wong, T.W., et al., 2013
PCDD* PCDF*	6.56 (no range provided) (age: mean 27.2; range 20 – 29)	Wong, T.W., et al., 2010
	7.48 (6.56 – 8.32) (age: mean 29.6; range 25 – 37)	Wong, T.W., et al., 2013
α-HCH	1.17 (0.2-8.38) (age: mean 27.2; range 20 – 29)	Wong, T.W., et al., 2010
	0.7 (0.5 – 1) (age: mean not given; range 17 – 42)	Hedley, A. J., et al., 2010
β-HCH	221.82 (45 - 792.9) (age: mean 27.2; range 20 – 29)	Wong, T.W., et al., 2010
	1133 (606 – 1380) (age: mean not given; range 17 – 42)	Hedley, A. J., et al., 2010
Chlordecone	-	-
HBB	-	-
γ-HCH	BDL (BDL – 0.64) (age: mean 27.2; range 20 – 29)	Wong, T.W., et al., 2010
	0.94 (BDL – 2) (age: mean not given; range 17 – 42)	Hedley, A. J., et al., 2010
PeCB	0.8 (0.49 – 1.3) (age: mean 27.2; range 20 – 29)	Wong, T.W., et al., 2010
PFOS, PFOSF	-	-
C-octaBDE C-pentaBDE	PBDE: 4 (1.7 – 4.2) (age: mean not given; range 17 – 42)	Hedley, A. J., et al., 2010
Endosulfan	BDL (BDL – BDL) (age: mean 27.2; range 20 – 29)	Wong, T.W., et al., 2010
	BDL (BDL – BDL) (age: mean not given; range 17 – 42)	Hedley, A. J., et al., 2010
HBCD	-	-

*: Unit of PCDD/PCDF/dioxin-like PCB = pg TEQ/g lw

a: Detection limits of aldrin, endrin, heptachlor, and endosulfan in human milk = 1 µg/kg lw; Detection limits of PCB and γ-HCH = 0.5 µg/kg lw.

Table 10: Mean Levels of POPs Contamination in Human Blood of Hong Kong Citizens for the Period 2011-2013

Chemical	Human Blood Plasma Concentration (µg/kg lw)
Aldrin	-
Chlordane	-
DDT	1,120 (308.25-2,749)
Dieldrin	-
Endrin	-
Heptachlor	-
HCB	1.5-49.5
Mirex	-
Toxaphene	-
PCB*	110 (245.4-254)
PCDD*	-
PCDF*	-
α-HCH	206
β-HCH	-
Chlordecone	-
HBB	-
γ-HCH	-
PeCB	-
PFOS, PFOSF	-
C-octaBDE	PBDE: 5.56 (4.52-16.54)
C-pentaBDE	
Endosulfan	-
HBCD	-

*: Unit of PCDD/PCDF/dioxin-like PCB = pg TEQ/g lw

2.4 Analysis of POPs Information Gaps

2.4.1 Environmental Levels of POPs

2.4.1.1 <u>Contamination Levels of POPS in Environmental Media</u>

Among the five categories of environmental media, ambient air and surface soil contain a comparatively more complete set of data on the Convention POPs, though several POPs (e.g. endosulfan and HBCD) were not shown to have monitoring data in the past decade. Moreover, not all 23 concerned POPs were routinely monitored in the ambient air, surface water and surface sediment. In particular, local data on POPs in fresh water and river sediment are limited, while that in vegetation (ground vegetation and tree bark) are particularly lacking.

2.4.1.2 Contamination Levels of POPs in Aquatic Biota

DDT is identified as the POP being the most frequently studied among all categories of aquatic biota. The contamination levels of the 12 initial POPs (DDT and PCB in particular) in local marine fish and shellfish had been well studied, yet only HCH, PFOS/PFOSF and PBDE among the 11 new POPs have been studied. Limited data of contamination levels of POPs in freshwater fish, local water birds and marine mammals were available.

2.4.2 Dietary Exposure to POPs

To better understand the local food consumption pattern and to assess the overall dietary exposure of the local population to POPs, a population-based local food consumption survey and The First Hong Kong Total Diet Study were conducted by FEHD from 2005 to 2007 and from 2010 to 2014 respectively. However, as the study involved many types of common locally consumed mixed food items (e.g. steamed barbecued pork bun, hamburger, raisin bread, and turnip cake), the analysis for the contamination level of POPs in individual food category (e.g. meat, poultry, cereal, vegetable) could not be clearly distinguished. Besides, not all 23 Convention POPs were adequately analyzed in all food categories. Among the 11 new POPs, only HCH, chlordecone, PeCB and endosulfan were studied while the data of the remaining seven POPs were unavailable.

2.4.3 Human Body Burden of POPs

Local data on the local contamination levels of 19 POPs in breast milk of lactating mothers were well documented in two recent studies of Hong Kong residents, but there is no available data for Chlordecone, HBB, PFOS/PFOSF, and HBCD. Research data on DDT, PCB, PCDD and PCDF are especially enriched in local academic studies. There is limited data available for the contamination levels of POPs in human blood.

2.5 Environmental and Human Health Risk Assessment of POPs

2.5.1 Human Health Risk Assessment

2.5.1.1 Human non-carcinogenic risk assessment

Results of assessment of non-carcinogenic risk associated with exposure of local residents to POPs in the locally consumed food items and the ambient air are presented in **Table 11.** The calculated hazard quotients (HQs) of all the POPs with the necessary information available under the Stockholm Convention were well below unity, indicating that there was no unacceptable non-carcinogenic risk of toxicological significance associated with a lifetime exposure of local residents to the current levels of POPs contamination in locally consumed food items and the ambient air. The estimated level of exposure of local residents to dioxins/furans (0.73 pg TEQ kg^{-1} bw d^{-1} or 21.9 pg TEQ kg^{-1} bw $month^{-1}$, assuming negligible intake via the drinking water route) was below the provisional tolerable monthly intake (PTMI) of 70 pg TEQ kg^{-1} bw $month^{-1}$, which was set by the Joint FAO/WHO Expert Committee on Food Additives (2001). Dietary exposure was the major route, accounting for 98.6% of total exposure to dioxins/furans, while inhalation exposure accounted for only 1.4%.

Table 11: Human Non-carcinogenic Risk Assessment of POPs in Hong Kong in 2002-2013

Chemical	Daily intake (mg kg^{-1} bw day^{-1})			Reference dose (RfD)/ tolerable daily intake (TDI) (mg kg^{-1} bw d^{-1})[e]	Hazard quotient (total daily intake/ RfD or TDI)
	Dietary[b]	Inhalation[c,d]	Total		
Aldrin	5.90×10^{-6}	2.88×10^{-10}	5.90×10^{-6}	3.00×10^{-5}	<1
Chlordane	1.42×10^{-5}	1.33×10^{-9}	1.42×10^{-5}	5.00×10^{-4}	<1
DDT	3.99×10^{-5}	3.51×10^{-9}	3.99×10^{-5}	5.00×10^{-4}	<1
Dieldrin	5.90×10^{-6}	1.50×10^{-9}	1.50×10^{-9}	5.00×10^{-5}	<1
Endrin	9.10×10^{-6}	1.73×10^{-10}	9.10×10^{-6}	3.00×10^{-4}	<1
Heptachlor	8.40×10^{-6}	6.88×10^{-10}	8.40×10^{-6}	5.00×10^{-4}	<1
HCB	4.80×10^{-6}	1.29×10^{-8}	4.81×10^{-6}	8.00×10^{-4}	<1
Mirex	2.80×10^{-6}	1.53×10^{-9}	2.80×10^{-6}	2.00×10^{-4}	<1
Toxaphene	1.71×10^{-5}	BDL	1.71×10^{-5}	-	-
PCBs	-	5.5×10^{-9}	5.5×10^{-9}	2.00×10^{-5}	<1
Dioxins/ furans[a]	0.72	0.01	0.73 (monthly intake = 21.9 pg TEQ kg^{-1} bw $month^{-1}$)	Provisional tolerable monthly intake = 70 pg TEQ kg^{-1} bw $month^{-1}$	<1
α-HCH	1.20×10^{-5}	6.39×10^{-10}	1.20×10^{-5}	-	-
β-HCH		6.71×10^{-10}		-	-
Chlordecone	-	BDL	-	3.00×10^{-4}	-
HBB	-	BDL	-	-	-
Lindane	2.90×10^{-6}	9.56×10^{-10}	2.90×10^{-6}	3.00×10^{-4}	<1
PeCB	3.00×10^{-6}	1.41×10^{-9}	3.00×10^{-6}	8.00×10^{-4}	<1
PFOS, PFOSF	-	1.19×10^{-9}	1.19×10^{-9}	-	-
PBDE[f]	1.34×10^{-6} (Total PBDE) 7×10^{-8} (BDE-99, penta- only)	1.26×10^{-8} (Total PBDE) 5×10^{-9} (BDE-99, penta- only	1.35×10^{-6} (Total PBDE) 7.5×10^{-8} (BDE-99, penta- only)	1.00×10^{-4} (BDE-99, penta- only)	<1 (BDE-99, penta- only)
Endosulfan	1.66×10^{-5}	4.13×10^{-8}	1.66×10^{-5}	6.00×10^{-3}	<1
HBCD	-	-	-	-	-

[a] Unit for daily intake/RfD/TDI of dioxins/furans = pg TEQ kg^{-1} bw d^{-1}. The provisional tolerable monthly intake (PTMI) of 70 pg TEQ/kg bw per month, set by the Joint FAO/WHO Expert Committee on Food Additives (2001), is used for dioxins/furans.

[b] Dietary intake estimated based on the measurements of contamination levels of POPs in various types of foods conducted by the Centre for Food Safety (CFS) of Hong Kong. Marker PCB in ambient air was detected through 7 cogeners – 28, 52, 101, 118, 138, 153 and 180. PBDE levels in ambient air are based on Wang, W., et. al. 2014; chlordecone and HBB levels are based on the EPD Investigation Study 2013.

[c] Assuming a respiratory rate of 20 min^{-1} and a tidal volume of 600 ml, for an average adult of 60 kg bw.

[d] "BDL" indicated that the values were below detection limits; detection limits of toxaphene, chlordecone and HBB in ambient air = 0.3, 0.002 and 0.016 pg/m^3 respectively.

[e] Data from USEPA Integrated Risk Information System (IRIS) database, except for dioxins/furans (TDI from WHO1998). The TDI of PCB has been determined from the Lowest Observed Adverse Effect Level (LOAEL) of one specific PCB mixture, Aroclor 1254.

[f] Only BDE-99 (one congener of penta-BDE) has a RfD value available therefore this congener was used to determine hazard quotient.

2.5.1.2 Human carcinogenic risk assessment

Results of assessment of dietary and inhalation carcinogenic risks associated with exposure of local residents to POPs in the locally consumed food items and the ambient air are presented in **Table 12**. The calculated dietary or inhalation or total excess lifetime cancer risks of POPs all fell within the $1 \times 10^{-4} – 1 \times 10^{-6}$ range, indicating there was no unacceptable dietary or inhalation or total cancer risk of toxicological concern associated with a lifetime exposure of local residents to the current levels of POPs contamination in the locally consumed foods and the ambient air. The total excess lifetime cancer risk is the sum of the excess lifetime dietary cancer risk (= daily intake x slope factor) and excess lifetime inhalation cancer risk (= mean ambient air concentration x inhalation unit risk).

Table 12: Human Carcinogenic Risk Assessment of POPs to the Residents of Hong Kong

Chemical	USEPA Cancer Classification[b]	Dietary			Inhalation				Total Excess Lifetime Cancer Risk	Acceptable Range of Excess Lifetime Cancer Risk (USEPA)
		Daily Intake (mg kg^{-1} bw d^{-1})	Slope Factor[d] (per (mg/kg)/ day)	Excess Lifetime Cancer Risk	Mean Ambient Air (pg/m^3) (Dioxin: pg I-TEQ/m^3)	Daily Intake[e] (mg kg^{-1} bw d^{-1})	Unit Risk[d] (per $\mu g/m^3$)	Excess Lifetime Cancer Risk		
Aldrin	B2	5.90×10^{-6}	1.70×10^{1}	1.00×10^{-4}	1	2.88×10^{-10}	4.90×10^{-3}	4.90×10^{-9}	1.00×10^{-4}	$1 \times 10^{-4} – 1 \times 10^{-6}$
Chlordane	B2	1.42×10^{-5}	3.50×10^{-1}	4.97×10^{-6}	4.61	1.33×10^{-9}	1.00×10^{-4}	4.61×10^{-10}	4.97×10^{-6}	$1 \times 10^{-4} – 1 \times 10^{-6}$
DDT	B2	3.99×10^{-5}	3.40×10^{-1}	1.36×10^{-5}	12.19	3.51×10^{-9}	9.70×10^{-5}	1.18×10^{-9}	1.36×10^{-5}	$1 \times 10^{-4} – 1 \times 10^{-6}$
Dieldrin	B2	5.90×10^{-6}	1.60×10^{1}	9.44×10^{-5}	5.21	1.50×10^{-9}	4.60×10^{-3}	2.40×10^{-8}	9.44×10^{-5}	$1 \times 10^{-4} – 1 \times 10^{-6}$
Endrin	D	9.10×10^{-6}	-	-	0.6	1.73×10^{-10}	-	-	-	-
Heptachlor	B2	8.40×10^{-6}	4.50×10^{0}	3.78×10^{-5}	2.38	6.88×10^{-10}	1.30×10^{-3}	3.09×10^{-9}	3.78×10^{-5}	$1 \times 10^{-4} – 1 \times 10^{-6}$
HCB	B2	4.80×10^{-6}	1.60×10^{0}	7.68×10^{-6}	44.88	1.29×10^{-8}	4.60×10^{-4}	2.06×10^{-8}	7.70×10^{-6}	$1 \times 10^{-4} – 1 \times 10^{-6}$
Mirex	2B[c]	2.80×10^{-6}	-	-	5.3	1.53×10^{-9}	-	-	-	-
Toxaphene	B2	1.71×10^{-5}	1.10×10^{0}	1.88×10^{-5}	BDL	BDL	3.20×10^{-4}	-	1.88×10^{-5}	$1 \times 10^{-4} – 1 \times 10^{-6}$
PCB	B2	-	4.00×10^{-1}	-	Dioxin-like : 0.003	5.5×10^{-9}	1.00×10^{-4}	-	-	$1 \times 10^{-4} – 1 \times 10^{-6}$
Dioxins/ furans[a]	B2	0.72	1.00×10^{5}	7.2×10^{-5}	0.044	0.01	3.30×10^{1}	1.45×10^{-6}	7.35×10^{-5}	$1 \times 10^{-4} – 1 \times 10^{-6}$
α-HCH	B2	1.20×10^{-5}	6.30×10^{0}	7.56×10^{-5}	2.22	6.39×10^{-10}	1.80×10^{-3}	4.00×10^{-9}	7.56×10^{-5}	$1 \times 10^{-4} – 1 \times 10^{-6}$
β-HCH	C		1.80×10^{0}	2.16×10^{-5}	2.33	6.71×10^{-10}	5.30×10^{-4}	1.23×10^{-9}	2.16×10^{-5}	$1 \times 10^{-4} – 1 \times 10^{-6}$
Chlordecone		-	10	-	BDL	BDL	-	-	-	-
HBB		-	-	-	BDL	BDL	-	-	-	-
Lindane		2.90×10^{-6}	-	-	3.32	9.56×10^{-10}	-	-	-	-
PeCB	D	3.00×10^{-6}	-	-	4.88	1.41×10^{-9}	-	-	-	-
PFOS, PFOSF		-	-	-	4.12	1.19×10^{-9}	-	-	-	-
PBDE	D	1.34×10^{-6}	-	-	43.8	1.26×10^{-8}	-	-	-	-
Endosulfan		1.66×10^{-5}	-	-	143.53	4.13×10^{-8}	-	-	-	-
HBCD		-	-	-	-	-	-	-	-	-

[a]Unit for daily intake of dioxins/furans = pg I-TEQ kg^{-1} bw d^{-1}.

[b]USEPA Weight-of-Evidence Cancer Classification System (B2 = probable human carcinogen; C = possible human carcinogen; D = not classifiable).

[c]International Agency for Research on Cancer (IARC) Cancer Classification (2B = possible human carcinogen).

[d]USEPA Integrated Risk Information System (IRIS) database.

[e]Assuming a respiratory rate of 20 min^{-1} and a tidal volume of 600 ml, for an average adult of 60 kg bw.

2.5.1.3 Health risk assessment of POPs in the local marine environment

The level of POPs contamination in marine fish and shellfish sampled in the local waters was examined against Food Safety Standards/Action Levels published by other regulatory authorities (**Table 13**). The level of POPs contamination in marine fish and shellfish from Hong Kong waters was well below (by 1–2 orders of magnitude) the Food Safety Standards/ Action Levels set by the US, Mainland China and/or the European Community. The results indicated that there was no unacceptable risk of toxicological concern associated specifically with a lifetime exposure of local residents to the current level of POPs contamination in the local marine environment via dietary intake of locally caught seafood (marine fish and shellfish).

Table 13: Comparison of the Level of POPs Contamination in Marine Fish and Shellfish sampled in Hong Kong Waters

Chemical	**Mean concentration (µg kg^{-1} ww)**		**Food safety standards / action levels**
	Marine fish	**Marine shellfish**	
Aldrin	0.06	0.11	300 (USFDA[b])
Chlordane	0.26	0.21	300 (USFDA[b])
DDT	4.12	3.27	5000 (USFDA[b]) 500 (PRC[c])
Dieldrin	0.04	0.09	300 (USFDA[b])
Endrin	0.06	BDL	-
Heptachlor	BDL	BDL	300 (USFDA[b])
HCB	BDL	BDL	-
Mirex	0.72	0.86	100 (USFDA[b])
Toxaphene	BDL	BDL	-
PCB[a]	Dioxin-like PCB: 0.08	Dioxin-like PCB: 0.13	500 (PRC[c])
Dioxins/ furans[a]	0.03	0.17	4 (EC[d])
α-HCH	0.08	0.11	-
β-HCH	0.04	BDL	-
Chlordecone	0.08	0.05	300 (USFDA[b])
HBB	2.1	0.8	-
Lindane	BDL	BDL	-
PeCB	BDL	BDL	-
PFOS, PFOSF	0.71	BDL	-
C-octaBDE	0.13	0.07	-
C-pentaBDE	0.38	0.57	-
Endosulfan	-	-	-
HBCD	-	-	-

[a]Unit for dioxins/furans and dioxin-like PCB = ng WHO-TEQ kg^{-1} ww

[b]USFDA Chemical Contaminant and Pesticide Action Levels, and Guidance Levels; unit = µg kg^{-1} ww.

[c]PRC Food Safety National Standard; unit = µg kg^{-1} ww.

[d]European Commission Seafood Standard for fish and fish products; unit = pg WHO-TEQ g^{-1} ww.

2.5.2 Comparison with other countries/regions

2.5.2.1 Annual Release of Dioxins/Furans

In 2012, the estimated annual release of dioxins/furans to the environment of Hong Kong via all vectors was 46.5 g TEQ. A comparison of the local annual dioxin/furan emission between the years of 2007 and 2013 with those of EU Regions (EEA, 2015), USA (USEPA, 2015), Switzerland (Bogdal, C., et al., 2014), Australia (Australia Government, 2014) and Iranian Provinces (Azari., M. R., et al., 2007) on a "per capital" basis was made, due to these countries and regions are also well economically developed (EU Regions, USA, Australia and Switzerland) or Asian country (Iranian Provinces).

Among the six countries/regions collected with annual dioxin/furan emission in **Table 14**, Hong Kong's total annual dioxin/furan release per capita was similar to Switzerland, USA, Australia and EU countries (i.e. in the same order of magnitude), but significantly lower than that of Iranian provinces.

Table 14 Comparison of annual emission of dioxin/furans in Hong Kong and Other Countries/Regions

Country/Region	Year	PCDD/PCDFs annual emission (g I-TEQ annual^{-1})	PCDD/PCDFs emissions per-capita (ng I-TEQ capita^{-1})
Hong Kong	2012	46.5	6,498
Switzerland	2011	64	8,030
USA	2013	1,372	4,403
Australia	2012	60	2,686
Iranian provinces	2007	1,282	16,997
EU countries	2012	1,771	3,581

2.5.2.2 Release of dioxins/furans in Ambient Air

Table 15 compares the reported ambient air concentrations of dioxins/furans in Hong Kong and other countries/regions worldwide. Overall, the mean local ambient air dioxin concentration of 0.044 pg I-TEQ m^{-3} measured in 2013 was highly comparable to the range reported in most other countries/regions such as Europe (Castro-Jimenez, J., et. al., 2011; Bruckmann, P., et. al., 2013; Ragazzi, M., et. al., 2014; Mari, M., et. al., 2008) Asia (Shin, S. K., et. al. 2011; Chi, K. H., et. al. 2008, 2013) and was lower than that reported in North Africa (Moussaoui, Y., et. al., 2012).

Table 15: Comparison of Ambient Air Concentrations of Dioxins/Furans (PCDD/PCDF) in Hong Kong and Other Countries/Regions

Location	Period	Concentrations of PCDD/PCDF (pg I-TEQ m^{-3}) mean (min-max)	Reference
Hong Kong	2013	0.044 (0.008-0.182)	EPD, EPD monitoring programme of POPs 2014
France	2007-2008	0.067-1.7	Castro-Jimenez, J., et. al., 2011
Germany	2011	0.017-0.024	Bruckmann, P., et. al., 2013
Italy	2009-2010	0.081 in Susa 0.061 in Torino	Ragazzi, M., et. al., 2014
North Africa	2009	0.21-0.78	Moussaoui, Y., et. al., 2012
South Korea	2008	0.028 (ND*-0.617)	Shin, S. K., et. al. 2011
Spain	2005-2006	0.018	Mari, M., et. al., 2008

*The values below the limit of detection (LOD, 0.05 pg m^{-3}) were noted as "ND" (not detected).

2.5.2.3 Release of PCB, α-HCH and Lindane in Ambient Air

Table 16 compares the reported ambient air concentrations of PCB, α-HCH and Lindane in Hong Kong and other countries/regions worldwide. Overall, the mean local ambient air PCB concentration of 0.003 pg WHO-TEQ m^{-3} (dioxin-like PCB) and 19.1 pg m^{-3} (Marker PCB) measured in 2013 was highly comparable to the range reported in most other locations in Asia (Hogarth, J. N., et. al., 2013; Shin, S. K., et. al. 2011), and was lower than that reported in Europe (Castro-Jimenez, J., et. al., 2011; Mari, M., et. al., 2008) and North Africa (Moussaoui, Y., et. al., 2012). The mean concentrations of α-HCH and lindane measured in 2014 in Hong Kong was much lower than North Africa (Moussaoui, Y., et. al., 2012).

Table 16: Comparison of Ambient Air concentrations of PCB, α-HCH and Lindane in Hong Kong and Other Countries/Regions

Location	Period	Concentration (pg m^{-3}) – mean (min-max)			Reference
		PCBs	α-HCH	Lindane	
Hong Kong	2013	Dioxin-like PCB*: 0.003 (0.002-0.008) Marker PCB*: 19.1 (7.2-42.8)	2.22 (0.85-6.6)	3.32 (0.65-13)	EPD, EPD monitoring programme of POPs 2014
France	2007- 2008	Dioxin-like PCB: 1-8 Indicator PCB: 11-87	-	-	Castro-Jimenez, J., et. al., 2011
Japan	2008	33-1125	-	-	Hogarh, J. N., et. al., 2013
North Africa	2009	Dioxin-like PCB: 0.04-0.15	16-888	106-974	Moussaoui, Y., et. al., 2012
South Korea	2008	Dioxin-like PCB#: 0.008 (ND-0.016)	-	-	Shin, S. K., et. al. 2011
Spain	2005- 2006	SAB area: 159 (62-127) BK area: 95 (62-127)	-	-	Mari, M., et. al., 2008

* Unit of Dioxin-like PCB in ambient air = pg WHO-TEQ/m^3; dioxin-like PCB in ambient air was detected by PCB with TEFs (12 congeners: 77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, and 189); marker PCB in ambient air was detected by 7 congeners: 28, 52, 101, 118, 138, 153, and 180.

Unit of Dioxin-like PCB in ambient air = pg WHO-TEQ/m^3; the values below the limit of detection (LOD, 0.05 pg m^{-3}) were noted as "ND" (not detected).

2.5.2.4 Surface Soil

Table 17 shows that the levels of PFOS contamination of surface soil in Hong Kong recorded in 2007–2013 was found to be lower than that reported in South Korea (Kim et al., 2014). As the levels for HBB, PeCB, PFOSF, PBDEs and endosulfan were all below the detection limit in Hong Kong (Zhang, H. B., et. al., 2007; EPD 2013 Investigation Study), a direct comparison with South Korea cannot be made.

Table 17: Comparison of the Level of POPs Contamination in Surface Soil of Hong Kong and Other Countries/Regions

Location	Period	HBB (µg/kg dw)	PeCB (µg/kg dw)	PFOS, PFOSF (µg/kg dw)	PBDE (µg/kg dw)	Endosulfan (µg/kg dw)	Reference
Hong Kong	2007-2013	BDL*	BDL*	PFOS: 0.197 (<0.3-0.624) PFOSF: BDL*	BDL*	BDL*	Zhang, H. B., et. al., 2007; EPD 2013 Investigation Study
South Korea	2010-2012	ND#	0.083 (ND#-0.531)	PFOS: 0.29 (ND#-0.92)	0.68 (ND#-4.78)	2.19 (0.058-8.42)	Kim, E. J., 2014

* "BDL" indicates values were below detection limits; Detection limits of PFOS and PFOSF in surface soil = 0.3 and 10 µg/kg dw, respectively; Detection limits of HBB, PeCB, C-octaBDE, C-pentaBDE and endosulfan in surface soil = 1, 0.1, 1, 0.1, 0.5, 1 and 7 µg/kg dw, respectively.

"ND" indicates values were below detection limits; Detection limits of PFOS and PFOSF in surface soil = 0.05 µg/kg dw; Detection limits of PBDE and endosulfan in surface soil = 0.01 and 0.02 µg/kg dw, respectively. The detection limits for HBB and PeCB were not provided in the reference paper

2.5.3 Ecological Risk Assessment

2.5.3.1 Pelagic organisms risk assessment

The calculated HQs for POPs, except DDT, were all below unity, indicating that there was no unacceptable risk of toxicological significance associated with exposure of local pelagic organisms to these POPs (**Table 18**). The mean concentration of DDT in marine water is slightly higher than the conservative screening chronic toxicity value, but significantly decreased from the level reported in the HKSARIP 2006 (<15 ng/L).

DDT was subject to further evaluation by the in-depth Tier 2 Probabilistic Risk Assessment (PRA). The conclusion published by Ma, S.W.Y., et al. in 2006 illustrated that the higher value of DDT (<15 ng/L) in ambient marine water was within a tolerable range by adopting the screening value of 1.4 ng/L. The results of the PRA indicated that the lower 5th centile of the estimated chronic DDT toxicity distribution was not exceeded by the upper 5th centile of aquatic DDT exposure distribution, suggesting the potential ecological risk posed by exposure of local pelagic organisms to DDT was within a tolerable range. The same conclusion can be also applied to a much lower value (1.9 ng/L) of DDT detected recently than in 2006, therefore, there is no significant ecological risk posed by exposure of local pelagic organisms to DDT.

Table 18: Tier 1 Ecological Risk Assessment of POPs to Pelagic Organisms in Hong Kong in 2009-2011

Chemical	Mean concentration in Hong Kong's marine water [b] (ng L^{-1})	Conservative screening chronic toxicity value (ng L^{-1})	Hazard quotient
Aldrin	<5	21.3[c]	<1
Chlordane	0.0418	88 [c]	<1
DDT	1.908	1.4 [c]	>1
Dieldrin	<5	22 [c]	<1
Endrin	<5	44 [c]	<1
Heptachlor	<5	68 [c]	<1
HCB	<5	600 [c]	<1
Mirex	<5	400 [d]	<1
Toxaphene	<5	43.2 [c]	<1
PCB	Total PCB: 0.356	7800 [c]	<1
Dioxins/ furans[a]	0.003	10 [e]	<1
α-HCH	0.119	-	-
β-HCH	0.246	7 [c]	<1
Chlordecone	<5	-	-
HBB	<5	-	-
Lindane	0.215	7 [d]	<1
PeCB	<5	-	-
PFOS, PFOSF	PFOS: 0.02 -12	-	-
C-octaBDE	0.041	-	-
C-pentaBDE	0.232	-	-
Endosulfan	0.0485	10 [d]	<1
HBCD	-	-	-

a Unit of PCDD/PCDF and dioxin-like PCB in marine/fresh water = pg WHO-TEQ/L.

b: The value reported Below Detection Limit was calculated assuming 0.5 Detection Limit.

c: The value represents LC_{50} divided by 50; LC_{50} = lethal concentration that kills 50% of the organisms under a specified time duration.

d; Value from ANZECC – Australian and New Zealand Guidelines for Marine Water Quality 2000.

e: Value from Human Health and Ecological Risk Assessment Work Plan (USEPA, 2004) and from Development of Aquatic Quality Standards for Dioxins (Final Report to the Department for Environment, Food and Rural Affairs, UK, 2003).

2.5.3.2 Benthic organisms risk assessment

The calculated HQs for all POPs in the marine sediment, against the range of published SQC/Guidelines, were <1 (**Table 19**). The mean contamination level of POPs in the marine sediment of Hong Kong generally fell at the lower end of the range of screening concentrations published in the SQC/Guidelines of the US, Canada and Australia/New Zealand. The results indicated that there would be unlikely to be any risk of toxicological significance associated with exposure of local benthic organisms to the current level of POPs in the marine sediment.

Table 19: Tier 1 Ecological Risk Assessment of POPs to benthic organisms in Hong Kong in 2009-2011

Chemical	Mean concentration in Hong Kong's marine sediment (µg kg^{-1} dw)[b]	Screening sediment quality criteria	Reference
Aldrin	0.164	9.5	NOAA, SQuiRTs™, AET[c]
Chlordane	0.135	4.50-8.87 0.5-6 0.5-6	Canadian Sediment Quality Guideline, ISQG to PEL[d] NOAA, SQuiRTs™, ERL to ERM[c] ANZECC ISQG, Low to high[e]
DDT	1.671	6.15-20.03 1.58-46.1 1.6-46	Canadian Sediment Quality Guideline, ISQG to PEL[d] NOAA, SQuiRTs™, ERL to ERM[c] ANZECC ISQG, Low to high[e]
Dieldrin	0.254	2.85-6.67 0.02-8 0.02-8	Canadian Sediment Quality Guideline, ISQG to PEL[d] NOAA, SQuiRTs™, ERL to ERM[c] ANZECC ISQG, Low to high[e]
Endrin	0.014	2.67-62.4 0.02-8	Canadian Sediment Quality Guideline, ISQG to PEL[d] ANZECC ISQG, Low to high[e]
Heptachlor	0.148	0.3 298	NOAA, SQuiRTs™, AET[c] Sediment Quality Criteria[f]
HCB	0.041	6	NOAA, SQuiRTs™, AET[c]
Mirex	0.471	96	Sediment Quality Criteria[f]
Toxaphene	BDL	0.1 43.2	Canadian Sediment Quality Guideline, ISQG[d] Sediment Quality Criteria[f]
PCB	Total PCB†: 0.15 Total PCB‡:18.36	34.1-277 22.7-180 23 237	Canadian Sediment Quality Guideline, ISQG to PEL[d] NOAA, SQuiRTs™, ERL to ERM[c] ANZECC ISQG, Low[e] Sediment Quality Criteria[f]
Dioxins/ furans[a]	PCDD/F†: 2.931 PCDD‡: 4.33 PCDF‡: 1.34	0.85-21.5 16.6	Canadian Sediment Quality Guideline, ISQG to PEL[d] Sediment Quality Criteria[f]
α-HCH	0.035	-	-
β-HCH	0.021	-	-
Chlordecone	BDL	-	-
HBB	0.002	-	-
Lindane	0.064	0.94-1.38 0.32-1	Canadian Sediment Quality Guideline, ISQG to PEL[d] ANZECC ISQG, Low to high[e]
PeCB	0.122	-	-
PFOS, PFOSF	PFOS: BDL PFOSF: BDL	-	-
C-octaBDE	0.089	-	-
C-pentaBDE	0.077	-	-
Endosulfan	7.08	-	-
HBCD	-	-	-

[a] Unit for dioxins/furans = ng I-TEQ kg^{-1} dw.

[b] The average organic carbon content in Hong Kong marine sediments is approximately 0.8% (2004 data); 1% is assumed for ease of calculation and comparison in this table.

[c] US National Oceanic and Atmospheric Administration (NOAA) Sediment Guidelines, Screening Quick Reference Table for Organics (SQuiRTTM), 1999; AET = Apparent Effects Threshold; ERL = Effect Range Low; ERM = Effect Range Medium.

[d] Canadian Sediment Quality Guideline for Protection of Aquatic Life, 2002; ISQG = Interim Sediment Quality Guideline; PEL = Probable Effect Level.

[e] ANZECC recommended interim sediment quality guideline (ISQG) (normalized to 1% organic carbon), 2000; the ISQG low and high values correspond to the ERL and ERM used in the NOAA listing.

[f] Sediment quality criteria adopted in EPD's consultancy study ''A Study of Toxic Substances Pollution in Hong Kong, Agreement No. CE 22/99 (Environmental)''; unit for dioxins/furans = ng I-TEQ kg^{-1}.

†: Values from the Toxic Substances Monitoring Programme; and

‡: Values from the EPD 2013 Investigation Study

2.5.3.3 Marine mammals risk assessment

Results of the ecological risk assessment of POPs in the marine environment to local cetaceans (the hump-backed dolphins and the finless porpoises) showed the HQs for 8 initial and 7 newly listed POPs studied (chlordane, DDT, dieldrin, heptachlor, HCB, toxaphene, PCB and dioxins/furans, chlordecone, HBB, lindane, PeCB, C-octaBDE, C-pentaBDE and endosulfan) were all less than unity, suggesting that there was no unacceptable risk of toxicological significance associated with exposure of local cetaceans to the current contamination level of these POPs in the marine environment (**Table 20**). The adopted toxicity values pertain to terrestrial mammals as values for marine mammals could not be found from the literature, which is identified as information gaps.

Table 20: Ecological Risk Assessment of POPs to cetaceans in Hong Kong in 2010 - 2011

Chemical	Overall exposure dose (µg kg^{-1} bw d^{-1})		Adopted toxicity value (µg kg^{-1} bw d^{-1})	Hazard quotient (exposure dose / toxicity value)	
	Dolphin	Porpoise		Dolphin	Porpoise
Aldrin	4.23×10^{-3}	6.38×10^{-3}	-		
Chlordane	1.66×10^{-2}	1.76×10^{-2}	1.88×10^{1}	<1	<1
DDT	2.62×10^{-1}	2.77×10^{-1}	1.00×10^{2}	<1	<1
Dieldrin	2.93×10^{-3}	4.88×10^{-3}	6.25×10^{-1}	<1	<1
Endrin	4.16×10^{-3}	6.00×10^{-3}	-		
Heptachlor	3.25×10^{-3}	3.75×10^{-3}	1.25×10^{0}	<1	<1
HCB	3.25×10^{-3}	3.75×10^{-3}	1.00×10^{1}	<1	<1
Mirex	4.77×10^{-2}	5.93×10^{-2}	-		
Toxaphene	6.50×10^{-2}	7.50×10^{-2}	4.38×10^{1}	<1	<1
PCB	5.53×10^{-6}	7.88×10^{-6}	6.25×10^{0}	<1	<1
Dioxins/ furans	2.86×10^{-6}	7.50×10^{-6}	1.25×10^{-4}	<1	<1
α-HCH	5.40×10^{-3}	7.13×10^{-3}	-	-	-
β-HCH	2.50×10^{-3}	2.44×10^{-3}	-	-	-
Chlordecone	5.01×10^{-3}	4.88×10^{-3}	8×10^{2}	<1	<1
HBB	1.28×10^{-1}	1.09×10^{-1}	2×10^{3}	<1	<1
Lindane	1.63×10^{-3}	1.88×10^{-3}	3.3×10^{2}	<1	<1

Chemical	Overall exposure dose ($\mu g\ kg^{-1}\ bw\ d^{-1}$)		Adopted toxicity value ($\mu g\ kg^{-1}\ bw\ d^{-1}$)	Hazard quotient (exposure dose / toxicity value)	
	Dolphin	Porpoise		Dolphin	Porpoise
PeCB	3.25×10^{-3}	3.75×10^{-3}	8.3×10^{3}	<1	<1
PFOS, PFOSF	4.19×10^{-2}	2.85×10^{-2}	-	-	-
C-octaBDE	8.06×10^{-3}	7.50×10^{-3}	4.5×10^{2}	<1	<1
C-pentaBDE	2.59×10^{-2}	3.56×10^{-2}	3.5×10^{2}	<1	<1
Endosulfan	-	-	6×10^{2}	-	-
HBCD	-	-		-	-

3 STRATEGIES, PRIORITIES, ACTION PLANS AND IMPLEMENTATION PROGRESS

3.1 POPs Management Framework and Implementation Strategy

- Update the Pesticides Ordinance and HCCO as and when necessary to ensure that all amendments to Annexes to the Convention are properly incorporated, with the view to effectively controlling, minimizing and preventing the potentially adverse impact of POPs on human health and the environment.

- Uphold the principle of environmental sustainability in pursuing community development, and apply best available techniques (BAT) / best environmental practices (BEP) to reduce environmental pollution by POPs.

- Continue with our structured monitoring programme to characterize and quantify the local POPs emission profile which is vital to the planning and development of a practical and successful action plan to reduce or ultimately eliminate POPs.

3.2 Overall Assessment of Current POPs Pollution in Hong Kong

- On a “per capita” basis, the current (2012) annual dioxin/furan release in Hong Kong was generally similar to similar to Switzerland, USA, Australia and EU countries, but significantly lower than that of Iranian provinces.

- The mean local ambient air dioxin concentration measured in 2013 was highly comparable to the range reported in most other countries/regions such as Europe (France, Germany, Italy, Spain) and Asia(South Korea).

- Assessment based on available data indicated that overall, there was unlikely to be any unacceptable ecological risk of toxicological significance associated with exposure of local marine life to the current level of POPs contamination in the marine environment of Hong Kong.

- Total monthly exposure of local residents to dioxins/furans was estimated to be 21.9 pg TEQ/kg bw/month, a value falling at the lower end of the provisional tolerable monthly intake (PTMI) of 70 pg TEQ/kg bw per month set by the Joint FAO/WHO Expert Committee on Food Additives (2001). Dietary intake was the major route, accounting for 98.6% of total exposure of local residents to dioxins/furans.

- Results of human health risk assessment indicated that there was no unacceptable inhalation nor dietary chronic/carcinogenic risk of toxicological concern associated with a lifetime exposure of Hong Kong residents to current levels of POPs contamination in the local environment and locally consumed foods.

- Levels of POPs in local marine biota were found to be well below national and overseas Food Safety Standards/Action Levels of the Mainland, the US and the EC.

3.3 Action Plans and Implementation Progress

3.3.1. Strengthening of the Institutional and Regulatory Systems

A summary of action items on institutional and regulation systems to meet the Stockholm Convention requirements and their implementation progress is presented in **Action Plan 1**.

Action Plan 1 - Legislative Framework for POPs Management and Control

No.	Action Item	Responsible Party	Implementation Progress
	POPs Pesticides		
1.	To review the overall pesticide control system in Hong Kong.	AFCD	• The Pesticides Ordinance (Cap 133) was amended in 2013 to include new provisions to ensure full compliance with the requirements of the Stockholm Convention on the control of POPs pesticides and the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade. • The amended legislation came into operation on 27 January 2014.
	Non-Pesticide POPs		
2.	To enact new legislation to regulate the import, export, manufacture and use of non-pesticide hazardous chemicals in Hong Kong.	EPD	• The Hazardous Chemicals Control Ordinance (HCCO) (Cap 595) came into operation on 1 April 2008. • In view of the listing of 5 non-pesticide new POPs under the Stockholm Convention in May 2009 and the acceptance of the listing by China in December 2013, EPD amended the HCCO and the amendment order has come into operation starting from 1 January 2015.

3.3.2. Validation and Refinement of the POPs Inventories

The compilation of a robust and reliable POPs inventory is vital to the planning and development of practical and relevant action plans to effectively reduce and ultimately eliminate POPs in Hong Kong. **Action Plan 2** summarizes the list of action items and their implementation progress to fill critical data gaps identified in the current POPs inventories, including the dioxin/furan source inventory, environmental levels of POPs contamination, dietary exposure to POPs and human body burden of POPs.

Action Plan 2 - Validation and Refinement of the POPs Inventories

No.	Action Item	Responsible Party	Implementation Progress
	Source Inventories on POPs - Release of Unintentional POPs as by-Products		
3.	To establish a more representative local annual activity and emission level of the "aluminium production" process.	EPD	• Study of a local factory was completed and a locally derived emission factor made available in October 2006. EPD has updated the dioxin emission inventory using this local emission factor for aluminium production process.
4.	To further analyze sewage effluent and sewage sludge at source.	EPD	• Further study on field sampling and laboratory analysis of toxic substances for effluent, sludge and treated landfill leachate in landfills and sewage treatment works was commissioned in October 2011 and completed in June 2012.
5.	To collate information on local stormwater production and analyze the stormwater for level of dioxin/furan contamination.	EPD	• EPD conducted baseline information gathering survey for the 3-year-cycle Toxic Substances Monitoring Programme (TSMP) from 2004 to 2012 and collected stormwater samples from 8 locations around Hong Kong. EPD will continue to collect storm water samples from 3 of the above 8 locations every 3 years for comparison with the baseline data, starting from the fourth cycle (i.e. 2013 to 2015).
6.	To analyze local livestock waste composting and establish a local dioxin/furan emission factor specific trade.	EPD	• Study was completed in February 2007. Local emission factor was available for the update of local POPs inventory.
7.	To further study the composition and fate of boiler ash residues generated from coal fired power boilers plants.	EPD	• Study was completed in February 2008. Local emission factor was available for the update of local POPs inventory.
8.	To control the PFOS/ PFOSF containing aqueous film forming foam	EPD	• EPD requested proper storage of the foam and conducted regular monitoring of PFOS/PFOSF levels in the environment. • The disposal of PFOS/PFOSF containing foam is controlled by the Waste Disposal Ordinance.

No.	Action Item	Responsible Party	Implementation Progress
	Environmental Levels of POPs - POPs in Local Environmental Media and Aquatic Biota		
9.	To include all 12 Convention POPs in the routine monitoring programme for local ambient air.	EPD	• EPD has regularly monitored ambient air levels of dioxins, furans and PCB in Hong Kong since mid-1997. In view of the listing of 10 new POPs under the Stockholm Convention in May 2009 and May 2011, we have worked with the Government Laboratory and commenced regularly monitoring of organochlorine pesticides in January 2011 with a view to including other POPs in our reporting programme in phases.
10	To include all 12 Convention POPs (dioxins/furans in particular) in the routine monitoring programme for local marine water, sediment and biota.	EPD	• Starting from the second cycle of the TSMP (2007-2009), all 12 Convention POPs have been included in the test list for local marine water, sediment and biota samples. • Since 2011, 9 more new POPs have been added to the monitoring list and thus EPD has regularly increased the number of POPs monitor for local marine water, sediment and biota to 21
11.	To conduct further studies of POPs in local water birds on a project basis	AFCD	• The Study was finalized in October 2007. The final report was forwarded to EPD in November 2008.
12.	To conduct further studies of POPs in local marine mammals on a project basis	AFCD	• The Study on Tissue Analyses and Ecological Risk Assessment for Marine Mammals in Hong Kong was finalized in October 2009.
13.	To monitor the level of POPs contamination in local inland water and river sediment on a project basis.	EPD	• EPD conducted baseline information gathering survey for the 3-year-cycle Toxic Substances Monitoring Programme (TSMP from 2004 to 2012 and collected inland water and sediment samples from 7 locations around Hong Kong. EPD will continue to collect inland water and sediment samples from 2 of the above 7 locations every 3 years for comparison with the baseline data, starting from the 4th cycle (i.e. 2013 to 2015),
14.	To monitor the level of POPs contamination in local surface soil and vegetation on a project basis	EPD	• Field sampling and laboratory analysis of POPs in local surface soil samples was commissioned in November 2009 and completed in March 2010.

No.	Action Item	Responsible Party	Implementation Progress
	Dietary Exposure to POPs – POPs Contamination in Locally Consumed Foods and Drinking Water, Food Consumption Patterns and Food Safety Standards/Action Levels		
15.	To include all 12 Convention POPs for analysis in all main locally consumed food groups in the routine food surveillance programme.	FEHD	• Eleven of the 12 Convention POPs (i.e., except toxaphene) are now included in the Food Surveillance Programme.
16.	To consider including all 12 Convention POPs in the routine drinking water surveillance programme.	WSD	• The surveillance program for the analysis of 12 Convention POPs in drinking water commenced in November 2006.
17.	To conduct the Hong Kong Population-based Food Consumption Survey commissioned by FEHD To conduct Total Diet Studies (TDS) in the future when additional resources are made available.	FEHD	• The results of the population-based food consumption survey were released in the CFS website in April 2010. • The food consumption data has been used for estimating the exposure of various nutrients and contaminants in many our risk assessment projects (e.g. Dietary Iodine Intake in Hong Kong Adults) as well as in the TDS for enhancing our understanding on the size of the risk from exposure to various contaminants and food additives and which population groups may be most at risk. Such information is vital for the Government in formulating public policies and education strategies to promote food safety in Hong Kong. • The reports on dioxins and dioxin-like PCB and polybrominated diphenyl ethers (PBDE) have been released in December 2011 and April 2012, respectively. • The laboratory testing for the other POPs in food, i.e. aldrin, dieldrin, endrin, chlordane, DDT, heptachlor, hexachlorobenzene (HCB), mirex and toxaphene, chlordecone, pentachlorobenzene, endosulfan, alpha-hexachlorocyclohexane, beta-hexachlorocyclohexane, and lindane has completed and the whole TDS project was completed in 2014.

No.	Action Item	Responsible Party	Implementation Progress
18.	To consider setting Food Safety Action Levels on POPs specific to Hong Kong	FEHD	• Reference to national and international food safety standards is made when considering food safety action levels. The action levels will be set, if necessary, subject to the findings of the Total Diet Study.
	Human Body Burden of POPs - Human Breast Milk and Blood/Serum		
19.	To participate in the 4th and subsequent WHO-Coordinated Survey of Human Milk for the 12 Convention POPs	DH	• Study on POPs level in human milk for Hong Kong population has been finalised in January 2011.
20.	To consider, taking into account international best practices, initiating measurements of POPs in the blood/serum of local residents on a project basis	DH	• Study to be considered later when resources are available.

3.3.3. Measures to Reduce Emission of Unintentionally Produced POPs

Article 5 of the Stockholm Convention calls for Parties to take measures to reduce the production and release of unintentionally produced POPs, i.e., dioxins/furans, and for BAT/BEP to be applied for new sources in the source categories identified in Part II of Annex C. In the HKSAR, all Annex C, Part II source categories identified, including incinerators (crematoria and chemical waste incineration works), aluminium (secondary) works and power plants, are Specified Processes subject to licensing control under the Air Pollution Control (Specified Processes) Regulations. Operators are required to implement best practicable means (BPM) to control and minimize air emission from their operations. The BPM set out minimum technical requirements for plant/process designs, work practices and emission standards. To ensure that the emission requirements are in line with the latest best international practice, the BPM will be reviewed from time to time and revised, as required, taking into consideration relevant international BAT/BEP guidelines including those of the Stockholm Convention on POPs. Any new development of the above source categories is also subject to a rigorous environmental impact assessment process under the EIAO.

Measures to reduce emissions of unintentionally produced POPs, i.e. dioxins/furans, and their implementation progress are summarized in **Action Plan 3**. These measures are being pursued as part of the HKSARG's environmental portfolio in accordance with the established timetable.

Action Plan 3 - Measures to Reduce Emission of Unintentionally Produced POPs

No.	Action Item	Responsible Party	Implementation Progress
	Emission of Dioxins/Furans to Air		
21.	To optimize the use of existing generating capacity of gas-fired power plants and to progressively phase out old coal-fired generation units and replace with gas-fired plants	EPD	• We promulgated in December 2010 and November 2012 and December 2014 the Second and Third and Fourth Technical Memorandum to further tighten the emission caps on the power sector from the 2010 emission caps level starting 2015, 2017 and 2019 respectively and in effect the power companies need to maximizing the use of their existing gas fired generation units and prioritizing the use of coal-fired generation units with retrofits to meet the tightened emission caps requirement. • For the long term strategy, we propose to revamp the energy mix to further increase the use of cleaner energy and reduce the reliance on coal generation by 2020.
22.	To tighten dioxin emission standards for crematoria under best practicable means and progressively phase out or replace old cremation units.	EPD / FEHD	• The revised guideline on the best practicable means for crematoria issued in September 2008 has tightened the dioxin/furan emission standard to 0.1ng I-TEQ/m^3 for new installations. Plans are being worked out to progressively replace the old cremators in public crematoria without causing major disruption of service. • Replacement work for the cremators in Wo Hop Shek Crematorium completed in late 2012. In addition, Phase 1 of replacement work for cremators in Cape Collinson Crematorium had been completed in late 2012 and Phase II be completed at about end of 2015.
23.	To introduce more stringent motor vehicle emission standards.	EPD	• We implemented the Euro V vehicle emission standards in phases starting from 1 June 2012. • All newly registered vehicles have to comply with Euro V emission standards starting from 31 December 2012. • Subject to the availability of compliant vehicle models, we will consider the timetable to implement Euro VI emission standards as soon as practicable.

No.	Action Item	Responsible Party	Implementation Progress
	Emission of Dioxins/Furans to the Marine Environment		
24.	To implement a territory-wide sewage improvement programme, including the Harbour Area Treatment Scheme (HATS) Stage 2A and upgrading of sewage treatment works	EPD	• With major works under the HATS Stage 2A completed in 2014, Stage 2A is expected to be commissioned in the third quarter of 2015 after the testing and commissioning progamme. • The construction of new sewage treatment works (STW) in Yung Shue Wan and Sok Kwu Wan of Lamma Island has commenced in 2010 for completion in 2014. • There are now plans to progressively expand and upgrade the regional STWs at Shek Wu Hui,Yuen Long, San Wai, Sha Tau Kok, Tuen Mun, Mui Wo, Tai O and Cheung Chau within the next five years.
	Integrated Environmental Waste Management		
25.	To implement integrated waste management in a sustainable and environmentally sound manner, including waste prevention and recycling as top priority and adoption of BAT and BEP to treat clinical waste, sewage sludge and unavoidable municipal solid waste	EPD	• “A Policy Framework for the Management of Municipal Solid Waste (MSW) (2005-2014)” was published in December 2005 to achieve sustainable waste management. • In May 2013, the "Hong Kong: Blueprint for Sustainable Use of Resources 2013-2022" (the Action Blueprint) was published. The Action Blueprint maps out a comprehensive strategy, targets, policies and action plans for waste management in Hong Kong for the coming 10 years, and it aims to reduce the per capita disposal rate of municipal solid waste (MSW) by 40 per cent by 2022. • The Government plans to build the first phase Integrated Waste Management Facilities (IWMF) with a daily capacity of 3,000 tonnes. Using advanced incineration as the core technology, the facility will reduce the volume of MSW treated by 90 per cent. The BAT and BEP would be adopted in designing and constructing the IWMF. We have commenced the tendering procedures for the project and plan to commission the facilities in 2022-23. • BAT and BEP will also be adopted in treating clinical waste and sewage sludge. A sewage sludge treatment facility (STF) with a capacity of 2,000 tonnes per day has been built at Tuen Mun. Sewage sludge from local sewage treatment plants has been diverted to the STF for high temperature incineration. All clinical waste has been collected for disposal by high temperature incineration at the designated Chemical Waste Treatment Centre (CWTC) starting from August 2011

3.3.4. Public Awareness Campaign

A summary of the action items to raise local public awareness of POPs-related issues and their implementation progress is presented in **Action Plan 4**.

Action Plan 4 - Public Awareness Campaign

No.	Action Item	Responsible Party	Implementation Progress
26.	To develop a dedicated POPs thematic website under EPD's website.	EPD	• EPD's thematic website on POPs was launched in May 2006 and updated in September 2014
27.	To produce POPs information pamphlets for distribution to the public, and to design exhibition panels for display in EPD's Environment Resource Centres and other appropriate venues.	EPD	• POPs publicity leaflets, posters and POPs thematic souvenirs were distributed to the public (students, adult visitors) through their visits to the Environment Resource Centres.
28.	To organize publicity events, education/training programmes and visits to various target groups on POPs-related themes and topics.	EPD	• POPs-related topics are included in the guided tours organized in the Environment Resource Centres. About 640 and 680 guided tours in 2013 and 2014 respectively covered topics related to POPs for primary and secondary students. • To celebrate the 10th anniversary of the signatory of the Stockholm Convention on Persistent Organic Pollutants (POPs) and to enhance public awareness on POPs, a "Roving Exhibition on Persistent Organic Pollutants" was held in 9 locations of Hong Kong from November 2011 to March 2012

3.3.5. Regional Collaboration with the Mainland

Hong Kong is geographically located at the Pearl River Estuary. Sound and effective environmental management of environmental pollution of POPs must encompass the PRD Region as a whole. **Action Plan 5** presents the action items and their implementation progress for strengthening regional collaboration with the Mainland especially the PRD.

Action Plan 5 - Regional Collaboration with the Mainland

No.	Action Item	Responsible Party	Implementation Progress
29.	To organize regional technical workshops and training seminars on POPs monitoring and analytical protocols, and risk assessment methodologies.	EPD/GL	• With EPD's coordination, GL participated in the Asian component of the "First Worldwide UNEP Intercalibration Study on Persistent Organic Pollutants" organized by the Chemicals Branch of UNEP. GL's representatives attended a project inception workshop in Beijing in April 2009. The project final workshop was held in February 2010 in Hong Kong. • A POPs Workshop was organized and held on 10-11 April 2012 in Hong Kong with participants from Pan-PRD provincial and municipal environmental authorities and various local academics.
30.	To conduct joint regional POPs monitoring programme on a project basis.	EPD/GL	• A pilot joint project on the analysis of POPs in water/sediment samples in Deep Bay was completed successfully by EPD/GL and SZ Environmental Monitoring Centre (SZEMC) / SZ Centre for Disease Control in 2009. • EPD and SZEMC also collaborated on the development and refinement of dioxin inventory in both places and joint regional dioxin monitoring prgramme at SZ and HK was held in September 2012. SZEMC and HKEPD exchanged the dioxin monitoring data in April 2013 for review.

3.3.6. Capacity Building

To achieve the objectives of the HKSARIP, the following capacities would need to be built up and/or strengthened within the HKSAR. The action items and their implementation progress are summarized in **Action Plan 6.**

Action Plan 6 - Capacity Building

No.	Action Item	Responsible Party	Implementation Progress
31.	To improve legislative and management systems for comprehensive and effective POPs control in Hong Kong.	EPD/AFCD	• The Pesticides Ordinance (Cap 133) and the Hazardous Chemicals Control Ordinance (Cap 595) have been enacted to set out legislative and management systems for comprehensive and effective POPs control in HKSAR.

No.	Action Item	Responsible Party	Implementation Progress
32.	To promote BAT/BEP in local community activities, industrial processes and public utilities.	EPD	• It is an ongoing process to review from time to time the best practicable means (BPM) guidelines on combustion related processes and the dioxin/furan control. Requirements would be revised, as necessary, in line with "Guidelines on Best Available Techniques and Provisional Guidance on Best Environmental Practices relevant to Article 5 and Annex C" of the Stockholm Convention on Persistent Organic Pollutant. • The dioxin/furan control requirements of the BPM guidelines for major emitting sources like crematoria, various types of waste incinerators, secondary steel production (Electric Arc Furnace) and cement production have been updated accordingly. The BPM guidelines for asphalt concrete production are being reviewed.
33.	To enhance local POPs monitoring and analytical capabilities, in close collaboration with the local academia and commercial laboratories.	EPD/GL	• The Government Laboratory is one of POPs laboratories under the UNEP Databank of Laboratories Analysing Persistent Organic Pollutants and participated the Inter-calibration Study for POPs laboratories - Asia Region in 2009
34.	To update the POPs database and refine the POPs inventories.	EPD	• EPD has commissioned a study to review the contamination levels of the 5 non-pesticide new POPs under the Stockholm Convention. The study assessed the levels of new POPs in our environment. The study was completed in May 2013.

3.3.7. Implementation Plan Review and Effectiveness Evaluation

Articles 15 and 16 of the Stockholm Convention call for periodic progress/effectiveness review of a National Implementation Plan and reporting to the Conference of the Parties. The HKSARIP has included action plans to control/restrict the import, export, manufacture and use of the intentionally produced POPs, to reduce dioxin/furan emission, and to improve local and regional control and management of POPs. The effectiveness of implementing these action plans has been evaluated based on the annual records of local import/export/manufacture/use activities, reports of routine monitoring and *ad hoc* studies of POPs in the local environment and foods, and human body exposure. The data generated have been used to update and refine the HKSAR's POPs inventories which are instrumental to a science-based re-assessment of our local POPs situation during the review years. The HKSAR Reports, which includes the updated POPs inventories and the HKSARIP Effectiveness Review, were provided to CPG to form part of the PRC's National Report to the Conference of the Parties in 2008 and 2014.

The HKSARIP will be reviewed and the POPs inventories updated at periodic intervals as determined by the CPG according to relevant provisions of the Stockholm Convention.

- END -

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