STOCKHOLM CONVENTION

Protecting human health and the environment from persistent organic pollutants

THIRD REGIONAL MONITORING REPORT ASIA-PACIFIC REGION

UNDER THE STOCKHOLM CONVENTION ARTICLE 16 ON EFFECTIVENESS EVALUATION

GLOBAL MONITORING PLAN FOR PERSISTENT ORGANIC POLLUTANTS

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PREFACE

Persistent organic pollutants (POPs) are a group of chemicals that have toxic properties, resist degradation in the environment, bioaccumulate through food chains and are transported long distances through moving air masses, water currents and migratory species, within and across international boundaries. POPs belong to three main groups, however some of the chemicals fit into more than one of these three general categories:

- pesticides used in agricultural applications[*]
- industrial chemicals used in various applications[†]
- chemicals generated unintentionally as a result of incomplete combustion and/or chemical reactions[‡].

Twelve POPs were initially listed in the Stockholm Convention (shown in bold font in footnotes). In general, these 'legacy' POPs were first produced and/or used several decades ago, their persistence, bioaccumulative properties and potential for long-range transport are well studied, and they have been globally banned or restricted since 2004. Eighteen additional chemicals have been listed in the Annexes of the Convention since, bringing the total number of POPs to thirty as of January 2020 (the meetings of the Conference of the Parties at which the listing of the chemicals took place are indicated in parenthesis in footnotes).

Article 16 of the Stockholm Convention requires the Conference of the Parties to evaluate periodically whether the Convention is an effective tool in achieving the objective of protecting human health and the environment from persistent organic pollutants. This evaluation is based on comparable and consistent monitoring data on the presence of POPs in the environment and in humans, as well as information from the national reports under Article 15 and non-compliance information under Article 17. The global monitoring plan for POPs, which has been put in place under the Convention, is a key component of the effectiveness evaluation and provides a harmonized framework to identify changes in concentrations of POPs over time, as well as information on their regional and global environmental transport.

While monitoring activities are ongoing in the frame of the global monitoring plan (GMP), every six years the information generated is collected, compiled and analyzed in monitoring reports (regional and global). The first two phases of the GMP have been implemented during the period 2004-2017, with two sets of regional monitoring reports and global reports developed to date in the frame of the GMP and have informed the effectiveness evaluation under Article 16 of the Convention. The GMP Data Warehouse has been made operational during the second GMP phase and continued to support the regional organization groups in the work for the collection, processing, storing and presentation of monitoring data during the third phase of implementation of the GMP.

The present (third) monitoring report is synthesizing information from the first, the second and the third phase of the global monitoring plan and presents the most up-to-date findings on POPs

[*] aldrin, chlordane, chlordecone (COP-4, 2009), dichlorodiphenyltrichloroethane (DDT), dicofol (COP-9, 2019), dieldrin, endosulfan (COP-5, 2011), endrin, heptachlor, hexachlorobenzene (HCB), gamma-hexachlorocyclohexane (γ-HCH, lindane) and by-products of lindane [alpha-hexachlorocyclohexane (α -HCH) and beta-hexachlorocyclohexane (β -HCH)] (COP-4, 2009), pentachlorophenol, its salts and esters (COP-7, 2015) mirex, toxaphene.

[†] tetra- and pentabromodiphenyl ethers (PBDEs) (COP-4, 2009), hexa- and heptabromodiphenyl ethers (PBDEs) (COP-4, 2009), decabromodiphneyl ether (COP-8, 2017), hexabromocyclododecane (HBCD) (COP-6, 2013), hexabromobiphenyl (COP-4, 2009), hexachlorobutadiene (COP-7, 2015), perfluorooctane sulfonic acid (PFOS), its salts and perfluorooctane sulfonyl fluoride (PFOS-F) (COP-4, 2009), perfluorooctanoic acid (PFOA), its salts and PFOA-related compounds (COP-9, 2019), pentachlorobenzene (PeCB) (COP-4, 2009), polychlorinated biphenyls (PCBs), polychlorinated naphthalenes (PCNs) (COP-7, 2015), short-chain chlorinated paraffins (SCCPs) (COP-8, 2017).

[‡] Hexachlorobenzene (HCB), hexachlorobutadiene (COP-8, 2017), pentachlorobenzene (PeCB) (COP-4, 2009), polychlorinated naphthalenes (PCN) (COP-7, 2015), polychlorinated biphenyls (PCBs) and polychlorinated dibenzo-*p*-dioxins (PCDDs) and dibenzofurans (PCDFs).

concentrations in the Asia-Pacific Region. While the first and the second monitoring reports, presented at the fourth and seventh meeting of the Conference of the Parties respectively, provided information as to the changes in concentrations of the chemicals initially listed in the Convention, as well as baseline information on some of the newly listed POPs, this third report builds on the increasing information base of POPs monitoring data and provides a further in-depth assessment of the changes measured over time in POPs concentrations, including time trends where available, as well as recent baseline information on the more recently listed POPs.

ABBREVIATIONS AND ACRONYMS

ACF	Active carbon fiber felt
ALRT	Atmospheric long-range transport
AMAP	Arctic monitoring and assessment programme
BCF	Bioconcentration factor
CEE	Central and Eastern Europe
COP	Conference of the Parties
CTD	Characteristic travel distance
DDD /DDE	Metabolites of DDT
DDT	Dichlorodiphenyltrichloroethane
dl-PCBs	Dioxin-like PCBs
EMEP	Co-operative program for monitoring and evaluation of the long-range transmission of air pollutants in Europe
GAPS	Global atmospheric passive sampling survey
GEF	Global environment facility
GMP	Global monitoring plan
HBCD	Hexabromocyclododecane
HCB	Hexachlorobenzene
HCBD	Hexachlorobutadiene
HCHs	Hexachlorocyclohexanes
HPLC	High performance liquid chromatography
HRGC	High resolution gas chromatography
HRMS	High resolution mass spectrometry
HV	High volume sir sampler
HxBB	Hexabromobiphenyl
IADN	Integrated atmospheric deposition network
I-TEQ	International toxicity equivalence
Kaw	Air/water partition coefficient
Koa	Octanol/air partition coefficient
Kow	Octanol/water partition coefficient
LOD	Limit of detection
LOQ	Limit of quantification
LRT	Long-range Transport
MDL	Minimum detectable level
ND	Not detected
OCPs	Organochlorine pesticides
PAHs	Polycyclic aromatic hydrocarbons
PBDEs	Polybrominated diphenyl ethers
PCA	Pentachloroanisole
PCBs	Polychlorinated biphenyls
PCDDs	Polychlorinated dibenzo- p-dioxins
PCDFs	Polychlorinated dibenzofurans
PCNs	Polychlorinated naphthalenes
PCP	Pentachlorophenol
PeCBz	Pentachlorobenzene
PFHxS	Perfluorohexane sulfonate
PFOA	Perfluorooctanoate
PFOS	Perfluorooctane sulfonate
PFOSF	Perfluorooctane sulfonyl fluoride
POPs	Persistent organic pollutants

POPsEA	POPs Monitoring Project in East Asian Countries
PTS	Persistent toxic substances
PUF	Polyurethane foam
QA/QC	Quality assurance and quality control
QFF	Quartz fiber filter
RECETOX	Research Centre for Environmental Chemistry and Ecotoxicology
ROGs	Regional Organization Groups for the Global Monitoring Plan
SCCPs	Short-chain chlorinated paraffins
SOP	Standard Operating Procedure
t	Tonnes
TCDD	Tetrachlorodibenzo-*p*-dioxin
TEQ	Toxicity equivalents
UNEP	United Nations Environment Programme
UNU-IAS	Unite Nations University – Institute for the Advanced Study of Sustainability
WHO	World Health Organisation
XAD	Styrene/divinylbenzene-co-polymer resin

GLOSSARY OF TERMS

Activity	Any program or other activity or project that generates data or information on the levels of POPs in the environment or in human that can contribute to the effectiveness evaluation under Article 16 of the Stockholm Convention.
CTD	The characteristic travel distance– defined as the “half-distance” for a substance present in a mobile phase.
IL-1	Instrumentation level 1 capable to analyze PCDD/PCDF and dioxin-like PCBs at ultra-trace concentrations: must be a high-resolution mass spectrometry in combination with a capillary column.
IL-2	Instrumentation level capable to analyze all POPs: (capillary column and a mass-selective detector).
IL-3	Instrumentation level capable to analyze all POPs without PCDD/PCDF and dioxin like PCBs (capillary column and an electron capture detector).
IL-4	Instrumentation level not capable to do congener-specific PCBs analysis (no capillary column, no electron capture detector or mass selective detector).
Intercomparisons	Participation in national and international intercalibration activities such as ring-tests, laboratory performance testing schemes, etc. LOD Limit of detection. Definition: The lowest concentration at which a compound can be detected; it is defined as that corresponding to a signal three times the noise.
<LOD	Results below the limit of detection.
LOQ	Limit of quantification. Definition: The lowest concentration that can quantitatively be determined is three times higher than LOD.
<LOQ	Result below limit of quantification. Compounds found at levels between LOD and LOQ can be reported as present, or possibly as being present at an estimated concentration, but in the latter case the result has to be clearly marked as being below LOQ.
MDL	Method detection limit. The MDL considers the whole method including sampling, sample treatment and instrumental analysis, including the blank levels in field (sampling)/during transport and storage/in the laboratory (clean-up and analysis).
Phase I	Activities to support the Article 16 effectiveness evaluation that will be conducted by the Conference of the Parties at its fourth meeting, information collected from 2000 to 2008.
Phase II	Activities to support the Article 16 effectiveness evaluation that will be conducted by the Conference of the Parties at its seventh meeting, information collected from 2009 to 2014.
Phase III	Activities to support the Article 16 effectiveness evaluation that will be conducted by the Conference of the Parties at its tenth meeting, information collected from 2015 to 2019.

EXECUTIVE SUMMARY

Overview of the region

Asia-Pacific Region is located in tropical, sub-tropical, temperate and sub-arctic climate area, with many countries under the strong influence of the monsoon climate. The region is characterized by huge agricultural and industrial activities to support large number of people, about 58% of the world population. Many countries in the Region have historically used POPs, *e.g.*, DDT for vector control and PCBs for industrial use. Some POPs are still used as a specific exemption in agricultures, fisheries and industries. In this Region, there are 63 countries/states, out of which 51 countries are either of ratification, acceptance, approval or accession to the Stockholm Convention on POPs. Most countries in the Region are developing countries or countries with their economies in transition.

Description of contributing programs

In the Asia-Pacific Region, several international and national POPs monitoring programs on air and human milk are available. For the air, passive sampling was conducted in the POPs Global Monitoring Plan in Asia and Pacific sub-regions (UNEP/GEF GMP2 programs in Asia and in Pacific Islands). In POPs Monitoring Project in East Asian Countries (POPsEA project), active sampling was operated in seven countries (Japan, Republic of Korea, Cambodia, Indonesia, Lao PDR, Malaysia, and Thailand). In China and Japan, some national ambient POPs air monitoring programs are performed. For human milk, Cambodia, Mongolia, Thailand, Vietnam, Fiji, Kiribati, Marshall Islands, Niue, Palau, Samoa, Solomon Islands, and Vanuatu participated in WHO human milk monitoring programs in East Asia and Pacific Islands. China and Japan also have some national POPs monitoring programs on human milk and/or blood.

However, it should be noted that only a few countries in the Region reported the POPs data. Some countries have been collecting POPs data for longer and more intensively than others, but most countries have not.

The data in this report was mainly collected over the period between 2014 and 2019. However, some earlier data related to the historical importance were presented and briefly described. The data was submitted through focal point of each Party and evaluated by the ROG members based on the information on analytical procedure, QA/QC protocol, etc. In addition to data on core media, the monitoring data on non-core media, such as soil and biota, were also collected as supplementary data and briefly discussed.

In the newly established monitoring programs, the methods for sampling and analysis of POPs in the air and human samples were conducted in principle in accordance with “Guidance on the Global Monitoring Plan for Persistent Organic Pollutants”. However, for the data reported and published earlier, various methods for sampling and analysis of POPs have been applied. Most POPs analyses described in the report involved series of QA/QC programs. Due to the difference of analytical procedures, however, the criteria of QA/QC and data validation from various countries were sometimes different.

Main findings

This Regional Report will cover the main findings in Asia-Pacific Region in two major categories: (1) the POPs classes listed in Stockholm Convention, and (2) POPs in key media. Compared to previous two reports, this report covers more data from POPsEA project or UNEP/GEF GMP2 programs in Asia and in Pacific Islands. Generally, the report provides adequate monitoring data for POPs in ambient air and human milk from some part of the region. Comprehensive spatial and temporal data on POPs monitoring are only available in few countries in the Region, *e.g.,* China, Japan and Republic of Korea.

Some countries are currently developing their programs on the monitoring and inventories, while others still lack of capacity for POPs monitoring. Because monitoring data do not exist in most countries to enable the assessment of long-range transport of POPs in the Region, substantial effort will be needed to fill the data and technical gaps in the Region.

A) Initial POPs and temporal trend

Temporal trend of POPs level is based on the data collected over the period between 2014 and 2019, compared to those gathered in the 1st and 2nd Asia-Pacific Regional Monitoring Reports. The concentration of chemical substance in the environment is expected to decrease after the establishment of relevant regulations. For initial POPs, it has been a while since many countries have already regulated its use, and the changes in the concentration in the environment has become smaller. On the other hand, for the new POPs, significant change in environmental concentration is expected to be seen after the implementation of regulation.

Air

In East Asia, the data show fairly large variations, due to seasonal changes of temperatures as well as prevailing wind directions as the result of Asian Monsoon. However, clear decreasing trends of total DDTs as well as isomers and their metabolites are observed at the two background stations, Hedo Okinawa and Gosan Jeju, during GMP-2 and GMP-3 period (2009 - 2018), suggesting the decrease of newly released DDT in the East Asian sub-region. Oxychlordane and *cis*-heptachlor epoxide showed statistically significant decrease in Okinawa as well as in Jeju Island, while the trends in other isomers of chlordanes and heptachlors did not show clear trend (Okinawa) or rather increased (Jeju). PCBs showed statistically significant increase in Okinawa (but not in Jeju).

Generally, the levels of PCDD/PCDFs, indicator PCBs and HCB in background air in China have been reduced significantly since 2014. From the national POPs monitoring program in Japan, decreasing trends were identified in PCBs, DDTs, some isomers of chlordanes and heptachlors, and (PCDD/PCDFs + *dl*-PCBs).

Human tissue

Total concentrations of PCDD/PCDFs and *dl*-PCBs in human breast milk in Japan tended to decline over time during 1998 - 2015. The decreasing speed of total dioxins slowed down in recent years (2011 – 2015), and individual levels for PCDD/PCDFs and *dl*-PCBs also followed this trend. The median concentration of PCDD/PCDFs and *dl*-PCBs in blood in the 2011 – 2016 survey was found to decrease compared to the 2002 – 2010 surveys in Japan.

In Fiji, PCDD/PCDFs levels do not show clear trends from 2002 to 2019, while *dl*-PCBs, indicator PCBs and DDTs (6 isomers) show the decreasing tendencies. In Kiribati, the trends of PCDD/PCDFs, *dl*-PCBs, indicator PCBs, and DDTs (6 isomers) in human breast milk show decreasing tendencies from 2006 to 2018.

Water and other media

Generally, many of POPs in surface water, sediment and biota showed the decreasing trends from 2002 to 2018 in Japan. Significant decreasing trend was observed in the concentrations of total PCBs, HCB, some of DDTs, cis-chlordane and cis-heptachlor epoxide in surface water. The concentrations of total PCBs, HCB, aldrin, dieldrin and some of chlordanes in sediment also decreased during this period. Moreover, inter-annual trend of decrease can be found in the levels of PCBs and some of DDTs in bivalves, and some of DDTs in fishes.

B) New POPs listed at COP4, COP5 and COP6

Air

In the Chinese national monitoring program, endosulfan, HBB, HCHs PBDEs, PeCBz were monitored. Japan also analyzed the new POPs including chlordecone, endosulfan, HBB, HBCDs, HCHs, PBDEs, PeCBz, and PFOS in ambient air throughout the nation (35 to 37 sites) since 2010. Among them, statistically significant declines were observed in some of HCHs, tetraBDEs, and PFOS.

In POPsEA, chlordecone, endosulfan, HBCDs, HCHs, PBDEs, PeCBz and PFOS were monitored in the air at background sites, Cape Hedo, Okinawa Island (from 2009) and Fukue, Goto Islands (from 2014). Among them, all the isomers of HCHs showed statistically significant decline. PFOS and PeCBz seemed to increase, though not significant statistically, at Hedo. In Fukue, on the other hand, PeCBz and α-/β-endosulfans showed statistically significant decline. Republic of Korea monitored chlordecone, endosulfans, HCHs, PBDEs, PeCBz in air at a regional background site, Jeju Island from 2013 to 2018. Among them, BDE-47 and BDE-99 showed statistically significant decline. In POPsEA project, a single year monitoring was conducted at Cambodia, Lao People's Democratic Republic, Malaysia and Thailand from 2014 to 2017, in which PeCBz and HCHs were monitored.

Human tissue

From 2017 to 2019, HCHs, chlordecone, endosulfan, HCBDs, PBDEs and PeCBz were monitored in WHO human breast milk survey involving twelve countries (Cambodia, Mongolia, Thailand, Vietnam, Fiji, Kiribati, Marshall Islands, Niue, Palau, Samoa, Solomon Islands, and Vanuatu). From 2013 to 2014, PeCBz and PBDEs were analyzed in human milk in Macao SAR, China.

Based on the result of trend analysis using GMP Data Warehouse (DWH), statistically significant decreasing trend was observed for PFOS concentrations in blood during FY2008 and FY2016 in Japan.

Water

PFOS in water was analyzed in the national monitoring programs of China and Japan. PFOS concentrations in Taihu Lake in 2019 decreased significantly from that in 2013. In Japanese national monitoring, statistically significant decline was observed in lake waters.

Other media

New POPs, including chlordecone, endosulfan, HBB, HCHs, PBDEs and PeCBz, were analyzed in water, sediment and biota collected throughout the nation of Japan. The decreasing trend can be found in the concentrations of α-/β-/γ-HCH in surface water, α-/γ-HCH in sediment and bivalves. The level of α-HBCD in fishes also followed this trend. Moreover, PFOS in marine sediments have shown the reduction tendency.

C) New POPs listed at COP7, COP8 and COP9

Air

Japan has already focused on the analysing the new POPs including dicofol, HCBD, PCNs, PCP, PFOA and SCCPs in ambient air throughout the nation since FY2013. POPsEA project also monitored HCBD, PCNs, PCP, PFOA and SCCPs in the background air at Cape Hedo (Okinawa Island) and Fukue (Goto Islands). Although no statistically significant trends were identified in any of the new POPs by the statistical tool in DWH, clear increase of HCBD levels were observed in both background sampling sites as well as many of national sampling sites from Spring 2017.

Human tissue

From 2017 to 2019, dicofol, HBCD, PCP, PCA and SCCPs have been monitored in WHO human breast milk survey involving twelve countries (Cambodia, Mongolia, Thailand, Vietnam, Fiji, Kiribati, Marshall Islands, Niue, Palau, Samoa, Solomon Islands, and Vanuatu).

Based on the result of trend analysis, statistically significant decreasing trend was not observed for PFOA concentrations in blood during FY2008 and FY2016 in Japan.

Other media

Some types of new POPs, including HCBD, PCA, PCNs, PCP, PFHxS, PFOA and SCCPs were analyzed in water and sediment in Japan. HCBD, dicofol, PCA, PCNs, PCP, PFOA and SCCPs were monitored in biota. Statistically significant decrease was observed in the concentrations of PFOA in river and river mouth sediments.

D) Summary on measurements of POPs in air

In the Pacific and East Asian sub-regions, there are some monitoring data on ambient air for the effectiveness evaluation. On the other hand, such data sets are lacking in South and West Asian sub-regions.

The UNEP/GEF GMP2 programs have been conducted in Asia and Pacific sub-regions. POPs monitoring in the background air by passive samplers were conducted. The data provided baselines for assessing the effectiveness in these sub-regions.

In China, 11 remote sampling sites, 3 rural and 3 urban sampling sites were selected, and PM_{10} high volume sampling was carried out to analyze POPs, and 2 to 6 sites were selected for the monitoring of some POPs in ambient air in Hong Kong SAR and Macao SAR of China from 2014 – 2019.

Japan has been monitoring POPs in the air by high volume sampler throughout the nation since 1997 for dioxins, and since 2002 for other POPs. For some POPs, the frequency of the monitoring was reviewed and were decided to be monitored once in a few years since 2009. Japan has also participated in POPsEA project. Air sample is collected and analyzed at Cape Hedo (Okinawa Island) and Fukue (Goto Islands), which are background sites, since 2009 and 2014, respectively.

The POPsEA project has also monitored POPs in the air with high volume sampler in Republic of Korea, Cambodia, Indonesia, Lao PDR, Malaysia and Thailand from 2014 to 2018. Republic of Korea conducted background air monitoring at a regional background site, Jeju Island, every month from 2009 to 2018 (except 2014).

Generally, the reported levels of POPs varied considerably from country to county, from site to site, but occasionally showed statistically significant trends. Particularly for DDTs, or at least some isomers of DDTs, statistically significant decrease in many monitoring programs, including POPsEA at Hedo, Fukue, and Jeju Islands, and Japanese national monitoring program was observed, supporting the view that input of DDTs in East Asian environment is clearly decreasing in recent years. The reported data provided relevant information of POPs in some countries. However, some POPs were not detected either because the levels were really low or the detection limits of analytical method were not low enough, which might provide difficulty for future comparison. Also, some data were collected in particular period of the year as a snapshot, and more data will be necessary for the discussion of the long-range transport.

E) Summary on measurements of POPs in human milk/blood

In Asia-Pacific Region, there is generally less information available on the levels of POPs in the human tissues than those in air.

As part of the UNEP/GEF GMP2 programs in East Asia and Pacific Islands, human breast milk sampling was conducted in Cambodia, Mongolia, Thailand, Vietnam (East Asia), Fiji, Kiribati, Marshall Islands, Niue, Palau, Samoa, Solomon Islands, and Vanuatu (Pacific Islands). The pooled samples in each country were analyzed for contents of both initial and newly added POPs.

Among the countries, Fiji and Kiribati had three or more temporal data, which apparently showed decreasing tendencies in PCDD/PCDFs, *dl*-PCBs and DDTs. Although more data are needed to assess statistical significance, the data clearly showed the important role of WHO human breast milk monitoring to support effectiveness evaluation of the Convention particularly in developing countries.

POPs concentrations in human milk in Japan were reported by the research supported by a governmental research grant from 2013 to 2018. In Japan, a project conducted by the Ministry of Environment to monitor POPs in human blood since 2002. From 2013 to 2016, the project targeted PCDDs, PCDFs, *dl*-PCBs, PFOS, PFOA and PFHxS.

While the trend data in Japan showed clear decline of dioxins (PCDD/PCDFs+*dl*-PCBs), PCBs and some other POPs levels in recent decades, more data are needed in Asia-Pacific Region to provide information for future evaluation.

F) Measurements and levels of POPs in water and other media

In Asia-Pacific Region, little information was available on the levels of POPs in media other than air and human milk/blood. Generally, data in the other media are much less than those in air.

In the Chinese national monitoring program, PFOS has been analyzed in bays and lakes. The PFOS concentrations in Qinghai Lake was lower than the detection limit in both 2013 and 2019. The PFOS concentrations in water from Taihu Lake in 2019 decreased significantly compared with that in 2013. The PFOS level in marine water of Hong Kong SAR of China was largely below the reporting limit in 2014 to 2018.

In Japan, PFOS and PFOA in the waters (river, estuary, coastal and lake) was monitored throughout the nation since 2009. What’s more, Japan have been continuously monitored POPs in water, groundwater, sediment, soil and biota from 2013 to 2017. In Japanese national monitoring, statistically significant decreasing trends were reported on other media from 2002 to 2018, including total PCBs, HCB and dieldrin in sediments in general, tetra- and pentaBDEs in river sediments, PFOS in marine sediments, PFOA in river and river mouth sediments, PCBs, some of DDTs, tetraBDE and α-/γ-HBCDs in bivalves, as well as some of DDTs and α-HBCD in fishes.

Long-range transport of POPs

Only some trends observed in the monitoring data in Asia-Pacific Region were studied due to the insufficient number of long-term regional monitoring programs or studies on POPs. Nevertheless, the back trajectory results of air monitoring data in East Asian Monitoring Programme provided some interesting trends and transport related information. Decreasing trends of DDTs and commercial pentaBDEs, as well as the increasing trends of HCBD were observed. Although the background monitoring stations were chosen with careful considerations on selection criteria, small scale industries, traffics and agricultural activities are designated stations on the islands. Therefore, determining the impact of local sources and long-range transportation is not easy. In this situation, a simple criterion of the effect of long-range transport is the identification of similar trends in different monitoring. In the case of HCBD, similar levels of its drastic increases are observed not only in Hedo, Okinawa, but also in Fukue, Nagasaki and in the Japanese national monitoring program within a same period in 2017. Similarly, a clear decreasing trend of DDTs, particularly *p,p’*-DDT and *o,p’*-DDT, are observed in Hedo, Okinawa and Gosan, Jeju as well as in measurements taken in the Japanese national monitoring program. These observations support the view that the temporal trends in HCBD and DDTs are the result of long-range transport, rather than the local effects (although national monitoring may also be affected by the local effects). Particularly, HCBD is volatile and belong to the highest CTD group among all POPs, and comparison of the observed data with other regions may provide us with more insight into the potential sources and their global transport.

Currently, the monitoring data are available only in East Asia and Pacific Islands. There is a strong need to establish environmental monitoring in the south, west and central Asia, and thus to expand the monitoring network to cover all Asia-Pacific regions. Further capacity building/enhancement activities in these regions as well as networking of existing monitoring activities are necessary for the implementation of the Convention.

Data gaps

China and Japan have been continuously monitoring POPs throughout the nation with well-established programs and facilities. However, other countries in Asia and Pacific Region still have limited facilities for POPs monitoring and inventory, especially for dioxins analysis. While the POPsEA project, the UNEP/GEF GMP2 programs, and the human milk program organized by WHO have successfully covered more countries and regions, number of POPs studies were still limited. In addition, specialists meeting the requirements of the knowledge and techniques for POPs analysis are still limited in the Asia-Pacific Region. Insufficient quality control and data validation were observed. It is suggested that in order to fill gaps and cover needs in the Asia-Pacific Region, further financial and technical supports on POPs monitoring should be provided according to articles 12 and 13 of the Convention, in addition to the continuation and further expansion of existing programs.

Conclusions and recommendations

Monitoring data on ambient air for the effectiveness evaluation of POPs levels in the East Asian and Pacific sub-regions were reported. However, no or limited data and information are available from South and West Asian sub-regions. Furthermore, studies on POPs in human tissues are mainly limited to human milk. There is very limited data of human blood over the region, primarily due to the poor availability of analytical facilities.

In Asian and Pacific Region, many countries do not have enough funding for the method development and transfer. Therefore, facilities for POPs analysis and monitoring are limited. In addition, the techniques and knowledge of many of the specialists in the region may need further enhancement to reach/surpass the standard levels to produce qualified data on POPs. In some cases, there is also insufficient monitoring of POPs, lack of programs of quality control. The current monitoring data are mostly available in East Asia and Pacific Islands. There is a strong need to establish environmental monitoring in the south, west and the middle Asia, and thus to expand monitoring network to cover all Asia-Pacific regions.

Therefore, further capacity building and program enhancement in Asia-Pacific Region are necessary for the implementation of the Convention.

A) Capacity building needs

Country representatives and ROG members assessed the capacity needed to monitor POPs in the regional counties through collection of information. China and Japan have comparatively well-established POPs monitoring systems within the Region. The Republic of Korea and Singapore also conducted POPs monitoring. The Republic of Korea submitted POPs monitoring data in Jeju Island as background data. Some other countries, such as Philippines, Thailand and Vietnam, are also developing POPs monitoring capabilities. Many other countries in the region, however, basically still lack capacity. Fiji started the air monitoring with passive sampling method more recently, but the monitoring highly depends on collaboration and knowledge sharing assistance. In addition, Fiji as well as other Pacific Islands currently have no facility for POPs inventory programs. However, there is still a long way to achieve an Asia-Pacific Monitoring System to provide timely and reliable data for GMPs and useful tools to support national and regional decisions on this important matter. The lack of capacity is also identified in most of the countries in the region. The difficulties involved in the lack of POPs monitoring capacity for most countries within the region include lack of funds and advanced technology as well as insufficient knowledge and training of technical groups. In particular, more resources are necessary for improving the analytical facilities and methods for the determination of POPs. In addition to analytical facilities and methods, more trained personnel should be employed for the daily operation of the instruments. To maintain or improve the analytical capability for POPs needs, good QA/QC among laboratories, including the regular use of reference standards and/or certified reference materials, training programs, inter-laboratory comparison exercise, and the identification of reference laboratories within the region for specific POPs, should be achieved.

Capacity building is not only needed for initial POPs, but also for new or emerging POPs analysis. To take PFASs as an example, most countries in Asia-Pacific Region currently do not have analytical facilities. While training and collaboration have been provided to some countries, even with the provisions of sampling equipment and consumables, laboratories analyses were conducted outside Asia-Pacific Region through collaborations. For example, there are currently no operational POPs laboratories in the Pacific Islands countries during the project implementation period on PFASs. Fiji started PFASs analysis in late 2019 with the assistance of the University of Queensland.

In order to have a better evaluation on the POPs level in the future, more regional/sub-regional programs, that are similar to POPs Monitoring Project in East Asian or POPs Global Monitoring Plan in the Pacific Island region, have to be established. The following areas are the key elements for the capacity building for the development of POPs analysis: enhanced human capacity, inter-calibration tests, strengthening skills for sampling and analysis infrastructure strengthening of existing laboratories for analysing the core media, QA/QC, and financial assistance to establish long-term, self-sufficient laboratories.

Eighteen countries and regions have participated in rounds of 2016/2017 and 2018/2019 rounds of POPs interlaboratory assessment coordinated by UN-Environment. For core matrix of "human milk", OCPs, PCBs and PFASs were analyzed in human milk under the collaboration of WHO and UNEP (Environment and Health Branch and Secretariat of the Stockholm Convention). For the new core matrix of "water", only PFASs were analyzed. For core matrix of "ambient air with passive samplers", all POPs were included in the analysis. The above UNEP-coordinated interlaboratory assessments provide significant impact on training and capacity building to Asia-Pacific laboratories.

POPs analysis laboratories within Asia and Pacific Region should implement robust and validated methods according to international scientific standards. By adopting the suitable analytical method to their circumstances and prove the capabilities with successful participation in international comparison studies. Therefore, capacity building has to be set as the top priorities for establishing new POPs laboratories and for improving the capabilities of most existing laboratories in the region. Countries in the region should be encouraged to participate in ongoing programs to promote the implementation of the Convention. In particular, countries in the region should be encouraged to participate in the inventory activities. Analytical capability for the POPs monitoring may be enhanced through existing mechanisms of collaborations and with seeking funds from national and international organizations.

B) Future monitoring program

National POPs monitoring programs which carried out by China and Japan should be continued to provide background POPs levels for future evaluation. Regional POPs monitoring programs, such as East Asian POPs Monitoring Programme (POPsEA) and UNEP/GEF programs should be also continued for capacity building/enhancement as well as for regional comparison and temporal trend analysis. Expansion of the latter program or establishment of new program(s) to cover south, west and middle Asia are also needed. Moreover, more countries and sub-regions should be encouraged to participate in future WHO-organized analytical programs for human samples. Finally, it is important to keep the monitoring program and sample analyses continued for future evaluation.

1 INTRODUCTION

The first phase of the GMP has been implemented during the period 2004-2009 and the second phase during 2010-2017, providing information on changes in concentrations of the 12 POPs initially listed in the Stockholm Convention and information on baseline concentrations of the 11 substances newly listed in the annexes to the Convention in 2009, 2011 and 2013. Two sets of regional monitoring reports and global reports have been developed to date in the frame of the GMP and have informed the effectiveness evaluation under Article 16 of the Convention.

The present (third) monitoring report synthesizes information from the first, the second, and the third phase of the global monitoring plan and presents the current findings on POPs concentrations in the Asia-Pacific Region. While the first and second monitoring reports, presented at the fourth and seventh meeting of the Conference of the Parties respectively, provided information as to the changes in concentrations of the chemicals initially listed in the Convention, as well as baseline information on some of the newly listed POPs, this third report builds on the increasing information base of POPs monitoring data and provides a further in-depth assessment of the changes measured over time in POPs concentrations, including time trends where available, as well as recent baseline information on the more recently listed POPs.

At its sixth meeting in May 2013, the Conference of the Parties, by decision SC-6/23 on the global monitoring plan for effectiveness evaluation, adopted the amended global monitoring plan for persistent organic pollutants (UNEP/POPS/COP.6/INF/31/Add.1) and the amended implementation plan for the global monitoring plan (UNEP/POPS/COP.6/INF/31/Add.2).

At its seventh meeting held in May 2015, the Conference of the Parties, by decision SC-7/25, welcomed the second regional monitoring reports, and, at its eighth meeting held in May 2017, by decision SC-8/19, it welcomed the second global monitoring report which marked the end of the second phase of implementation of the GMP. COP-8 requested the Secretariat to continue to support the work on the GMP to provide relevant input to the process of effectiveness evaluation under Article 16 of the Stockholm Convention and ensure sustainability of POPs monitoring toward the third GMP phase.

Monitoring activities have been ongoing in the five UN regions to support POPs monitoring data generation for the third GMP phase. The global coordination group met four times over the period 2015-2018 in order to oversee and guide implementation of the third phase of the global monitoring plan, with particular emphasis on addressing the sampling and analysis of the newly listed POPs, harmonizing data collection, storage and handling, addressing the needs for ensuring sustainability of ongoing monitoring activities and for further capacity strengthening to fill the existing data gaps, as well as improving data comparability within and across monitoring programs.

Long term viability of existing monitoring programs (air and human biomonitoring) is essential to ensure that changes in concentrations over time can be investigated. National air monitoring activities having contributed data to the first and second monitoring reports continued during the third phase, and new programs have been identified to support the development of the third reports. Likewise, the continued operation of global and regional air monitoring programs was a major pillar in the third phase. For the new monitoring activities, collaboration with strategic partners has ensured cost-effective generation of data and use of harmonized protocols for POPs monitoring. The implementation of the UNEP/WHO human milk survey is another important pillar of the global monitoring plan, providing useful long-term results showing how human exposure to POPs changed over time as measures are implemented to enforce the Convention.

Enhanced comparability within and across monitoring programs to evaluate changes in levels over time and the regional and global transport of POPs was an equally important milestone. QA/QC practices have been and continue to be essential for ensuring comparability, along with inter-laboratory exercises and intercalibration studies. Efforts continue to be directed at ensuring comparability within and across programs, providing for evaluation of changes in concentrations of POPs over time and enabling regional comparisons.

The GMP Data Warehouse has been made operational during the second GMP phase, supporting the regional organization groups in the work for the collection, processing, storing and presentation of monitoring data. The global monitoring plan data warehouse also constitutes a publicly available repository of valuable information that can serve as a useful resource for policy makers and researchers worldwide. The data warehouse was further enhanced and kept up to date to provide on-line access to the GMP monitoring data and enable data collection and processing during the third GMP phase and support the development of the third monitoring reports.

The process for updating the GMP guidance document has continued; information relevant to the POPs listed more recently in annexes to the Convention and on the chemicals recommended for listing or in the process of review by the POPs Review Committee has been included in the guidance. The Guidance on the Global Monitoring Plan for Persistent Organic Pollutants has been streamlined and updated in 2019 (UNEP/POPS/COP.9/INF/36) and provided a useful basis as the reference document for POPs monitoring in the third phase of the GMP, as well as for harmonized data collection, storage and handling.

2 DESCRIPTION OF THE REGION

2.1 Overall composition of the region

2.1.1 General features

Asia-Pacific Region is one of the five United Nation regions (Figure 2.1–1). The region is constituted by the countries listed below. As sub-regional arrangements, Table 2.1–1 shows the sub-region and the countries contained.

Table 2.1–1 Countries/states in the Asia-Pacific Region

Afghanistan	Kuwait	Qatar
Bahrain	(Kyrgyzstan)*	Samoa
Bangladesh	Lao People's Democratic Republic	Saudi Arabia
Bhutan	Lebanon	Singapore
Brunei Darussalam	Malaysia	Solomon Islands
Cambodia	Maldives	Sri Lanka
China	Marshall Islands	Syrian Arab Republic
Cyprus	Micronesia (Federated States of)	(Tajikistan)*
Cook Islands	Mongolia	Thailand
Fiji	Myanmar	Tokelau
French Polynesia	Nauru	Tonga
Guam	Nepal	(Turkmenistan)*
India	New Caledonia	Tuvalu
Indonesia	Niue	United Arab Emirates
Iran (Islamic Republic of)	N. Mariana Islands	(Uzbekistan)*
Iraq	Oman	Vanuatu
Japan	Pakistan	Vietnam
Jordan	Palau (Republic of)	Wallis and Futuna
(Kazakhstan)*	Palestine (State of)	Yemen
Kiribati	Papua New Guinea	
Korea (DPRK)	Pitcairn Islands	
Korea (Republic of)	Philippines	

Note: Underline shows countries that are either of ratification, acceptance, approval or accession to the Convention, but signature or succession to signature only (as of April 30, 2020).
()*: The countries in Central Asia will be included in CEE (Central and Eastern Europe) regional report.

The feature of Asia-Pacific Region is as described below.

- ■ The region is located between 55 deg N to 30 deg S, and 35 deg E to 155 deg W.
- ■ The region covers 24% of the world land area, and is inhabited by 58% (approx. 4.4billion) of the world population[1]. The region includes the two "billion" countries, China and India, either of which alone has the population size of other regions.
- ■ The region makes up about 46% of world total GDP (PPP)[2].
- ■ In Asia-Pacific Region, there are 63 countries[*], out of which 51 are either of ratification, acceptance, approval or accession to the Convention.

[*] "Countries" include islands and states.

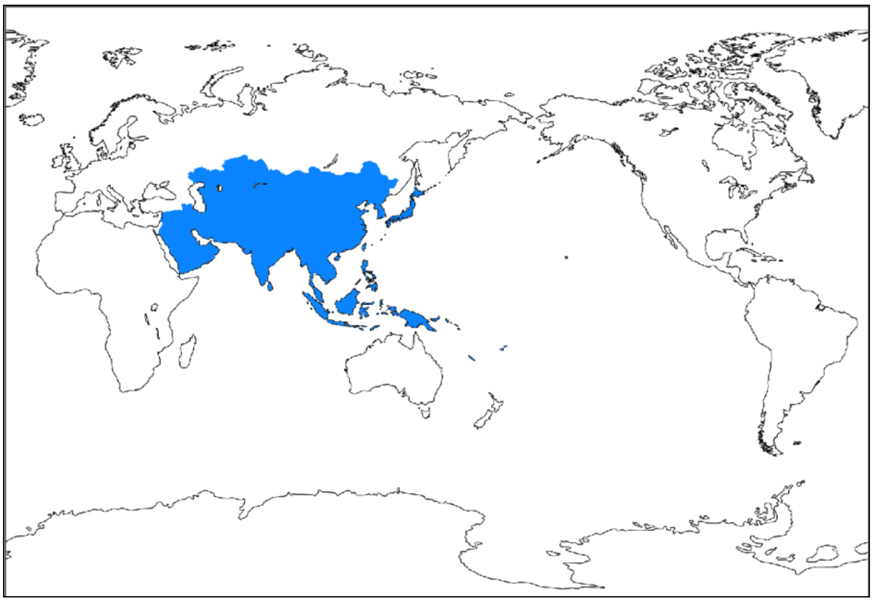


Figure 2.1–1 Map showing the Asia-Pacific Region.

2.1.2 Natural environment

(1) Climate of the region

- ■ The air circulation in the region is governed by Hadley cell (equatorial to 30 degrees north or south), or Ferrel cell (30 to 60 degrees in both hemisphere).
- ■ Near equator, the wind is easterlies (Trade wind), converging to the equator where ascending air gives much rain to support tropical rain forest (Intertropical Convergence Zone; ITCZ).
- ■ Around 30 deg N, there are dry downward flow, making arid in the area (Figure 2.1–2).
- ■ The areas higher than 30 deg is controlled by Ferrel cell with strong westerly wind at around 30 to 40 degrees especially in winter season.

This general pattern is modulated by the geographical characteristics of the region, especially by the presence of Tibetan Plateau and Western Pacific Warm Pool (WPWP), which cause “Monsoon” climatic pattern in Southern and South Eastern Asia, and huge precipitation in South Eastern Asia.

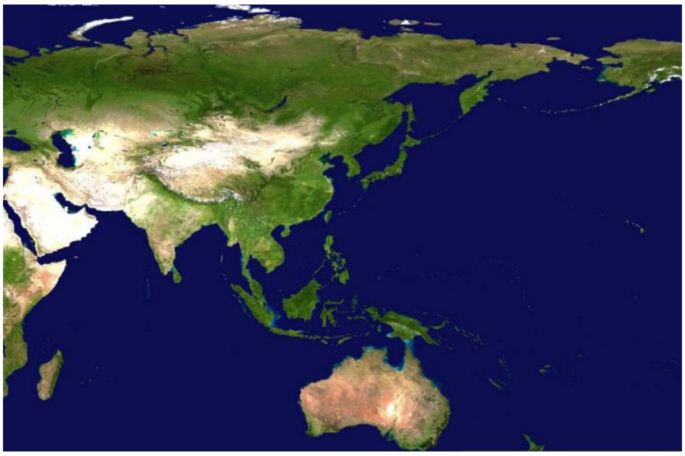
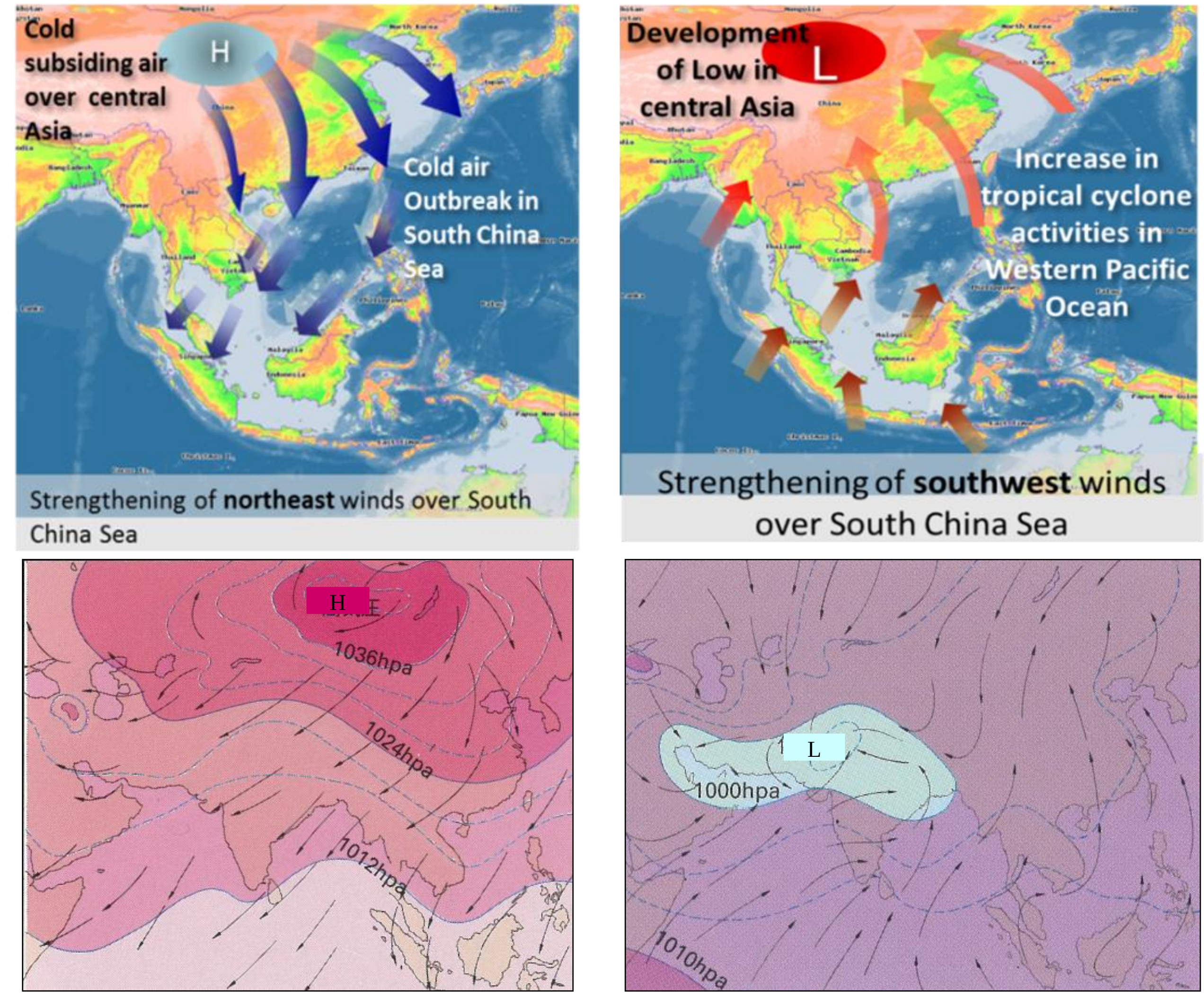


Figure 2.1–2 Satellite map of Asia-Pacific Region[3].

(a) Seasonal change of the wind direction

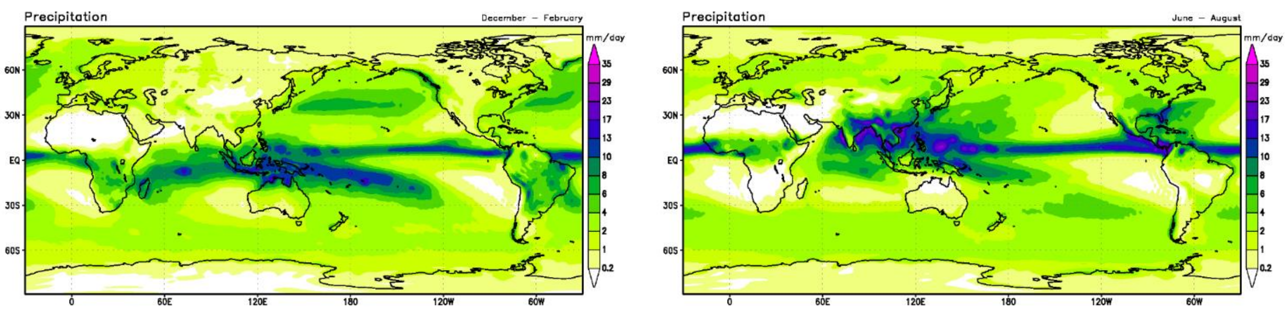


(A) Wind from high pressure in north Asia causes northeast monsoon in the winter

(B) Wind to low pressure caused by heating of the air above land occurs southeast monsoon in the summer

Figure 2.1–3 Summer and winter monsoon circulation[4].

(b) Seasonal change of the regional precipitation caused by monsoon



(A) December to February

(B) June to August

Figure 2.1–4 World precipitation of the summer and winter (3 month average)[5].

2.1.3 POPs in Asia-Pacific region

Asia-Pacific region has many characteristic features which tend to cause pollution by POPs. Although many of intentional POPs are now banned or restricted in many countries in the region, they once had been used extensively to support agricultural or industrial activities in order to support huge population and economy as well as to control malaria and pests particularly in tropical areas. In addition to these intentional production and usages, unintentional production of POPs in chemical reactions or incineration, high temperature processes in industries and waste treatment have been contaminating the environment and human beings. Thus, POPs have been of major concern in the region.

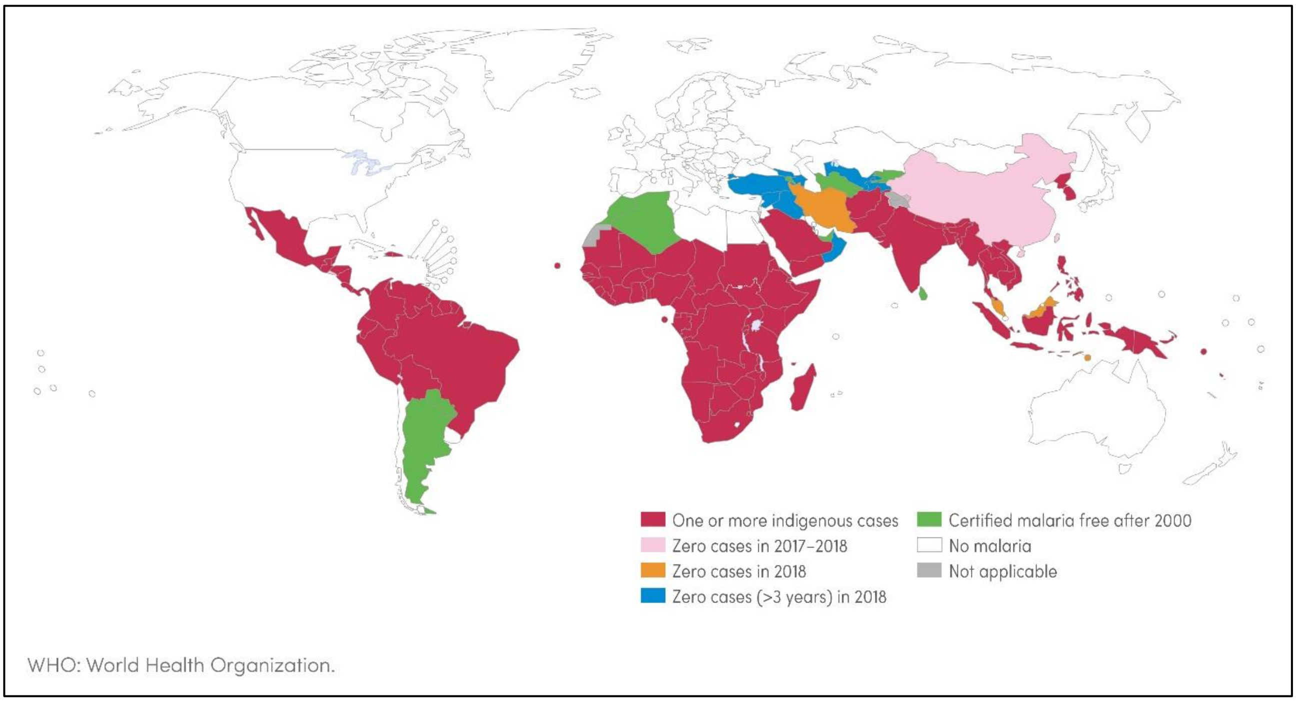


Figure 2.1–5 Countries with indigenous cases of Malaria in 2000 and their status by 2018[6].

2.2 Historical and current sources

For each POPs, information on regulation and purpose of use, production and importation for the countries in this region was organized based on the NIP, Regionally Based Assessment of Persistent Toxic Substances (published by UNEP, 2002), etc.

2.2.1 Exemption of the Convention

Parties of the Stockholm Convention reported their specific exemption to the Convention. Following information is based on the registered information on special exemption from the Stockholm Convention website[7].

A) Chemicals listed in Annex A

Table 2.2–1 Register of specific exemptions for the Stockholm Convention in the countries within Asia-Pacific region

Chemical	Activity	Specific exemption	Party	Expiry date	Estimated quantity of production/use	Purpose(s) of production/use	Reason for exemption	Remarks
Decabromodiphenyl ether (BDE-209)	Production	As allowed for the Parties listed in the Register.	Republic of Korea	Not provided	(Based on 2016) Production - Adhesives/Bonding agent: 5 ton/year Imports - Flame retardant: 519 ton/year Other: 20 ton/year	Additives in plastic housings and parts used for heating home appliances, irons, fans, immersion heaters that contain or are in direct contact with electrical parts or are required to comply with fire retardancy standards, at concentrations lower than 10 per cent by weight of the part.	Given the past distribution volume and major uses of decaBDE in Korea, decaBDE might be used for manufacturing vehicles, aircrafts or their parts. Therefore, it is needed to consider an impact on the used car market and trade of Korea and the service life of already manufactured aircraft. Under the Act on Resource Circulation of Electrical and Electronic Equipment and Vehicles, Korea has developed a flame retardancy standard for 26 electrical and electronic products such as heaters and electric ovens, which is less than 0.1wt%. Korea is now considering to add more product types into the coverage under this standard	
	Use	• Textile products that require anti-flammable characteristics, excluding clothing and toys.	Iran (Islamic Republic of)	18 Dec 2023	100 tons	Use as fire retardant in textile.	DecaBDE is used as an additive flame retardant and has a variety of applications including textiles, coatings etc., in Iran.	The date of entry into force of the amendment for Iran will be 18 Dec2018.
		• Parts for use in vehicles specified in paragraph 2 of Part IX of Annex A. • Aircraft for which type approval has been applied for before December 2018 and has been received before December 2022 and spare parts for those aircraft. • Additives in plastic housings and parts used for heating home appliances, irons, fans, immersion	Republic of Korea	Not provided	(Based on 2016) Total: 647 ton/year • Flame retardant 459 ton/year • Adhesives/Bonding agent 116 ton/year • Other: 72 ton/year	• Parts for use in vehicles specified in paragraph 2 of Part IX of Annex A. • Aircraft for which type approval has been applied for before December 2018 and has been received before December 2022 and spare parts for those aircraft. • Additives in plastic housings and parts used for heating home appliances, irons, fans, immersion heaters that contain or are in direct contact with electrical parts or are required to	Given the past distribution volume and major uses of decaBDE in Korea, decaBDE might be used for manufacturing vehicles, aircrafts or their parts. Therefore, it is needed to consider an impact on the used car market and trade of Korea and the service life of already manufactured aircraft. Under the Act on Resource Circulation of Electrical and Electronic Equipment and Vehicles, Korea has developed a flame retardancy standard for 26 electrical and electronic products such as heaters and electric ovens, which is less than 0.1wt%. Korea	

Chemical	Activity	Specific exemption	Party	Expiry date	Estimated quantity of production/use	Purpose(s) of production/use	Reason for exemption	Remarks
		heaters that contain or are in direct contact with electrical parts or are required to comply with fire retardancy standards, at concentrations lower than 10 per cent by weight of the part.				comply with fire retardancy standards, at concentrations lower than 10 per cent by weight of the part.	is now considering to add more product types into the coverage under this standard	
Hexabromocyclo-dodecane	Production	As allowed for the parties listed in the Register in accordance with the provisions of Part VII of Annex A	China	Five years	Not known yet	Production of HBCD for expanded polystyrene and extruded polystyrene in buildings in accordance with the provisions of Part VII of the Annex A	Currently in production and use, transition will take some time.	It is difficult to estimate the quantity of annual use of HBCD, because of the lack of information.
	Use	Expanded polystyrene and extruded polystyrene in buildings in accordance with the provisions of Part VII of Annex A	China	Five years	Not known yet	Use of HBCD in expanded polystyrene and extruded polystyrene in buildings in accordance with the provisions of Part VII of the Annex A	Currently in production and use, transition will take some time.	It is difficult to estimate the quantity of annual use of HBCD, because of the lack of information.
		Expanded polystyrene and extruded polystyrene in buildings in accordance with the provisions of Part VII of Annex A	Republic of Korea	5 years (27/10/2020)	1,536 tons		Research for HBCD alternative materials is on-going but HBCD is still used as building materials	
Hexabromodiphenyl ether and heptabromodiphenyl ether	Use	Articles in accordance with the provisions of Part IV of Annex A	Cambodia	Not provided	Not known	In accordance with Part IV of Annex A	CRT casings of TVs and of monitors of PC containing HexaBDE and HeptaBDE are recycled within the country.	None
		Articles in accordance with the provisions of Part IV of Annex A	Japan	Not provided	N/A	Recycling plastics from post-consumer use specific home appliances (Air-conditioner, TV sets, refrigerator, freezer, washing machine and clothes dryer) and personal computers to construction materials and daily necessities such as hanger and bookends.	Recycling post-consumer use specific home appliances is an obligation for home appliances manufacturers and importers under Home Appliance Recycling Law. It is necessary to enable recycling of plastics from post-consumer use specific home appliances to maintain appropriate management system of the post-consumer specific home appliances	Approx. 108,000 tons of plastics from post-consumer use specific home appliances which might contain the chemicals are recycled annually. Approx. 6,000 tons of used

Chemical	Activity	Specific exemption	Party	Expiry date	Estimated quantity of production/use	Purpose(s) of production/use	Reason for exemption	Remarks
							and establish a sound material-cycle society. Recycling of such plastics is operated in environmentally sound manner under the law. Recycling used personal computers is an obligation for personal computers manufacturers and importers under Law for the Promotion of Effective Utilization of Resources. It is necessary to enable recycling of plastics from used personal computers to maintain appropriate management system of the used personal computers and establish a sound material-cycle society. Recycling of such plastics is operated in environmentally sound manner under the law.	personal computers are recycled annually. On average, the weight of plastics which might contain the chemicals listed above is approx. 15% of total weight of personal computers.
		Articles in accordance with the provisions of Part IV of Annex A	Republic of Korea		Not known	In accordance with Part IV of Annex A	While manufacture, import and use of hexa- and heptaBDE are prohibited, some products and articles containing the chemicals could still be in use and recycled	
Tetrabromodiphenyl ether and pentabromodiphenyl ether	Use	Articles in accordance with the provisions of Part V of Annex A	Japan	Not provided	N/A	Recycling plastics from post-consumer use specific home appliances (Air-conditioner, TV sets, refrigerator, freezer, washing machine and clothes dryer) and personal computers to construction materials and daily necessities such as hanger and bookends.	Recycling post-consumer use specific home appliances is an obligation for home appliances manufacturers and importers under Home Appliance Recycling Law. It is necessary to enable recycling of plastics from post-consumer use specific home appliances to maintain appropriate management system of the post-consumer specific home appliances and establish a sound material-cycle society. Recycling of such plastics is operated in environmentally sound manner under the law. Recycling used personal computers is an obligation for personal computers manufacturers and importers under Law for the Promotion of Effective Utilization of Resources. It is necessary to enable	Approx.08, 000 tons of plastics from post-consumer use specific home appliances which might contain the chemicals are recycled annually. Approx. 6,000 tons of used personal computers are recycled annually. On average, the weight of plastics which might contain the chemicals listed above is approx. 15% of total

Chemical	Activity	Specific exemption	Party	Expiry date	Estimated quantity of production/use	Purpose(s) of production/use	Reason for exemption	Remarks
							recycling of plastics from used personal computers to maintain appropriate management system of the used personal computers and establish a sound material-cycle society. Recycling of such plastics is operated in environmentally sound manner under the law.	weight of personal computers.
		Articles in accordance with the provisions of Part V of Annex A	Republic of Korea		Not known	In accordance with Part V of Annex A	While manufacture, import and use of tetra- and pentaBDE are prohibited, some products and articles containing the chemicals could still be in use and recycled	None

B) Chemicals listed in Annex B

Table 2.2–2 DDT register pursuant to paragraph 1 of Part II of Annex B of the Stockholm Convention

Party	Production notification (x = received)	Use notification (x = received)	Date of notification	Comments
India	X	X	27 October 2006	Malaria (Anopheles culicifacies, An fluviatilis, An. Minimus, An. Dirus) Kala-azar (Sandfly) M/s Hindustan Insecticide Limited (HIL) is the sole manufacturer of DDT in the country.
Marshall Islands		X	22 May 2004	Acceptable purpose: Disease vector control in accordance with Part II of Annex B (Malaria/Other related illnesses)

Table 2.2–3 Register of PFOS, its salts and PFOSF pursuant to paragraph 1 of part III of annex B of the Stockholm Convention

Party	Production notification (x = received)	Use notification (x = received)	Acceptable purpose activities	Chemical name of the precursor (if relevant)	Remarks
Cambodia		X	• Fire-fighting foam	No specific chemicals identified in the NIP update.	The needs for continued use of stockpiles of PFOS containing firefighting foam was determined by our NIP update submitted to the Secretariat.
China	X	X	• Photo-imaging • Photo-resistant and anti-reflective coatings for semi-conductors • Etching agent for compound semi-conductors and ceramic filters • Aviation hydraulic fluids • Metal plating (hard metal plating) only in closed-loop systems • Certain medical devices (such as ethylene tetrafluoroethylene copolymer (ETFE) layers and radio-opaque ETFE production, in-vitro diagnostic medical devices, and CCD colour filters) • Fire-fighting foam		Applicable to Hong Kong SAR and Macao SAR of China
Japan	X	X	• Photo-imaging; • Photo-resistant and anti-reflective coatings for semi-conductors; • Etching agent for compound semi-conductors and ceramic filters; • Certain medical devices	Perfluotooctane-1-sulfonyl fluoride (PFOS-F, CAS no. 307-.35-7)	
Vietnam	X	X	• Photo-imaging; • Photo-resistant and anti-reflective coatings for semi-conductors; • Etching agent for compound semi-conductors and ceramic filters; • Aviation hydraulic fluids; • Metal plating (hard metal plating) only in closed-loop systems; • Certain medical devices (such as ethylene tetrafluoroethylene copolymer (ETFE) layers and radio-opaque ETFE production, in-vitro diagnostic medical devices, and CCD colour filters); • Fire-fighting foam; • Insect baits for control of leaf-cutting ants from Atta spp. and Acromyrmex spp.	• Perfluorooctane sulfonic acid (CAS No: 1763-23-1); • Potassium perfluorooctane sulfonate (CAS no. 2795-39-3); • Lithium perfluorooctane sulfonate (CAS no. 29457-72-5); • Ammonium perfluorooctane sulfonate (CAS no. 29081-56-9); • Diethanol-ammonium perfluorooctane sulfonate (CAS no. 70225-14-8); • Tetraethyl-ammonium perfluorooctane sulfonate (CAS no. 56773-42-3); • Didecyldimethyl-ammonium perfluorooctane sulfonate (CAS no. 251099-16-8) • Perfluorooctane sulfonyl fluoride (CAS No: 307-35-7).	Vietnam is in the process of PFOS inventory and will update information when available.

Table 2.2–4 Listing notifications of articles in use pursuant to Note (ii) of Annex A and Note (ii) of Annex B of the Stockholm Convention

Party	Chemical	Article in use	Date of notification
Cambodia	Tetrabromodiphenyl ether and pentabromodiphenyl ether	Cars with PUR foam in car seats contaminated with TetraBDE and PentaBDE remain in use within the country.	1/20/2016
China	Lindane	Human health pharmaceutical for control of head lice and scabies as second line treatment	10/31/2019
	Perfluorooctane sulfonic acid, its salts and perfluorooctane sulfonyl fluoride	- Photo masks in the semiconductor and liquid crystal display (LCD) industries. - Electric and electronic parts for some colour printers and colour copy machines. - Product for control of red imported fire ants and termites.	10/31/2019
Japan	Chlordane	Termiticide in structures of houses where chlordane occurs as a constituent	8/30/2002
	Heptachlor	Termiticide in structures of houses where heptachlor occurs as a constituent	8/30/2002
	PFOS, its salts and PFOSF	• Photo imaging • Photo resistant and anti-reflective coatings for semi-conductors • Etching agent for compound semi-conductors and ceramic filters • Fire-fighting foam • Certain medical devices	9/2/2010
	Hexabromocyclododecane	- Flame retarded extruded polystyrene (XPS) - Flame retarded expanded polystyrene (EPS) - Flame retarded textiles.	11/25/2014
	Decabromodiphenyl ether (BDE-209) present in commercial decabromodiphenyl ether	- Flame-retardant treatment agent - Flame-retardant materials for automobiles, aircrafts, and railway vehicles - Flame-retardant materials for building and equipment - Flame-retardant textiles - Flame-retardant adhesives and sealing filters - Flame-retardant plastic cases for home appliances.	11/28/2018
	Short-chain chlorinated paraffins	- Paints (limited to those for waterproof and ant-flammable use) - Plasticizers for resin and rubber - Adhesives and sealing filters - Fat liquoring agent for leather - Flame-retardant treatment agent - Lubricating, cutting and hydraulic oils - Materials for industrial machines - Tubes for outdoor decoration.	11/28/2018

2.2.2 Agricultural use and regulations

The information on agricultural use and regulations on POP substances from NIPs [8] and information submitted from countries in the region are shown below (also see Annex A).

(1) Aldrin

In Indonesia, Palau and Yemen, aldrin was not historically used for agricultural and pest control purposes, and China used aldrin only for experimental purpose. Currently, most of the countries in Asia-Pacific Region (e.g., Cambodia, China, Cyprus, India, Indonesia, Iran, Japan, Jordan, Korea (Republic of), Kyrgyzstan, Lao PDR, Lebanon, Mongolia, Nepal, Pakistan, Philippines, Singapore, Thailand, Tonga, United Arab Emirates, Vietnam and Yemen) have banned aldrin for agricultural and pest control uses.

(2) Chlordane

In Palau and Yemen, chlordane was not historically used for agricultural and pest control purposes. According to NIP of Lao People's Democratic Republic (2016), chlordane is still being illegally used in Lao People's Democratic Republic. Japan has already banned the use of chlordane, however Japan registered that chlordane can be found as termiticide in structures of houses.

Recently, most of the countries in this region (e.g., Cambodia, China, Cyprus, India, Indonesia, Iran, Japan, Jordan, Korea (Republic of), Kyrgyzstan, Lao PDR, Lebanon, Mongolia, Nepal, Philippines, Singapore, Thailand, Tonga, United Arab Emirates, Vietnam and Yemen) have banned the use of chlordane for pest control and agricultural purpose.

(3) DDT

India and Marshal Islands are still using DDT for vector control as an acceptable purpose to the Convention. According to NIP of Korea (DPRK) in 2008, Korea (DPRK) has not registered to the Convention, but still using DDT for vector control and insecticide. According to NIP of Lao People's Democratic Republic 2016, DDT is still being illegally used in Lao People's Democratic Republic. China used to register DDT for vector control use and dicofol production, and Myanmar used to register DDT for vector control use. But both countries withdrew the register in 2014 and 2012, respectively. According to the withdrawal notification, China decided to further the cease of use of DDT for vector control use and dicofol production and Myanmar imports the alternative insecticides such as malathion and alphacypermethrin instead of DDT. Currently, most of the countries in this region (e.g., Cambodia, China, Cyprus, Indonesia, Iran, Japan, Jordan, Korea (republic of), Kyrgyzstan, Lao PDR, Lebanon, Maldives, Mongolia, Myanmar, Nepal, Oman, Palau, Philippines, Singapore, Thailand, Tonga, United Arab Emirates, Vietnam and Yemen) have banned DDT for agricultural and pest control uses.

(4) Dieldrin

In China, Palau and Yemen, dieldrin was not historically used for agricultural and pest control purposes. Currently, most of the countries in this region (e.g., Cambodia, China, Cyprus, India, Iran, Japan, Jordan, Korea (Republic of), Kyrgyzstan, Lebanon, Mongolia, Nepal, Pakistan, Philippines, Singapore, Thailand, Tonga, United Arab Emirates, Vietnam and Yemen) have banned dieldrin for agricultural and pest control uses.

(5) Endrin

In China, Cyprus, Indonesia, Palau and Yemen, endrin was not historically used for agricultural and pest control purposes. Currently, most of the countries in this region (e.g., Cambodia, China, Cyprus, India, Indonesia, Iran, Japan, Jordan, Korea (republic of), Kyrgyzstan, Lao PDR, Lebanon, Mongolia, Nepal, Pakistan, Philippines, Singapore, Thailand, Tonga, United Arab Emirates, Vietnam and Yemen) have banned endrin for agricultural and pest control uses.

(6) Heptachlor

In Cyprus, Indonesia, Palau and Yemen, heptachlor was not historically used for agricultural and pest control purposes. China and Japan have already banned the use of heptachlor. Japan registered that heptachlor can be found in structures of the houses, because heptachlor is a component of technical chlordane which had been used as a termiticide.

Currently, most of the countries in this region (e.g., Cambodia, China, Cyprus, India, Indonesia, Iran, Japan, Jordan, Korea (Republic of), Kyrgyzstan, Lao PDR, Lebanon, Mongolia, Nepal, Pakistan, Philippines, Singapore, Thailand, Tonga, United Arab Emirates, Vietnam and Yemen) have banned heptachlor for agricultural and pest control uses.

(7) Hexachlorobenzene (HCB)

In Cyprus, India, Indonesia, Palau, Philippines, Korea (Republic of), Sri Lanka, Thailand, and Yemen, HCB was not historically used for agricultural and pest control purposes. According to NIP of Korea (DPRK) (2008), Korea (DPRK) has not registered to the Convention, however still using HCBs as pesticide for seed treatment in agriculture. Currently, most of the countries in this region (e.g., Cambodia, China, Cyprus, Indonesia, Iran, Japan, Kyrgyzstan, Lao PDR, Lebanon, Mongolia, Pakistan, Tonga, United Arab Emirates, Vietnam and Yemen) have banned the use of HCBs for agricultural and pest control uses.

(8) Mirex

In Cyprus, India, Indonesia, Japan, Kazakhstan, Palau, Philippines, Korea (Republic of), Sri Lanka, Thailand, and Yemen, mirex was not historically used for agricultural and pest control purposes.

Currently, most of the countries in this region (e.g., Cambodia, China, Cyprus, Indonesia, Iran, Japan, Kyrgyzstan, Lao PDR, Lebanon, Mongolia, Nepal, Singapore, Thailand, Tonga, United Arab Emirates, Vietnam and Yemen) have banned the use of mirex for agricultural and pest control uses.

(9) Toxaphene

In Cyprus, Japan, Palau and Yemen, toxaphene was not historically used for agricultural and pest control purposes. Currently, most of the countries in this region (e.g., Cambodia, China, Cyprus, India, Indonesia, Iran, Japan, Jordan, Korea (Republic of), Leo PDR, Lebanon, Mongolia, Nepal, Philippines, Singapore, Thailand, Tonga, Vietnam and Yemen) have banned the use of toxaphene for agricultural and pest control uses.

(10) Chlordecone

In China, Cyprus, Japan, Jordan, Korea (Republic of), and Philippines, chlordecone was not historically used for agricultural and pest control purposes. In Japan, chlordane has never been registered domestically as agricultural chemicals, and there is no record of manufacture and import. It was designated as Class I Specified Chemical Substance in April 2010 under the Chemical Substances Control Law, and its manufacture, import and use are virtually prohibited. Currently, some countries in this region (e.g., China, Cyprus, Iran, Japan, Lebanon, Mongolia, Korea (Republic of), United Arab Emirates and Yemen) have banned the use of chlordecone for agricultural and pest control uses.

(11) Lindane, α-HCH, and β-HCH

Currently, many countries in this region (e.g., China, Cyprus, Iran, Japan, Jordan, Korea (Republic of), Lebanon, Nepal, United Arab Emirates, Vietnam and Yemen) have banned the use of lindane, α-HCH, and β-HCH for agricultural and pest control purposes. In Indonesia, lindane is still being used for second line head lice treatment.

(12) PFOS, its salts and PFOSF

Vietnam registered PFOS, its salts and PFOSF to the Convention for insect baits for control of leaf-cutting ants from Atta spp. and Acromyrmex spp. Currently, some countries in this region (e.g., China, Iran, Japan, Jordan, Maldives, Mongolia, and Yemen) have banned the use of PFOS, its salts and PFOSF for pest control use.

(13) Pentachlorobenzene (PeCBz)

In China, Japan, Jordan and Korea (Republic of), PeCBz was not historically used for agricultural and pest control purposes. Currently, some countries in this region (e.g., China, Cyprus, Iran, Japan, Korea (Republic of), United Arab Emirates and Yemen) have banned the use of PeCBz for agricultural purpose.

(14) Technical endosulfan and its related isomers

Currently, some countries in this region (e.g., China, Cyprus, Indonesia, Iran, Japan, Korea (Republic of), Lebanon, Nepal, Philippines, United Arab Emirates, Vietnam and Yemen) have banned the use of Technical endosulfan for agricultural and pest control purposes.

(15) Pentachlorophenol and its salts and esters

In Iran, the use of pentachlorophenol (PCP) was banned by the Iranian Ministry of Agriculture in 2007.

In Japan, registration of PCP expired in 1990 under the Agricultural Chemicals Regulation Law, and its distribution and use have been prohibited since April 2012 based on the same law. Furthermore, pentachlorophenol and its salts and esters were designated as Class I Specified Chemical Substance in April 2016 under the Chemical Substances Control Law, and their manufacture, import and use are virtually prohibited.

In Republic of Korea, PCP was added into the POPs Control Act in 2017. According to the 2014 Statistical Survey on Chemicals, there was no industrial purpose of PCP while five companies imported and distributed PCP as a chemical reagent for research. However, they were not placed on the Korean market as confirmed by the 2016survey.

In United Arab Emirates, Pentachlorophenol and its salts and esters are listed as banned pesticides under the Decision of the Minister of Water and Environment No. 30 of 2016.

In Yemen, Pentachlorophenol and its salts and esters are listed as banned pesticides under the Decision of the Minister of Water and Environment No. 86 of 2017.

(16) Dicofol

Currently, China, Iran, United Arab Emirates and Yemen have banned dicofol for agricultural purposes.

In Japan, registration of dicofol expired in 2004 under the Agricultural Chemicals Regulation Law, and its distribution and use have been prohibited since April 2010 based on the same law.

2.2.3 Industrial use and regulations

The information on industrial use and regulations from NIPs8and information submitted from countries in the region are shown below (also see Annex A).

(1) DDT

In China and India, DDT was used and/or produced as intermediate for the dicofol production. However, the specific exemption expired in May 2009 for both countries.

On 17 May 2009, there were no Parties registered for the specific exemptions for intermediate in production of dicofol which is listed in Annex B pertaining to DDT. Therefore, in accordance with paragraph 9 of Article 4 of the Conventions, no new registrations may be made with respect to exemptions for intermediate in production of dicofol.

(2) HCB

Currently, China, Japan, Singapore, Vietnam and Yemen have banned HCB for the industrial use.

(3) PCBs

Currently, some countries in this region (e.g., China, Cyprus, Indonesia, Iran, Japan, Korea (Republic of), Lebanon, Oman, Singapore, Thailand, Tonga and Yemen) have banned PCBs for the industrial use. In Jordan, there is no regulation on handling, disposal and banning of PCBs, but recent regulation banned importing and using oils containing PCBs more than 0.005% of PCBs by weight.

(4) Tetrabromodiphenyl ether, Pentabromodiphenyl ether

Currently, China, Iran, Japan, Jordan, Korea (Republic of), Mongolia and Yemen have banned tetrabromodiphenyl ether (TeBDE) and pentabromodiphenyl ether (PeBDE) for the industrial use. In addition, Japan and Korea (Republic of) registered for specific exemption of TeBDE and PeBDE to the Convention. For Japan and Korea (Republic of), purpose of use is for recycling.

(5) Hexabromodiphenyl ether, Heptabromodiphenyl ether

Currently, China, Iran, Japan, Jordan, Korea (Republic of), Mongolia and Yemen have banned hexabromodiphenyl ether (HxBDE) and heptabromodiphenyl ether (HpBDE) for the industrial use. In addition, Cambodia, Japan and Korea (Republic of) registered for specific exemption of HxBDE and HpBDE to the Convention. For Japan and Korea (Republic of), purpose of use is for recycling.

(6) Hexabromobiphenyl

Currently, China, Japan, Korea (Republic of) and Yemen have banned hexabromobiphenyl (HBB) for the industrial use. In Japan, HBB was used as fire retardants for plastic products. It was designated as Class I Specified Chemical Substance under the Chemical Substances Control Law in April 2010, and their manufacture, import and use are virtually prohibited.

(7) Hexabromocyclododecane

Currently, Japan, Republic of Korea and Yemen have banned hexabromocyclododecane (HBCD) for the industrial use. In Japan, HBCD was designated as Class I Specified Chemical Substance in May 2014 under the Chemical Substances Control Law, and their manufacture, import and use are virtually prohibited.

In Republic of Korea, HBCD was added to the POPs Control Act in March 2015 with specific exemptions of EPS and XPS for construction insulation, and the exemptions will be expired on 27 October 2020. In addition, as HBCD was designated as phase-in chemicals subject to registration under the Act on Registration and Evaluation of Chemical Substances, they shall be registered until 30 June 2018.

China registered for specific exemption of HBCD to the Convention.

(8) PFOS, its salts and PFOSF

Currently, Japan, Jordan, Korea (Republic of), Mongolia and Yemen have banned PFOS, its salts and PFOSF for the industrial use. In addition, Cambodia, China, Japan and Vietnam registered for specific exemption of PFOS, its salts and PFOSF to the Convention for either use, or use and production for purposes such as photo-imaging, firefighting foams, etc.

In Japan, PFOS, its salts and PFOSF were designated as Class I Specified Chemical Substance under the Chemical Substances Control Law in April 2010, and their manufacture, import and use are virtually prohibited. However, some uses of PFOS or its salts are approved based on the premise of stringent controls.

(9) PeCBz

Currently, China, Japan, Mongolia, Korea (Republic of) and Yemen have banned PeCBz for the industrial use.

(10) Polychlorinated naphthalenes

Currently, Japan, Korea (Republic of) and Yemen have banned polychlorinated naphthalenes (PCNs) for the industrial use. In Japan, polychlorinated naphthalenes containing three or more chlorine atoms were designated as Class I Specified Chemical Substance in August 1979 under the Chemical Substances Control Law, and their manufacture, import and use are virtually prohibited.

Furthermore, polychlorinated naphthalenes with two atoms of chlorine were designated as Class I Specified Chemical Substance in April 2016.

In Republic of Korea, PCNs were added to the POPs Control Act in 2017. In the 2006 and 2014 surveys, 10 companies were found to import and distribute PCN as a reagent for research only. However, the 2016 survey confirmed they were not available on the Korean market.

(11) Hexachlorobutadiene

Currently, Japan, Korea (Republic of) and Yemen have banned hexachlorobutadiene (HCBD) for the industrial use. In Japan, HCBD was used as a solvent. It was designated as Class I Specified Chemical Substance in April 2005 under the Chemical Substances Control Law, and their manufacture, import and use are virtually prohibited.

In Republic of Korea, HCBD was added into the POPs Control Act in 2017. It was believed not to be used as organochlorine solvent in the ROK. The 2006 and 2014 surveys revealed that a company imported and distributed HCBD as a reagent for the purpose of research. However, it was confirmed not to be on the market by the 2016 survey.

In Yemen, HCBD is listed as banned chemicals under the Decision of the Minister of Water and Environment No. 86 of 2017.

(12) Decabromodiphenyl ether

Currently, Japan and Yemen have banned decabromodiphenyl ether (DeBDE) for the industrial use. In Japan, DeBDE was designated as Class I Specified Chemical Substance under the Chemical Substances Control Law in July 2017, and their manufacture, import and use are virtually prohibited.

In Yemen, DeBDE is listed as banned chemicals under the Decision of the Minister of Water and Environment No. 86 of 2017.

(13) Short-chain chlorinated paraffins

Currently, Japan and Yemen have banned short-chain chlorinated paraffins (SCCPs) for the industrial use. In Japan, SCCPs were designated as Class I Specified Chemical Substance under the Chemical Substances Control Law in April 2018, and their manufacture, import and use are virtually prohibited.

In Yemen, SCCPs are listed as banned chemicals under the Decision of the Minister of Water and Environment No. 86 of 2017.

(14) PFOA, its salts and PFOA-related compounds

In Japan, all the POPs listed in Annex A to C have been banned/regulated under Chemicals management law or Special measures to dioxins, and PFOA and its salts, related compound will be regulated by nominating them as Class 1 specified chemical substances under the Chemicals management law. Currently a provisional guideline values are set for drinking water (PFOS + PFOA ≦ 70 ppt) and environmental water (PFOS + PFOA ≦ 50 ppt).

In Yemen, PFOA and its salts and esters are listed as banned chemicals under the Decision of the Minister of Water and Environment No. 86 of 2017.

2.2.4 Unintentional production

Information on the inventory of the following POPs formed and released unintentionally from anthropogenic sources is listed below (also see Annex B).

(1) PCDDs, PCDFs, and *dl*-PCBs

In Japan, PCDDs, PCDFs and *dl*-PCBs are categorized as dioxins under the Dioxins Law. Measures against dioxins have mainly focused upon controlling releases from waste incinerators etc. Releases (estimate) in 2018 were 117 – 119 g-TEQ per annum, which represents a decline of approximately 99% from the level of releases in 1997 (7,680– 8,135 g-TEQ per annum).

In Republic of Korea, methods have been developed for classifying the sources of dioxins emission and calculation of the emission quantity since 2001. Dioxins emissions from waste incinerators have decreased continuously compared to the 2001 due to constant control measures, such as the progressive strengthening of emission standards.

In other parties to the Stockholm Convention in the Asia-Pacific Region, information on emission inventory of PCDDs, PCDFs, and *dl*-PCBs for single year is organized in their NIP. Detail is shown in Annex B.

(2) HCB

In Japan, the emission inventory of HCB was calculated for 2002 and 2018. It was estimated that HCB release reduced by approximately 30% from 2002 to 2018 (see Annex B).

In Republic of Korea, the emission of HCB increased from 57.8 kg/yr in 2001 to 1,120.1 kg/yr in 2008. But the HCB emission considerably reduced to 628.7 kg/yr in 2009 and it kept decreasing to 55.7 kg/yr in 2015.This reduction may be due to the enforcement of the POPs Control Act in 2008, which started to control industrial facilities such as steel/non-ferrous metal manufacturing facilities under the Act.

In Sri Lanka, information on emission inventory of HCB for a single year is calculated in its NIP. Detail is shown in Annex B.

(3) PCBs

In Japan, the emission inventory of PCBs was calculated t for 2002 and 2018. PCBs releases from thermal processes in cement combustion furnaces and metallurgical industry were relatively higher compared with other sources, with emission rates of 64% and 33%, respectively. Estimations showed a PCBs emission increase of 32% from 2014 to 2018, however, a long-term estimation from 2002 to 2018 showed a globally flat trend (see Annex B).

In Republic of Korea, the emission of dl-PCBs reduced from 15.7 g WHO-TEQ/yr in 2001 to 12.0 g WHO-TEQ/yr in 2015.The emissions from the steel industry made up 64% of the total emission as of 2015 (see Annex B).

(4) PeCBz

In Japan, the emission inventory of PeCBz was calculated for 2012 and 2018. According to surveys conducted for domestic operating facilities, unintentionally produced PeCB was generated from heat combustion processes similar to those of dioxins. PeCB releases from waste incinerators were relatively higher than other sources, with emission rates of 49% (see Annex B).

(5) Polychlorinated naphthalenes (PCNs)

In Japan, the emission inventory of PCNs was calculated for 2018. Although the emission from sinter plants in the iron and steel industry is not calculated yet and total emission is a reference value, total emission was estimated to be 378 kg/year (see Annex B).

According to the NIP of Republic of Korea (2019), PCNs concentrations in emission gas were found in steel sintering furnace of 21.135 ng/m^3, steel electric arc furnace of 69.852 ng/m^3, municipal waste incinerator of 0.653 ng/m^3, hazardous waste incinerator of 17.305 ng/m^3, and general industrial waste incinerator of 21.748 ng/m^3 in 2018.

(6) Hexachlorobutadiene

According to the NIP of Republic of Korea (2019), HCBD concentrations in emission gas were found in municipal waste incinerator of 13.756 ng/m^3, hazardous waste incinerator of 12.534 g/m^3, and general industrial waste incinerator of 20.290 ng/m^3 in 2018.

3 ORGANIZATION OF REGIONAL IMPLEMENTATION

3.1 Preparatory workshops

To facilitate Regional Monitoring Report for Asia-Pacific Region, the three meetings were held for this region (Table 3.1–1). At each workshop, ROG members discussed structure of the report, selection of data, capacity building, etc.

Work plans and timetables to finalize the regional monitoring report are summarized in Table 3.1-2.

Table 3.1–1 Preparatory workshops for regional monitoring report in Asia-Pacific region

	Meeting of the Regional Organization Groups and the Global Coordination Group for the Global Monitoring Plan under the Stockholm Convention	Meeting of the Coordination Group for the Global Monitoring Plan for Persistent Organic Pollutants	Asia-Pacific Regional Organization Group Workshop on the 3rd Regional POPs Monitoring Report
Date	May 30th– June 1st 2018	October 15th- 17th 2019	August 24th – 26th, 2020
Location	Brno, Czech Republic	Geneva, Switzerland	Online conference
Objective	To initiate the work on the implementation of the third phase of the GMP, including the update of the GMP guidance document to address the newly listed POPs, and considerations for monitoring of core media (air, human matrices, water for PFOS) and for data handling in the third phase.	To discuss on the arrangements (and tools) in place for the preparation of the third monitoring reports and for the updating of the GMP guidance document.	To discuss on and finalize the detail structure of the report; and to discuss the mechanism for further review and revision of the report.
Items dealt	Regional strategies for implementation of the GMP in the regions, including monitoring arrangements and timelines for completion of the third regional monitoring reports.	Progress on regional implementation of the third phase global monitoring plan, including data availability, data handling, analysis and interpretation, and status of the regional monitoring report.	Agreements on the structure of the report, procedure for the finalization of the report, and additional data that may be available are included in the report.
Remarks	As it was in the last time, consultant from Japan will be the initial author and professor from China will be the principle author.		

Table 3.1–2 Work plans and time tables to finalize the regional monitoring report

Work plan	Time table
ROG meeting to discuss the modifications on the draft regional report	August 24-27, 2020
ROGs finalized the executive summary and the conclusions and recommendations	September 30, 2020
Consultant team developed the first draft of the regional report and annex	September 30, 2020
ROGs gave input to the draft report and finalize the second draft. The second draft regional monitoring report will be sent to national focal points for consultations by Asia-Pacific countries.	February 8, 2021
Finalization of the report on the basis of comments received from the parties in this region and submission of the report to the Secretariat	April 29, 2021

3.2 Establishment and responsibilities of the regional organization group

As the result of discussion at the ROG Workshop described in 3.1, six regional organization group members took responsibility for the countries within their sub-region for collecting data and preparing the third regional monitoring report.

Table 3.2–1 Sub-regional framework of responsibilities in ROG members

ROG Member	Member of countries within the sub-region		
Yemen	● Bahrain ● Iraq ● Jordan ● Kuwait	● Lebanon ● Oman ● Palestine ● Qatar	● Saudi Arabia ● Syria ● United Arab Emirates ● Yemen
India and Iran	● Afghanistan ● Bangladesh ● Bhutan	● India ● Iran ● Maldives	● Nepal ● Pakistan ● Sri Lanka
China	● China ● Korea (DPRK) ● Lao People’s Democratic Republic	● Mongolia ● Vietnam	
Japan	● Brunei Darussalam ● Cambodia ● Indonesia	● Japan ● Korea (Republic of) ● Myanmar	● Philippines ● Singapore ● Thailand
Fiji	● Samoa ● Cook Islands ● Fiji ● French Polynesia ● Guam ● Kiribati ● Micronesia (Federated States of)	● Marshall Islands ● Nauru ● New Caledonia ● Niue ● N. Mariana Islands ● Palau (Republic of) ● Papua New Guinea ● Pitcairn Islands	● Samoa ● Solomon Islands ● Tokelau ● Tonga ● Tuvalu ● Vanuatu ● Wallis and Futuna

Table 3.2–2 ROG members for sub-regions

Country	Member
China	Mr. Minghui Zheng
Fiji	Mr. Johann Poinapen
India	Mr. Dinesh Runiwal
Iran	Mr. Abdulrahman Bahrami
Japan	Mr. Yasuyuki Shibata
Yemen	Mr. Anas Ali Saeed AL-Nadhari

3.3 Agreement on a basic framework to provide comparable information

The ROG members have agreed, at the preparation of the first regional monitoring report, that data submitted in the regional report should include information regarding QA/QC, such as LOD, blank testing, recovery, accuracy, precision, etc. Information of sampling (location, method, procedure) and analytical method should be provided. Moreover, the source of data should be provided.

3.4 Regionally developed and executed implementation plans

The existing sub-regional initiative of POPs Monitoring Project in East Asian Countries, conducted by Ministry of the Environment, Japan, comprises of two parts: (1) organizing workshops to discuss and guide the project; and (2) providing technical assistance for background field monitoring of POPs in air (e.g., sampling, high resolution GC/MS analysis, data validation, QA/QC). For the project of Background Air Monitoring of POPs in East Asian Countries from 2004–2007, 2009–2013 and 2014-2017, ten countries (Cambodia, Indonesia, Japan, Republic of Korea, Lao PDR, Malaysia, Mongolia, Philippines, Thailand and Vietnam) have reported the result of the monitoring. Republic of Korea also took initiative to implement information warehouse and Analysis Training of POPs in East Asian Countries.

Organized human milk monitoring programs have been implemented by WHO since 1987. WHO organized and completed six rounds of exposure studies in 1987-1988, 1992-1993, 2000-2003, 2004-2007, 2008-2011 and 2012-2015 on levels of specific POPs in human milk, and new round has begun since 2016.The main objectives of these studies were: 1) to produce more reliable and comparable data on concentrations of certain POPs in human milk for further improvement of health risk assessment in infants, 2) to provide an overview of exposure levels in various countries and geographical areas, 3) to identify highly exposed local populations in relation to their daily intake for guidance on risk management actions, including epidemiological follow-up studies, and 4) to promote, if necessary, additional national studies to be closely linked with the respective studies through the use of the same protocol.

UNEP/GEF Project “Implementation of the POPs Monitoring Plan in the Asian Region under the Stockholm Convention” and “Continuing Regional Support for the POPs Global Monitoring Plan under the Stockholm Convention (GMP2) in the Pacific Region” are also relevant activity in Asia-Pacific Region. Seven Asian countries (Cambodia, Indonesia, Lao PDR, Mongolia, Philippines, Thailand and Vietnam) and nine Pacific countries/islands (Fiji, Kiribati, Marshall Islands, Niue, Palau, Samoa, Solomon Islands, Tuvalu and Vanuatu) are participating in the projects, respectively.

Institute for the Advanced Study of Sustainability at United Nations University (UNU-IAS) has implemented a project “Monitoring and Management of Persistent Organic Pollutants in Asia,” since 1996, supported by Shimadzu Co. Ltd. The aim is to strengthen management of environmental pollutants based on scientific monitoring, with a focus on the hydrosphere in Asia. The project focuses on perfluorochemicals (PFCs), including which were listed (as PFOS and its salts, and PFOSF) in May 2009 in Annex B of the Stockholm Convention in the phase VI (2012-2015) and phase VII (2016-2018). However, the project finished after the end of phase VII.

3.5 Information gathering strategy

ROG agreed that data submission from each country for third phase regional monitoring report should follow criteria in Chapter 6 of the GMP guidance document and submit to GMP Data Warehouse or electronically through the reporting system. Strategy on how the information should be received/obtained was agreed as described below:

1. Data should be uploaded by national focal points.
2. Data from global or inter-regional monitoring projects will be considered including in the regional report after obtaining a permission from focal points.
3. ROG members contact the national focal points for the sub-region he/she is responsible for. ROG coordinator will gather information from each ROG member.

All the data will be submitted to the GMP Data Warehouse developed by the Stockholm Convention Regional Centre in the Czech Republic, under the guidance of the GMP Global Coordination Group, and will be used together with the data of the first and second phase of the GMP for Effectiveness Evaluation in the future.

There is also a way to get information by analyzing samples stored in the sample bank to obtain the concentrations of POPs in the past. The sample banking programs in Japan and Republic of Korea are shown in Table 3.5–1.

Table 3.5–1 Sample banking in Japan and Republic of Korea

Countries	Programs	Organization	Media	Storage
Japan	Time Capsule Program for Environmental Specimens[9]	National Institute for Environmental Studies	Bivalves, fish, atmospheric sample, human milk, marine reptile	Liquid nitrogen vapor (–150°C), Freezer (–60°C and –80°C)
	Environmental Specimen Bank for Global Monitoring (*es*-BANK)[10,11]	Ehime University, Center for Marine Environmental Studies	Wildlife species & organs, atmospheric sample, sediment, *etc*.	Liquid nitrogen vapor (–150°C), *etc.*
	Kyoto University Human Specimen Bank for Biological Monitoring[12]	Kyoto University	Food, human blood, human milk, urine	Freezer (–20°C)
Republic of Korea	National Environmental Specimen Bank	National Institute of Environmental Research	Leave & branch, fish, bivalves, egg, human sample (blood, blood serum, plasma, urine, colostrum, placenta)	Liquid nitrogen vapor (–150°C)
			Human blood, urine	Freezer (–80°C)

3.6 Strategy for using information from existing programs

Information used for the third regional monitoring report is submitted by national focal points, in principle. Data from global or inter-regional monitoring projects, such as Background Air Monitoring of POPs in East Asian Countries, should consider including in the report after obtaining permission from each of the focal points.

3.7 Preparation of the monitoring reports

The drafting team for the preparation of the third regional monitoring report is consisted of ROG members and consultants. The drafting team worked and completed the first and second draft of the regional report accordingly. The second draft regional report was sent to all national focal points in the region for the comments. ROG members received comments from sub-regional countries on the second draft of the regional report. Discussions among the ROG members and drafting team were conducted for the modifications on the second draft regional report and to finalize the report.

4 METHODS FOR SAMPLING, ANALYSIS AND DATA HANDLING

4.1 *Environmental monitoring programs in Asia-Pacific to support the effectiveness evaluation*

Article 16 of the Stockholm Convention states the essential role of environmental monitoring to support effectiveness evaluation of the Convention. The guidance document, i.e., "Guidance on the Global Monitoring Plan (GMP) for Persistent Organic Pollutants [13], was made and up-dated periodically in order to support harmonized environmental monitoring globally. A key issue of GMP is to produce "high quality" and "comparable" data worldwide; i.e., the monitoring data should have enough accuracy and precision for the analysis of temporal trends and movements of POPs in the environment so that the effectiveness of the action of Parties will be properly assessed. The guidance document, therefore, describes recommended analytes lists, core media, selection of sampling sites, sampling, sample preparation and analytical methods, data handling and reporting, and sample banking activities. In order to keep comparability of the data, the monitoring method should implement appropriate QA/QC procedures, such as determination of limit of detection (LOD)/limit of quantification (LOQ), method detection limit (MDL)/method quantification limit (MQL), method and travel blanks, extraction efficiencies and recoveries, repeatability (or duplicate analysis), linearity and range of calibration curve, etc. Use of standard reference materials or in-house reference materials, or participation to round robin analytical campaign as well as banking of environmental specimens for enabling re-analysis in future will be useful to assess and improve technical levels and keep comparability of the monitoring data.

Some of the environmental monitoring programs, such as national monitoring program in China[14] and UNEP/GEF GMP2 program, follow this guidance. In these cases, the primary data of POPs level in core matrices, i.e., air, human tissues, and water for PFOS, are analyzed and handled according to the guidance document so that they will have sufficient quality and level of details. They are consistent and comparable over time and relevant to the objectives of the effectiveness evaluation of the Stockholm Convention. Other programs, such as POPs Monitoring in East Asian Countries (POPsEA)[15] and Japanese national POPs monitoring[16,17], also basically similar to the guidance but do not strictly follow it, for some of them have long history and keep continuity of their own, or follow other established analytical methods, such as EPA or Japanese methods. These programs also have their own QA/QC protocols and assessed by the expert committee periodically, and thus are recognized to have sufficient quality to support the Convention. Majority of analytical institutions supporting the programs in this Asia-Pacific region, i.e., those in the national programs of China[14] and Japan[16], and East Asian POPs monitoring program[15], also regularly participate in the inter-laboratory exercise organized by UNEP Chemicals and/or other organizations in order to assess the technical capability and comparability with other programs. UNEP/GEF GMP-2 program itself is aiming to build/enhance analytical capacity of participating countries by conducting laboratory exercise and training and supplying SOPs. In East Asian sub-region, R. Korea organizes POPs analysis training workshop every year from 2011to support capacity building/enhancement in the countries participating in the POPsEA program. Furthermore, Japan and R. Korea have been conducting a bilateral research program on the harmonization of POPs monitoring methods for more than a decade. United Nations University – Institute for the Advanced Study of Sustainability (UNU-IAS)/Shimadzu project on POPs monitoring and management in Asia was another capacity building/enhancement program in East Asian sub-region. Through these activities, POPs monitoring capacities are growing in harmonized manner in East Asian countries.

4.2 Sampling methods

Various methods for sampling and analysis for POPs monitoring have been applied in countries of Asia-Pacific region. The information is summarized in the Tables 4–1 to 4–5. As for air monitoring, several programs use active samplers, including high volume sampler (sucking speed of several hundred litters/min) with glass (or quartz) fiber filter (GFF or QFF) and polyurethane foam plug (PUF) combinations for dioxins[17], QFF, PUF and XAD-resin or active carbon fiber felt (ACF) combination for general POPs[14,15,16], and a low volume sampler (sucking speed of 0.1 litter/min) with Tenax TA adsorbent for HCBD[16]. Other programs, including UNEP/GEF GMP2 program, use passive sampler with a PUF or a SIP disk. Sampling period is typically from one day to one week in the active sampling while one to six months in passive sampling. In the active sampling, large volume of air (typically, 1,000m^3/sample in Japanese HV system) is sucked and the POPs concentrations are accurately determined by correcting losses in sampling and/or clean-up processes by using isotope-labelled surrogates. Due to its rather short sampling period, an active sampling data may not represent the average POPs levels, but active sampling will be useful to know the averages as well as temporal changes by the repeated periodical monitoring. Passive sampling, on the other hand, is expected to better represent average POPs levels due to longer sampling period, but its absorption rate and linear range tends to be affected by the chemical properties of POPs and climate/weather conditions during sampling. Due to ambiguities in sampling rate/volume in different locations, some of passive sampling data are presented as amounts/sample instead of amounts/air volume. Thus, data obtained by passive samplers and those by active samplers may not be easily comparable. It should be pointed out that the air monitoring data compiled in this report is primarily to be used for temporal trend analysis of POPs in the same location, while care should be taken to use the data for comparison among different locations/areas.

4.3 Selection of sampling sites

Several programs select air sampling locations in remote islands or mountains in pristine areas, such as National Parks, which will be useful as background sites for long term monitoring. In Chinese national monitoring program, for example, 11 remote air sampling sites are selected based on the criteria, i.e., regional representativeness, minimum meso-scale meteorological circulation influences, long-term stability, ancillary measurement data, and appropriate infrastructure and utility[14]. In POPs Monitoring Project in East Asian Countries (POPsEA), remote islands (Okinawa (also in National Park) and Fukue (Japan), Jeju (R. Korea)) and mountains (Indonesia, Thailand (also in National Park), and Vietnam are selected as background locations[15].

It should be pointed out that travel distance of chemicals varies depending on their chemical properties; some POPs, like HCB, PeCBz, α-HCH and HCBD, show higher volatility and longer travel distances than others, like dioxins and PBDEs, which show quite low volatility, attached to particles in the air, and thus show shorter travel distances. Former group of POPs may easily be transported transboundary, and even circulate around the globe until trapped in the sampler of a background site, while the latter in the sampler may reflect the effects of nearby sources within, for example, a few tens km from the site. In Japanese monitoring, for example, majority of POPs, except dioxins, are monitored once a year in 37 sampling locations covering all over Japan while monthly monitoring is conducted at two remote islands in western part of Japan[16]. Dioxins, furans and dioxin-like PCBs, on the other hand, are monitored in the ambient air once a year at 680 sites (total 2016 samples; the numbers in 2018)[17].

In water sampling, the concept of background monitoring is not easy to be realized. Several programs conduct water sampling at down-stream areas in large rivers, or lakes or bays in densely populated areas, which are expected to reflect total human activities along a river or surrounding a lake or a bay. In Chinese national monitoring program, for example, water was sampled at large lakes (Qinghai Lake and Taihu Lake) and coastal zone along the Bohai Sea, the Huanghai Sea, and Hong

Kong SAR[14]. In Japan, water was sampled at major rivers (at downstream area or river mouth), center of lakes, and along bays (Tokyo Bay, Osaka Bay, etc.)[16]. Water sampling for PFOS is usually conducted by grab sampling. In some programs, sampling of water is conducted once in the same season every year (Japanese national POPs monitoring) while in others the sampling is conducted four times a year (GMP2 program) or twice a year, i.e., in wet and dry season (UNU-IAS/Shimadzu project).

For human POPs monitoring, both human breast milk and bloods are used in the region. In UNEP/GEF GMP-2 program in East Asia and Pacific Islands, human breast milk was collected according to the sampling protocol and pooled samples in each Party was analyzed of POPs contents. Human breast milk was also collected and analyzed in the national monitoring of China (reported in the 2nd regional report). In Japan, human blood samples are collected and analyzed of their dioxins and some of POPs levels. In addition, result of dioxin analysis in human breast milk reported in scientific papers are also compiled in this report.

In addition to these core media, soils/sediments and biota (fishes, bivalves, birds and bird eggs) samples are analyzed in Japanese POPs monitoring program and the data are reported in "Other Media" section. For example, analysis of POPs except dioxins are conducted in water at 47 sites, in sediments at 61 sites, and in biota (bivalves, fishes and birds (or bird eggs) at 3, 18 and 4 sites, respectively) in 2018[17]. Dioxins analysis, on the other hand, are conducted in environmental water at 1,442 sites, bottom sediments at 1,205 sites, underground water at 513 sites, and soils at 847 sites in 2017 under the law concerning special measures to dioxins[17].

4.4 Analytical methods for POPs

GC/MS or GC/MS/MS is a method of choice for the majority of POPs except PFOS, HBCD and chlordecone, which need LC/MS/MS for the analysis. A combination of capillary GC with a high resolution sector MS or TOF-MS, or a highly selective MS/MS, is among the most popular GC/MS method for the majority of POPs including PCDD/PCDFs (dioxins), while a small GC/quadrupole MS (qMS) combined with a thermal desorption unit is used for the analysis of HCBD trapped in Tenax TA adsorbent. GC/μECD is also used for selected organochlorine pesticides and PCBs indicator congeners. Among the newly added POPs, PFOA is also analyzed by LC/MS/MS. SCCPs analysis is a real challenge, and a variety of analytical methods, such as GC/NCI-qMS, GC/NCI-high resolution MS (Sector MS, TOF, and Orbitrap), GCxGC/TOF-MS, GCxGC/ECD, APCI-TOF- MS, LC/qMS, LC/TOF-MS, and LC/MS/MS, have been applied for the development and establishment of the analytical method.

Generally speaking, a more expensive, higher resolution instrument will show higher sensitivity (lower detection limits) and higher selectivity. As a result, such instruments need less amount of samples and less extensive clean-up procedures for the analysis. In other words, analytical methods using GC/ECD or GC/qMS may need careful and extensive clean-up procedure to eliminate many interferences and obtain reliable data. Mass spectrometry-based instrument has a capability to correct recoveries of chemicals during sampling or clean-up procedure by adding known amount of same chemicals labelled with stable isotopes (same chemical with different mass) in the adsorbent or extracts. Such analytical method based on isotope-labelled surrogates (or isotope-dilution strategy) is suitable to keep and improve the quality of the data and is becoming a routine method in organic pollutants analysis. Due to increasing number of POPs under the Convention, the analytical methods, including clean-up procedure, have been becoming more and more complicated, and systematic grouping of chemicals based on their chemical properties is a key to conduct clean-up and analysis efficiently and smoothly. More detailed information on sampling, clean-up procedures and analysis are given in the homepage of some of the monitoring programs.

Table 4–1 Sampling, analytical method and QA/QC for monitoring programs (core media: Air)[14,15,17,16]

Sampling	Analytical Method	Chemicals	QA/QC	Country
• High Volume sampler	• HRGC/HRMS or GC/LRMS	• PCBs, HCB, DDTs, chlordanes, heptachlors, aldrin, endrin, dieldrin, mirex, toxaphene, α-/β-/γ-HCH, PeCBz	• Yes	• Cambodia • China • Japan • Lao PDR • Malaysia • Thailand
			• No	-
		• PCDDs, PCDFs	• Yes	• Cambodia • China • Japan • Lao PDR • Malaysia
			• No	-
		• Tetra/penta-BDE, hexa/hepta-BDE, deca-BDE, HexBBs, endosulfan, PCNs, HCBD, PCP, PCA, dicofol, PCN	• Yes	• Japan • China
			• No	-
	• LC/MS	• SCCPs	• Yes	• Japan
			• No	-
	• LC/MS/MS	• PFOS, PFOA, HBCD, chlordecone	• Yes	• Japan • China
			• No	-

• Passive sampler	• LCMS/MS	• PFOS, PFOA, PFHxS, FOSA, NMeFOSA, NEtFOSA, NMeFOSE, NMeFOSE	• Yes	• Indonesia • Cambodia • Lao People's Democratic Republic • Mongolia • Philippines • Thailand • Viet Nam • Fiji • Kiribati • Marshall Islands • Niue • Palau • Solomon Islands • Tuvalu • Vanuatu
			• No	-
	• HRGC/HRMS or GC/MS	• PCDDs, PCDFs, *dl*-PCBs • HCB, aldrin, dieldrin, endrin, chlordanes, HBCDs, DDTs, PCBs, heptachlors, mirex, toxaphene, α-/β-/γ-HCH, HBB, HxBDE/HepBDE, HexBDE/HepBDE, PeCBz, Endosulfan	• Yes	• Indonesia • Cambodia • Lao People's Democratic Republic • Mongolia • Philippines • Thailand • Viet Nam • Fiji • Kiribati • Marshall Islands • Niue • Palau • Solomon Islands • Tuvalu Vanuatu
			• No	-

Table 4–2 Sampling and Analytical Method, and QA/QC for monitoring programs (core media: Human Milk)

Sampling	Analytical Method	Chemicals	QA/QC	Country
• WHO Protocol	• HRGC-HRMS	PCDDs, PCDFs, *dl*-PCBs	• Yes	China
			• No	
	• GC-MS	OCPs	• Yes	China
			• No	
• UNEP Protocol 2017 based on WHO 2007 protocol	• LC/MS/MS	• PFOS, PFOA, PFHxS	• Yes	• Fiji • Cambodia • Kiribati • Marshall Islands • Mongolia • Palau • Solomon Islands • Thailand • Viet Nam • Vanuatu • Samoa • Niue
	• GC-MS-MS; GC-ECD	• HCB, β-HCH, dieldrin, chlordanes, HBCDDs, DDTs and PCBs • Heptachlors, aldrin, endrin, mirex, toxaphene, α-/γ-HCH, HBB, HxBDE/HepBDE, HexBDE/HepBDE, PeCBz, endosulfan • PCDDs, PCDFs, *dl*-PCBs • Mirex	• Yes	• Fiji • Cambodia • Kiribati • Marshall Islands • Mongolia • Palau • Solomon Islands • Thailand • Viet Nam • Vanuatu • Samoa • Niue
	• HRGC/HRMS	• PCDD, PCDF, PCB(6), dl-PCB, HxBDE/HepBDE, HexBDE/HepBDE; (sector field) • SCCPs (orbitrap)	• Yes	• Fiji • Cambodia • Kiribati • Marshall Islands • Mongolia • Palau • Solomon Islands

				• Thailand • Viet Nam • Vanuatu • Samoa • Niue
• Other Protocol	• GC/MS	• PCDDs, PCDFs, *dl*-PCBs	• Yes	• Japan
			• No	-

Table 4–3 Sampling and Analytical Method, and QA/QC for monitoring programs (core media: Human Blood)

Sampling	Analytical Method	Chemicals	QA/QC	Country
• Unpooled	• HRGC/HRMS	• PCDDs, PCDFs, *dl*-PCBs	• Yes	• Japan
			• No	-
	• LC/MS/MS	• PFOS, PFOA, PFHxS	• Yes	• Japan
			• No	-

Table 4–4 Sampling and Analytical Method, and QA/QC for monitoring programs (core media: Water (PFOS))

Sampling	Analytical Method	Chemicals	QA/QC	Country
• Collected with Water Sampler (e.g., Niskin sampler)	• LC/MS/MS	• PFOS, PFOA	• Yes	• Japan • China
			• No	-
• UNEP Protocol 2017	• LC/MS/MS	• PFOS, PFOA, PFHxS	• Yes	• Fiji • Kiribati • Mongolia • Niue • Palau • Solomon Islands • Tuvalu • Viet Nam • Vanuatu • Samoa • Marshall Islands

5 RESULTS AND DISCUSSION

5.1 Results

Information on POPs concentrations collected through the monitoring programs and methods described in the previous chapters is organized in the following section.

5.1.1 Ambient air

5.1.1.1 POPs monitoring by active sampling

In the Asia-Pacific Region, several international and national POPs air monitoring programs are available. First those using active sampling are explained. In POPs Monitoring Project in East Asian Countries, sampling was operated in seven countries from 2014 to 2018 (see Table 5.1.1–1). In China and Japan, some national ambient POPs air monitoring programs are performed (see Table 5.1.1–2).

Table 5.1.1–1 Summary for regional air monitoring programs after 2nd Asia-Pacific Regional Monitoring Report

Sampling	Country	Period	Location	Number of site/sample (/year)	POPs	Remarks
Active	Japan	FY2014-2018	Hedo, Okinawa (Fukue, Nagasaki) *	12 samples (or 36 samples)/ year (Hedo) (6 samples (or 18 samples) /year (Fukue; only half a year including winter time))*	PeCBz, HCB, aldrin, dieldrin, endrin, DDTs (6 isomers), chlordane (5 isomers), heptachlors (3 isomers9, mirex, toxaphene (3 isomers), HCH (4 isomers) + PCBs, PBDEs, PFOS, PFOA, endosulfan, HBCDs, HCBD, PCP, PCA, SCCPs, HBB, PCNs	POPs Monitoring Project in East Asian Countries[15] (POPsEA project)
	R. Korea	2014-2018	Jeju Island	12 samples/year	PeCBz, HCB, aldrin, dieldrin, endrin, DDTs (6 isomers), chlordane (5 isomers), heptachlors (3 isomers9, mirex, toxaphene (3 isomers), HCH (3 isomers) + chlordecone, PBDEs, endosulfan sulfate, endosulfan II, *dl*-PCBs, PCDD/PCDFs	
	Cambodia	2015	Sihanoukville	3 samples	PeCBz, HCB, aldrin, dieldrin, endrin, DDTs (6 isomers), chlordane (5 isomers), heptachlors (3 isomers), mirex, toxaphene (3 isomers), HCH (4 isomers), PCBs**, PCDDs**, PCDFs**	
	Indonesia	2018	Kototabang	3 samples		
	Lao PDR	2017	Na Long Koun Village	3 samples		
	Malaysia	2017	Batu Embun	3 samples		
	Thailand	2014	Khao Yai National Park	3 samples		

*: Monitoring at Fukue, Nagasaki, is officially not included in POPsEA project but included in this table, for it is conducted by the Ministry of the Environment, Japan, together with the monthly monitoring at Hedo, Okinawa.
**: PCBs, PCDDs, PCDFs were not analyzed in Thailand.

Table 5.1.1–2 Summary for national air monitoring programs after 2nd Asia-Pacific Regional Monitoring Report

Sampling	Country	Period	Location	Number of site/sample (/year)	POPs	Remarks
Active	China	2014-2019	Throughout the nation	25 sites	PCDD/PCDFs, *dl*-PCBs, indicator PCBs, HBB, PBDEs (8 isomers), PeCBz, HCB, aldrin, dieldrin, endrin, DDTs (6 isomers), chlordanes (5 isomers), heptachlors (3 isomers), endosulfan I, II, mirex, HCHs (4 isomers), toxaphenes (3 isomers), PFOA, PFOS, HBCDs, chlordecone	Ministry of Ecology and Environment, China[14]
	Japan	FY2013-2018	Throughout the nation	433-681 sites	PCDD/PCDFs, *dl*-PCBs	Ministry of the Environment, Japan[17]
		FY2013-2018	Throughout the nation	34-37sites	Aldrin, chlordanes, DDTs, dieldrin, endrin, HCB, heptachlors, mirex, PCBs, toxaphenes, chlordecone, endosulfan, HBB, HBCDs, HCHs, PBDEs, PeCBz, PFOS, PFOA, dicofol, HCBD, PCA, PCP, SCCPs	From 2003 to 2013, monitoring was conducted twice a year (warm and cold seasons), but from 2014, monitoring was conducted only in warm season. Ministry of the Environment, Japan[16]

*: In Japan, monitoring methods for newly added POPs were developed during the reviewing process at POPRC and their monitoring frequently started before listing to the Annexes. Monitoring of POPs is conducted every year for priority POPs (such as PCBs) or newly added POPs, while once in every 2 to 6 years for others which are quite low levels (ND in many places) or show little changes if any due to domestic regulation (ban or restriction) enforced in few decades ago (such as many organochlorine pesticides).

5.1.1.1.1 The 12 initial POPs

(1) Aldrin

China is continuously monitoring aldrin in the air throughout the nation since 2007. The concentration of aldrin ranged from ND to 28.1 pg/m^3 during 2014-2019[14].

Aldrin has been analyzed together with other organochlorine pesticides in air samples in Japanese and East Asian POPs monitoring programs. After the development of the 2nd regional monitoring report, aldrin was only analyzed in FY2014 in Japanese national monitoring program[16] with a range from ND to 17 pg/m^3.For POPs Monitoring Project in East Asian Countries[15], aldrin was analyzed from 2014 to 2017 with a range from ND to 1.6 pg/m^3. Aldrin, however, was found to be unstable and showed always low recoveries in high volume sampling. Therefore, aldrin data in these monitoring should be considered as reference values only. Its low recovery is easily recognized by adding isotope-labelled aldrin as a surrogate before the sampling, but is overlooked when other chemicals, such as isotope-labelled dieldrin, is used as surrogate or when surrogate is added after the sampling. A collaborative research was conducted to clarify the reason and to improve the recovery in Korea-Japan bilateral program, but the reason is still not clarified yet[18].

Republic of Korea reported mean levels of aldrin to 0.059 and 0.10 pg/m^3 in 2015 and 2016 while ND for 2013, 2017 and 2018.

(2) Chlordane

Chlordanes (trans-chlordane, cis-chlordane, oxychlordane, trans-nonachlor, cis-nonachlor) have been analyzed in Chinese national monitoring program. The concentrations of trans-chlordane, cis-chlordane, oxychlordane, trans-nonachlor, cis-nonachlor) in the air during 2014-2019 were ND-34.4, ND-22.3, ND-20.5, 0.01-10.7 and ND-5.50 pg/m^3 , respectively[14].

Japan is monitoring chlordanes in the air throughout the nation (22 to 37 sites) since FY2002[16]. Since FY2009, the frequency of the monitoring was reviewed and were decided to be monitored once every few years, therefore, chlordanes were analyzed in FY2013, FY2015 and FY2016 after the development of the 2nd regional monitoring report. For *cis*-chlordane, the concentration was between 0.4 (quantification limit was 0.21 – 0.3) and 810 pg/m^3. POPs Monitoring Project in East Asian Countries is also monitoring chlordanes in the air at Cape Hedo (Okinawa Island) and Fukue (Goto Islands), which are background sites, since 2009 and 2014, respectively[15]. The concentration of *cis*-chlordane from 2014 to 2019 was between 0.4 and 21 pg/m^3.

POPs Monitoring Project in East Asian Countries is also monitoring chlordanes in the air at Cambodia, Lao People's Democratic Republic, Malaysia and Thailand from 2014 to 2017[15]. The concentrations vary with the countries (e.g., *cis*-chlordane:1.0–4.5 pg/m^3).

Republic of Korea reported chlordanes in Jeju Island from 2009 to 2018 (except 2014). The range of the annual mean levels of *trans*-chlordane, *cis*-chlordane, oxychlordane, trans-nonachlor and *cis*-nonachlor are reported as 0.93-3.5, 0.91-2.8, nd-0.42, 0.84-2.2, and 0.001-0.24 pg/m^3, respectively.

(3) DDT

China is continuously monitoring DDTs (*p,p'*-DDT, *p,p'*-DDD, *p,p'*-DDE, *o,p'*-DDT, *o,p'*-DDD, *o,p'*-DDE) in the air throughout the nation since 2007. The concentrations of *p,p'*-DDT, *p,p'*-DDD, *p,p'*-DDE, *o,p'*-DDT, *o,p'*-DDD, *o,p'*-DDE in the air during 2014-2019 were 0.0008-16.0, ND-23.8, 0.0009-373, 0.002-21.4, ND-49.90 and 0.0007-55.5 pg/m^3, respectively[14].

Japan is continuously monitoring DDT in the air throughout the nation (22 to 37 sites) since FY2002[16]. The concentration of *p,p'*-DDT from FY2013 to FY2018 was between 0.15 and 45 pg/m^3. POPs Monitoring Project in East Asian Countries is also monitoring DDT in the air at Cape Hedo (Okinawa Island) and Fukue (Goto Islands), which are background sites, since 2009 and 2014, respectively[15]. The concentration from 2014 to 2019 was between 0.09 and 1.3 pg/m^3.

POPs Monitoring Project in East Asian Countries is also monitoring DDT in the air at Cambodia, Lao People's Democratic Republic, Malaysia and Thailand from 2014 to 2017[15]. The concentration of *p,p'*-DDT varies with the countries (5.1–30 pg/m^3).

Republic of Korea reported DDTs in Jeju Island from 2009 to 2018 (except 2014). The range of the annual mean levels of *p,p'*-DDT, *p,p'*-DDE, *p,p'*-DDD, *o,p'*-DDT, *o,p'*-DDE and *o,p'*-DDD are reported as 0.16-3.1, 1.6-3.5, 0.06-1.3, 0.22-2.5, 0.15-1.1, and 0.13-0.97 pg/m^3, respectively.

(4) Dieldrin

China is continuously monitoring dieldrin in the air throughout the nation since 2007. The concentrations of Dieldrin ranged from ND to 33.6 pg/m^3 during 2014-2019[14].

Japan is monitoring dieldrin in the air throughout the nation (22 to 37 sites) since FY2002[16]. Since FY2009, the frequency of the monitoring was reviewed and were decided to be monitored once every few years, therefore, dieldrin was only analyzed in FY2014 after the development of 2nd regional monitoring report. The concentration was between 0.89 and 160 pg/m^3 in FY2014. POPs Monitoring

Project in East Asian Countries is also monitoring dieldrin in the air at Cape Hedo (Okinawa Island) and Fukue (Goto Islands), which are background sites, since 2009 and 2014, respectively[15]. The concentration from 2014 to 2019 was between 0.2 and 6.7 pg/m^3.

POPs Monitoring Project in East Asian Countries is also monitoring dieldrin in the air at Cambodia, Lao People's Democratic Republic, Malaysia and Thailand from 2014 to 2017[15]. The concentrations vary with the countries (1.3-6 pg/m^3).

Republic of Korea reported dieldrin in Jeju Island from 2009 to 2018 (except 2014). The range of the annual mean levels of dieldrin was reported as 0.5-3.6 pg/m^3.

(5) Endrin

China is continuously monitoring endrin in the air throughout the nation since 2007. The concentrations of endrin were ranged from ND to 7.80 pg/m^3 during 2014-2019[14].

Japan is monitoring endrin in the air throughout the nation (22 to 37 sites) since FY2002[16]. Since FY2009, the frequency of the monitoring was reviewed and were decided to be monitored once every few years, therefore, endrin was only analyzed in FY2014 after the development of 2nd regional monitoring report. The concentration was from ND (detection limit: 0.07 pg/m^3) to 2.9 pg/m^3 in FY2014. POPs Monitoring Project in East Asian Countries is also monitoring endrinin the air at Cape Hedo (Okinawa Island) and Fukue (Goto Islands), which are background sites, since 2009 and 2014, respectively[15]. The concentration from 2014 to 2019 was between ND (detection limits for 2014-2019: 0.02 – 0.04 pg/m^3) and 0.24 pg/m^3.

POPs Monitoring Project in East Asian Countries is also monitoring endrin in the air at Cambodia, Lao People's Democratic Republic, Malaysia and Thailand from 2014 to 2017[15]. The concentrations vary with the countries (ND-1.1 pg/m^3).

Republic of Korea reported endrin in Jeju Island from 2009 to 2018 (except 2014). The range of the annual mean levels of endrin was reported as nd-0.8 pg/m^3.

(6) Heptachlor

China is continuously monitoring heptachlor, trans-heptachlor epoxide and cis-heptachlor epoxide in the air throughout the nation since 2007. The concentrations of heptachlor, trans-heptachlor epoxide and cis-heptachlor epoxide in the air during 2014-2019 were ND-56.4, ND-1.16 and ND-21.4 pg/m^3, respectively[14].

Japan is monitoring heptachlor in the air throughout the nation (22 to 37 sites) since FY2002[16]. Since FY2013, the analysis of heptachlors are conducted once every few years (i.e. FY2013, FY2015 and FY2016). The concentration was between <0.16 and 120 pg/m^3. POPs Monitoring Project in East Asian Countries is also monitoring heptachlors in the air at Cape Hedo (Okinawa Island) and Fukue (Goto Islands), which are background sites, since 2009 and 2014, respectively [15]. The concentration from 2014 to 2019 was between 0.06 and 5.0 pg/m^3.

POPs Monitoring Project in East Asian Countries is also monitoring heptachlors in the air at Cambodia, Lao People's Democratic Republic, Malaysia and Thailand from 2014 to 2017[15]. The concentrations vary with the countries (0.3–4.9 pg/m^3).

Republic of Korea reported heptachlors in Jeju Island from 2009 to 2018 (except 2014). The range of the annual mean levels of heptachlor and *cis*-heptachlor epoxide was reported as 0.016-0.36 and 0.24-0.87 pg/m^3, respectively.

(7) HCB

China is continuously monitoring HCB in the air throughout the nation since 2007. The concentration of HCB ranged from 2.77 to 507 pg/m^3 during 2014-2019[14].

Japan is continuously monitoring HCB in the air throughout the nation (22 to 37 sites) since FY2002[16]. The concentration from FY2013 to FY2018 was between 52 and 550 pg/m^3. POPs

Monitoring Project in East Asian Countries is also monitoring HCB in the air at Cape Hedo (Okinawa Island) and Fukue (Goto Islands), which are background sites, since 2009 and 2014, respectively[15]. The concentration from 2014 to 2017 was between 49 and 280 pg/m^3. The detailed result is shown in Annex D.

POPs Monitoring Project in East Asian Countries is also monitoring HCB in the air at Cambodia, Lao People's Democratic Republic, Malaysia and Thailand from 2014 to 2017[15]. The concentrations vary with the countries (77– 360 pg/m^3).

Republic of Korea reported HCB in Jeju Island from 2013 to 2017 (except 2014). The range of the annual mean levels of HCB were reported as 59-163 pg/m^3.

(8) Mirex

China is continuously monitoring mirex in the air throughout the nation since 2007. The concentration of mirex ranged from 0.004 to 8.90 pg/m^3 during 2014-2019[14].

Japan is monitoring mirex in the air throughout the nation (22 to 37 sites) since FY2002[16]. Since FY2009, the frequency of the monitoring was reviewed and were decided to be monitored once every few years, therefore, mirex was only analyzed in FY2018 after the development of 2nd regional monitoring report. The concentration in FY2018 was between 0.05 and 0.2 pg/m^3. POPs Monitoring Project in East Asian Countries is also monitoring mirex in the air at Cape Hedo (Okinawa Island) and Fukue (Goto Islands), which are background sites, since 2009 and 2014, respectively[15]. The concentration from 2014 to 2019 was between 0.03 and 0.84 pg/m^3.

POPs Monitoring Project in East Asian Countries is also monitoring mirex in the air at Cambodia, Lao People's Democratic Republic, Malaysia and Thailand from 2014 to 2017[15]. The concentrations vary with the countries (0.28–2.2 pg/m^3).

Republic of Korea reported mirex in Jeju Island from 2009 to 2018 (except 2014). The range of the annual mean levels of mirex was reported as 0.1-0.27 pg/m^3.

(9) Toxaphene

China is continuously monitoring toxaphene in the air throughout the nation since 2010. The concentrations of toxaphene (P26, P50 and P62) in the air were below the detection limit during 2014-2019[14].

Japan is monitoring toxaphene in the air throughout the nation (22 to 37 sites) since FY2002[16]. Since FY2009, the frequency of the monitoring was reviewed and were decided to be monitored once every few years, therefore, toxaphene was only analyzed in FY2018 after the development of 2nd regional monitoring report. For example, the concentration of Parlar-26 in FY2018 was ND (detection limit: 0.2 pg/m^3). POPs Monitoring Project in East Asian Countries is also monitoring toxaphene in the air at Cape Hedo (Okinawa Island) and Fukue (Goto Islands), which are background sites, since 2009 and 2014, respectively[15]. The concentration of Parlar-26 from 2014 to 2019 was between ND and 0.3 pg/m^3.

POPs Monitoring Project in East Asian Countries is also monitoring toxaphene in the air at Cambodia, Lao People's Democratic Republic, Malaysia and Thailand from 2014 to 2017[15]. The concentrations vary with the countries (e.g., Parlar-26: ND-0.19 pg/m^3).

(10) PCBs

China is continuously monitoring indicator PCBs in the air throughout the nation since 2007. The concentrations of 6 indicator PCBs were 1.18 – 32.0 pg/m^3 during 2014-2019[14].

Japan is continuously monitoring PCBs in the air throughout the nation (22 to 37 sites) since FY2002[16]. The concentration from FY2013 to FY2018 was between 16 and 3,300 pg/m^3 (as sum of all PCBs congeners). POPs Monitoring Project in East Asian Countries is also monitoring PCBs in the air at Cape Hedo (Okinawa Island) and Fukue (Goto Islands), which are background sites, since

2009 and 2014, respectively[15]. The concentration of PCBs from 2014 to 2019 was from 21 to 130 pg/m^3 (as sum of all PCB congeners).

POPs Monitoring Project in East Asian Countries is also monitoring PCBs in the air at Cambodia, Lao People's Democratic Republic, Malaysia and Thailand from 2014 to 2017[15]. The concentrations vary with the countries (49 – 410 pg/m^3 (as sum of all PCB congeners)).

(11) PCDD/PCDFs and *dl*-PCBs

China is continuously monitoring PCDD/PCDFs and dl-PCBs in the air throughout the nation since 2007. During 2014-2019, the concentrations of PCDD/PCDFs 0.86-306 WHO-TEQ fg/m^3. The concentrations of 12 dioxin-like polychlorinated biphenyls (*dl*-PCBs) were 0.044 - 18.0 WHO-TEQ fg/m^3 [14].

Japan is continuously monitoring PCDD/PCDFs and *dl*-PCBs in the air throughout the nation (68 to 979 sites) since 1997[17] (see Table 5.1.1–3).

Table 5.1.1–3 PCDD/PCDFs and *dl*-PCBs concentrations in air from general sampling sites in Japan

FY	2013	2014	2015	2016	2017	2018
Average (pg-TEQ/m^3)	0.023	0.021	0.021	0.018	0.019	0.018
Range (pg-TEQ/m^3)	0.0029 - 0.20	0.0036 - 0.42	0.0042 - 0.49	0.0034 - 0.27	0.0033 - 0.32	0.0032 – 0.17
(Number of sites)	(666)	(645)	(660)	(642)	(629)	(619)

Note 1: WHO-TEF (2006) has been used.
Note 2: The toxicity equivalent is calculated by using the value of 1/2 of the detection limit, when the measured value of each isomer is below the detection limit.

Republic of Korea reported PCDD/PCDFs and *dl*-PCBs in Jeju Island from 2013 to 2018 (2017 for *dl*-PCBs). The range of annual mean levels of PCDDs and *dl*-PCBs were reported as nd-2.7 and nd-0.05 TEQ fg/m^3, respectively.

5.1.1.1.2 The new POPs listed atCOP4, COP5 and COP6

(1) Chlordecone

China reported chlordecone in Hong Kong SAR from 2011 to 2018. The concentrations of chlordecone were below the detection limits[14].
Monitoring Project in East Asian Countries is monitoring chlordecone in the air at Cape Hedo (Okinawa Island) and Fukue (Goto Islands), which are background sites since 2010 and 2014, respectively[15]. Chlordecone was not detected from 2014 to 2019. In Japanese national monitoring, chlordecone was also monitored occasionally but many of the data were below the detection limits.

Republic of Korea reported chlordecone in Jeju Island from 2013 to 2018. The range of the annual mean levels of chlordecone were reported as ND-0.16 pg/m^3.

(2) Endosulfan

In the Chinese national monitoring program, endosulfan I and endosulfan II have been monitored. The concentrations of endosulfan I and endosulfan II were 0.2-430 and ND-61.0 pg/m^3, respectively[14].

Japan has monitored endosulfan in the air throughout the nation (35 to 37 sites) in FY2011, FY2012 and 2014 to 2016[16]. The concentration of α-endosulfan from FY2014 to FY2016 was between 1.0 and 140 pg/m^3. POPs Monitoring Project in East Asian Countries is also monitoring endosulfan in the air at Cape Hedo (Okinawa Island) and Fukue (Goto Islands), which are background sites, since 2014[15]. The concentration of α-endosulfan from 2014 to 2019 was between 1.0 and 120 pg/m^3.

Republic of Korea reported endosulfans in Jeju Island from 2013 to 2018 (2014-2018 for endosulfan sulfate). The range of the annual mean levels of endosulfan I, endosulfan II and endosulfan sulfate were reported as 28-70, 3.7-21 and 0.29-6.1 pg/m^3, respectively.

(3) HBB

In the Chinese national monitoring during 2014-2019, the concentrations of polybrominated biphenyl (HBB) in the air were ND-0.11 pg/m^3, with a mean value of 0.03 pg/m^3, as well as ND-3.10 pg/m^3 and ND-0.12 pg/m^3 in the air from urban sites and rural sites, respectively[14].

Japan has monitored HBB in the air throughout the nation (35 to 37 sites) in FY2010, FY2011 and FY2015[16]. The concentration of HBB in FY2015 was between ND and 1.1 pg/m^3. The detailed results are shown in Annex D.

(4) HBCDs

China reported HBCDs in Hong Kong SAR in 2018. The concentrations of α-HBCD, γ-HBCD were 2.95-6.90 and 2.95-6.60 pg/m^3. The concentrations of β-HBCD were below detection limit[14].

Japan has monitored HBCDs in the air throughout the nation (36 to 37 sites) in FY2012 and FY2014 to FY2017[16]. The concentration of α-HBCD in FY2014 to FY2017 was between ND to 30 pg/m^3. POPs Monitoring Project in East Asian Countries is also monitoring HBCDs in the air at Cape Hedo (Okinawa Island) and Fukue (Goto Islands), which are background sites, since 2014[15]. The concentration of α-HBCD from 2014 to 2019 was between ND and 3.7 pg/m^3.

(5) HCHs

China is continuously monitoring HCHs in the air throughout the nation since 2010. During 2014-2019, the concentrations of α-HCH, β-HCH, γ-HCH, δ-HCH were 0.002-187, 0.0002-115, ND-33.7 and ND-29.1 pg/m^3, respectively[14].

Japan is continuously monitoring HCHs in the air throughout the nation (35 to 37 sites) since 2009[16]. The concentration of α-HCH from FY2013 to FY2017 was between 4.9 and 700 pg/m^3. POPs Monitoring Project in East Asian Countries is also monitoring HCHs in the air at Cape Hedo (Okinawa Island) and Fukue (Goto Islands), which are background sites, since 2009 and 2017, respectively[15]. The concentration of α-HCH from 2014 to 2019 was between 1.5 and 40 pg/m^3.

POPs Monitoring Project in East Asian Countries is also monitoring HCHs in the air at Cambodia, Lao People's Democratic Republic, Malaysia and Thailand from 2014 to 2017[15]. The concentrations vary with the countries (e.g., α-HCH: 8.8–720 pg/m^3).

Republic of Korea reported HCHs in Jeju Island from 20011 to 2018 (except 2014). The range of the annual mean levels of α-HCH, β-HCH and γ-HCH were reported as 5.7-14, 0.46-1.1 and 2.3-3.3 pg/m^3, respectively.

(6) PBDEs

China is continuously monitoring PBDEs in the air. During 2015-2019, the concentrations of eight PBDE congeners were mostly stable at 0.64-42.2 pg/m^3[14].

Japan is continuously monitoring PBDEs in the air throughout the nation (35 to 37 sites) sinceFY2009, except for FY2013[16]. The concentration of TeBDE from FY2014 to FY2018 was between ND and 28 pg/m^3. The detailed results are shown in Annex D. POPs Monitoring Project in East Asian Countries is also monitoring PBDEs in the air at Cape Hedo (Okinawa Island) and Fukue (Goto Islands), which are background sites, since 2010 and 2017, respectively[15]. The concentration from 2014 to 2019 was between 0.1 and 4.6 pg/m^3.

Republic of Korea reported PBDE isomers in Jeju Island from 2013 to 2018. For example, the range of the annual mean levels of BDE-47 and BDE-99 were reported as 0.17-1.7 and 0.04-1.5 pg/m^3, respectively.

(7) PeCBz

In the Chinese national monitoring program, PeCBz have been monitored. During 2014-2019, PeCBz concentrations were 1.0-69.0 pg/m^3 [14].

Japan is continuously monitoring PeCBz in the air throughout the nation (25 to 37 sites) since FY2007, except for FY2008[16]. The concentration from FY2013 to FY2018 was between 27 and 220 pg/m^3. POPs Monitoring Project in East Asian Countries is also monitoring PeCBz in the air at Cape Hedo (Okinawa Island) and Fukue (Goto Islands), which are background sites, since 2009 and 2017, respectively[15]. The concentration from 2014 to 2019 was between 17 and 200 pg/m^3.

POPs Monitoring Project in East Asian Countries is also monitoring PeCBz in the air at Cambodia, Lao People's Democratic Republic, Malaysia, and Thailand from2014to 2017[15]. The concentrations vary with the countries (53–540 pg/m^3).

Republic of Korea reported PeCBz in Jeju Island from 2013 to 2018 (except 2014). The range of the annual mean levels of PeCBz were reported as 58-113 pg/m^3.

(8) PFOS

China reported PFOS in Hong Kong SAR ranged from 0.20-23.0 pg/m^3 during 2014-2018[14].

Japan is continuously monitoring PFOS in the air throughout the nation (35 to 37 sites) since FY2010[16]. The concentration of PFOS from FY2013 to FY2017 was between 0.5 and 19.6 pg/m^3. POPs Monitoring Project in East Asian Countries is also monitoring PFOS in the air at Cape Hedo (Okinawa Island) and Fukue (Goto Islands), which are background sites, since 2010 and 2017, respectively[15]. The concentration from 2014 to 2019 was between ND and 17 pg/m^3.

5.1.1.1.3 The new POPs listed at COP7, COP8 and COP9

(1) Dicofol

Japan monitored dicofol in the air throughout the nation (37 sites) in FY2016[16]. The concentration of dicofol in FY2016 was between ND and 1.0 pg/m^3.

(2) HCBD

Japan is monitoring HCBD in the air throughout the nation (34 to 37 sites) since FY2015[16]. The concentration of HCBD from FY2015 to FY2018 was between 45 and 23,000 pg/m^3. POPs Monitoring Project in East Asian Countries is also monitoring HCBD in the air at Cape Hedo (Okinawa Island) and Fukue (Goto Islands), which are background sites, since 2016[15]. The concentration from 2016 to 2019 was between 300 and 16000 pg/m^3.

(3) PCNs

Japan is monitoring PCNs in the air throughout the nation (37 to 38 sites) since FY2014, except for FY2015[16]. The concentration of total PCNs from FY2014 to FY2018 was between 5.3 and 1,600 pg/m^3. POPs Monitoring Project in East Asian Countries is also monitoring PCNs in the air at Cape Hedo (Okinawa Island) and Fukue (Goto Islands), which are background sites, since 2016[15]. The concentration of PCN (mono chlorinated) from 2016 to 2019 was between 4.9 and 37 pg/m^3.

(4) PCP

Japan is monitoring PCP in the air throughout the nation (37 sites) since FY2016[16]. The concentration of PCP from FY2016 to FY2018 was between 0.6 and 33 pg/m^3. POPs Monitoring Project in East Asian Countries is also monitoring PCB in the air at Cape Hedo (Okinawa Island) and Fukue (Goto Islands), which are background sites, since 2016[15]. The concentration from 2016 to 2019 was between ND and 2.2 pg/m^3.

(5) PFOA

China reported PFOA in Hong Kong SAR ranged from 5.80-40.1 pg/m^3 during 2014-2018[14].

Japan is monitoring PFOA in the air throughout the nation (35 to 37 sites) since FY2013[16]. The concentration of PFOA from FY2013 to FY2017 was between 2.0 and 260 pg/m^3. POPs Monitoring Project in East Asian Countries is also monitoring PFOA in the air at Cape Hedo (Okinawa Island) and Fukue (Goto Islands), which are background sites, since 2014[15]. The concentration from 2016 to 2019 was between 1.6 and 120 pg/m^3.

(6) SCCPs

Japan is monitoring SCCPs in the air throughout the nation (37 sites) since FY2016[16]. The concentration of SCCPs from FY2016 to FY2018 was between ND and 5,700 pg/m^3. POPs Monitoring Project in East Asian Countries is also monitoring SCCPs in the air at Cape Hedo (Okinawa Island) and Fukue (Goto Islands), which are background sites, since 2017[15]. The concentration from 2016 to 2019 was between 130 and 1,500 pg/m^3.

5.1.1.2 POPs monitoring by passive sampling

The UNEP/GEF GMP2 projects for the implementation of the POPs monitoring plan under the Stockholm Convention, have been conducted in Asia and Pacific sub-regions. During the project, POPs monitoring in the background air by passive samplers were conducted (Figure 5.1.1–1). The data will provide baselines for assessing the effectiveness in these sub-regions in future.

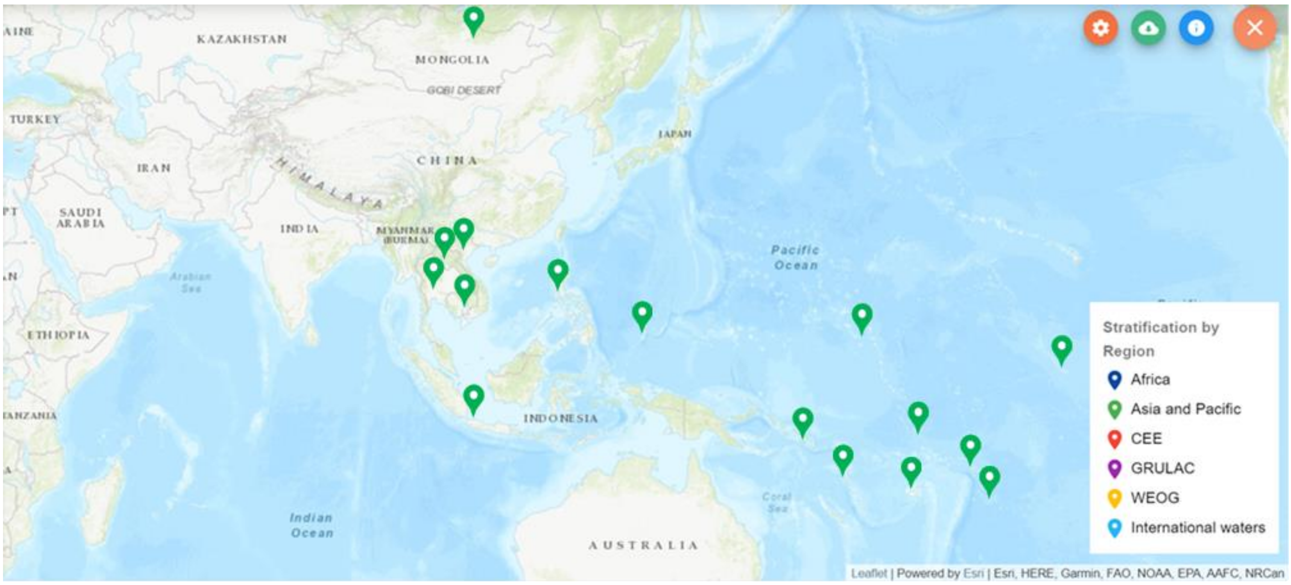


Figure 5.1.1–1 Map of air sampling locations by UNEP/GEF GMP2 projects.

5.1.2 Human tissues (milk and blood)

5.1.2.1 Milk

Only the data not included in the previous regional reports are summarized here. In the Asia-Pacific Region, several international and national POPs human milk monitoring programs are available in the GMP-3 period (see Table 5.1.2–1 and Figure 5.1.2–1).

As part of the UNEP/GEF GMP-2 capacity building program in East Asia and Pacific Islands, human breast milk sampling was conducted in Cambodia, Mongolia, Thailand, Vietnam (East Asia), Fiji, Kiribati, Marshall Islands, Niue, Palau, Samoa, Solomon Islands, Tuvalu and Vanuatu (Pacific Islands), and pooled samples in each country was analyzed of all the POPs contents (both original and newly added POPs).

POPs concentrations in human milk in China were reported by the research project entitled "A study of the level of POPs in human milk in Macao SAR" during 2013-2014[14].

POPs concentrations in human milk in Japan were reported by the research supported by a governmental research grant (Oka et al. 2014, 2015, 2016, 2017, 2018 and 2019).

Table 5.1.2–1 Summary of human milk monitoring programs in Asia-Pacific

Country	Period	Location	Number of samples/sites (/year)	POPs	Remarks
China	2013-2014	Macao SAR	pooled	β-HCH, *cis*-heptachlor epoxide, *cis*-chlordane, *cis*-nonachlor, endosulfan sulfate, DDTs (6), PeCB, HCB, indicator PCBs, PBDEs (total), PCDD/PCDFs, *dl*-PCBs	Data is not included in the 2nd regional monitoring report
Japan	2013-2018		19-30 samples	PCDD/PCDFs, *dl*-PCBs	Oka et al. (2014, 2015, 2016, 2017, 2018, 2019)[19,20,21,22]
Cambodia	2019		pooled	Aldrin, HCHs (3), DDTs (6), chlordanes (5), mirex, endrin, dicofol, dieldrin, heptachlors (3), HBCD (3), chlordecone, PCBs (7), endosulfan (I, II, sulfate), HCB, HCBD, PCP, PCA, PBDEs, PeCBz, PCDDs, PCDFs, *dl*-PCBs, SCCPs, toxaphenes (3)	WHO milk survey
Fiji	2019		pooled	(same as above)	WHO milk survey
Kiribati	2018		pooled	(same as above)	WHO milk survey
Marshall Islands	2019		pooled	(same as above)	WHO milk survey
Mongolia	2018		pooled	(same as above)	WHO milk survey
Niue	2017		pooled	(same as above)	WHO milk survey
Palau	2018		pooled	(same as above)	WHO milk survey
Samoa	2019		pooled	(same as above)	WHO milk survey
Solomon Islands	2019		pooled	(same as above)	WHO milk survey
Thailand	2018		pooled	(same as above)	WHO milk survey
Tuvalu			pooled	(same as above)	WHO milk survey
Vanuatu	2018		pooled	(same as above)	WHO milk survey
Vietnam	2019		pooled	(same as above)	WHO milk survey

Note: Human milk sample in Tuvalu is not yet analyzed.

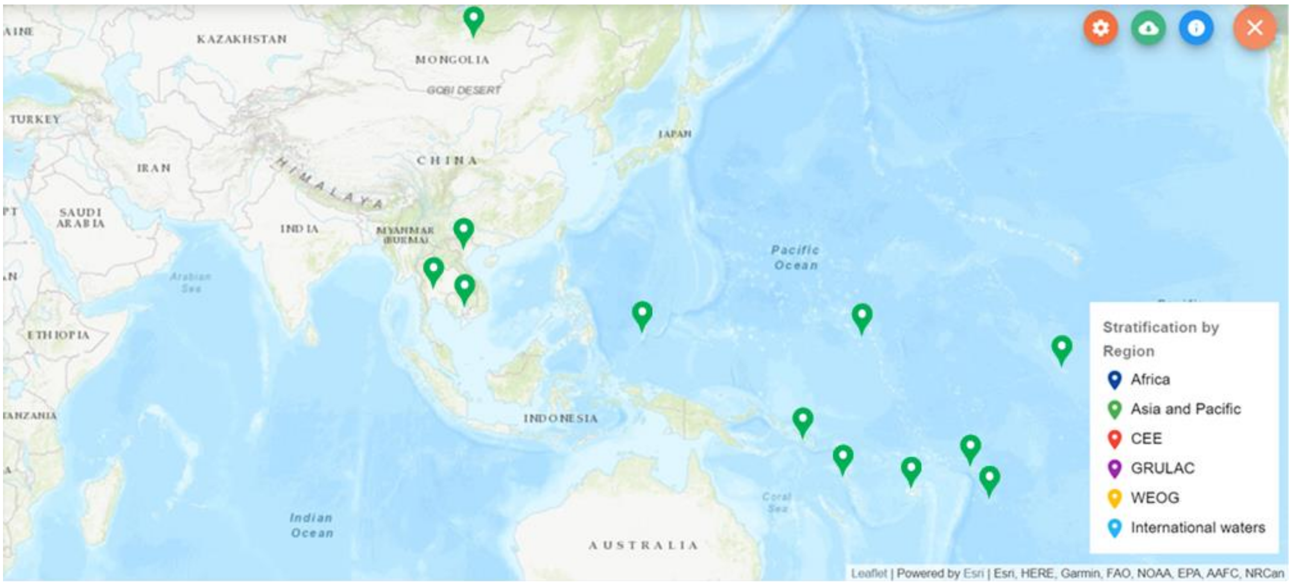


Figure 5.1.2–1 Map of human milk sampling locations by UNEP/GEF GMP2 projects.

POPs concentrations in human milk surveyed through UNEP/GEF GMP-2 program in East Asia and Pacific Islands are summarized in Annex E.

China reported POPs concentrations in human milk from Macao SAR. Twenty six pesticides POPs were determined. β-HCH, cis-heptachlor epoxide, cis-chlordane, cis-nonachlor, endosulfan sulfate, *o,p'*-DDE, *p,p'*-DDE, *p,p'*-DDD, *o,p'*-DDT, *p,p'*-DDT, PeCB and HCB were detectable. The concentrations of indicator PCBs and total PBDEs were 14.9 and 3.89 pg/g lipid weight, respectively. The concentrations of PCDD/PCDFs and *dl*-PCBs were 5.1 and 2.7 pg WHO-TEQ/g lipid weight, respectively[14].

In Japan, concentrations of PCDD/PCDFs and *dl*-PCBs in breast milk collected from 2013 to 2018 are reported by Oka et al. (2016, 2017, 2018 and 2019). The concentrations of PCDDs, PCDFs and *dl*-PCBs ranged from1.0 to 11 pg TEQ/g fat, from 0.5 to 5.4 pg TEQ/g fat and from 1.0 to 10.3 pg TEQ/g fat, respectively.

5.1.2.2 Blood

In Japan, national monitoring program on human blood is performed (see Table 5.1.2–2).

Table 5.1.2–2 Summary for national human blood monitoring programs which was collected after the 2nd Asia-Pacific Regional Monitoring Report.

country	period	Location	number of samples	POPs	Remarks
Japan	FY2013-2016	2-3 locations	76-83 samples	PCDD/PCDFs, *dl*-PCBs, PFOS, PFOA, PFHxS	Ministry of the Environment, Japan[23]

In Japan, there is a project conducted by the Ministry of Environment, Japan which is monitoring POPs in human blood since 2002[23]. From FY2013 to FY2016, the project targeted following POPs: PCDDs, PCDFs, *dl*-PCBs, PFOS, PFOA and PFHxS. The concentrations of PCDD/PCDFs and *dl*-PCBs ranged from 0.01 to 22 pg-TEQ/g fat and from 0.05 to 28 pg-TEQ/g fat, respectively. The concentrations of PFOS, PFOA and PFHxS ranged from 290 to 16,000 ng/L, from 27 to 13,000 ng/L and from ND to 1,800 ng/L, respectively.

5.1.3 Water

In the Asia-Pacific Region, several POPs monitoring programs for PFOS and PFOA in water are available (see Table 5.1.3–1 and Figure 5.1.3–1).

China monitored PFOS in the waters (lake and coastal) during 2014-2019. The concentrations of PFOS in Taihu Lake and Qinghai Lake ranged from ND to 13ng/L, and the concentrations of PFOS in marine water (Yellow Sea, Bohai Sea and South China Sea) ranged from ND to 6 ng/L. The PFOS level in marine water of Hong Kong SAR, China (South China Sea) continues to be low, largely below the reporting limit of 2.0 ng/L in 2014 to 2018[14].

Japan is continuously monitoring PFOS and PFOA in the waters (river, estuary, coastal and lake) throughout the nation since FY2009[16]. The concentrations of PFOS and PFOA from FY2014 to FY2018 (except for FY2017) were from ND to 14,000 pg/L and from 140 to 28,000 pg/L, respectively.

Table 5.1.3–1 Summary for water monitoring programs

Country	Period	Location	Number of samples/sites	POPs	Remarks
China	2014, 2016, 2018, 2019	Throughout the nation (lake and coastal)	26 sites	PFOS	Ministry of Ecology and Environment China[14]
Japan	FY2014-2016, 2018	Throughout the nation (river, estuary, coastal, lake)	47-48 sites/year	PFOS, PFOA	Ministry of the Environment, Japan[16]
Mongolia	2017-2018			PFOS, PFOA, PFHxS	UNEP/GEF GMP2 Project
Viet Nam	2017-2019				
Fiji	2017-2019				
Kiribati	2017-2019				
Niue	2017				
Palau	2017-2018				
Solomon Islands	2017-2018				
Tuvalu	2017-2018				
Vanuatu	2017-2019				
Samoa	2017-2019				
Marshall Islands	2018				

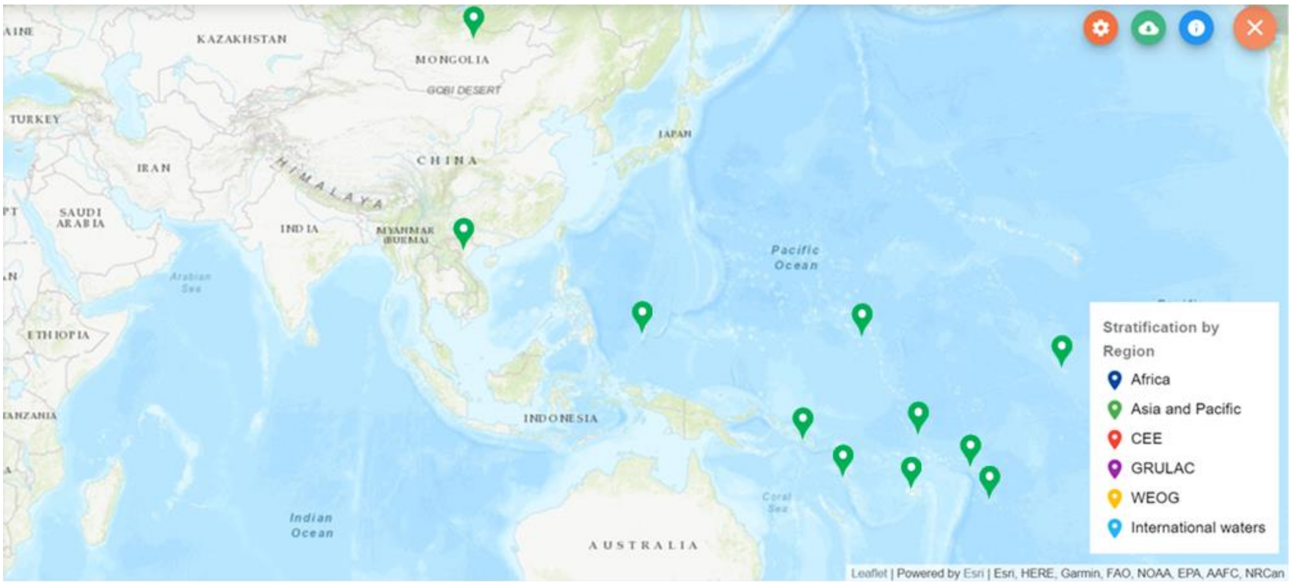


Figure 5.1.3–1 Map of water sampling locations by UNEP/GEF GMP2 projects.

5.1.4 Other media

5.1.4.1 Other POPs in water

Japan is continuously monitoring POPs in the water throughout the nation since FY2002[16]. Concentrations of following POPs are measured in the monitoring survey: aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, HCB, mirex, toxaphene, PCBs, chlordecone, endosulfan, HBB, HBCD, HCHs, PeCBz, PBDEs, HCBD, PCA, PCNs, PCP, PFHxS and SCCPs. However, aldrin, chlordecone and HBB were not measured in FY2013-FY2018. There is another program from Ministry of Environment, Japan which is monitoring PCDD/PCDFs and dl-PCBs in public water including water from river, lake, estuary and coastal sea as well as ground-water in Japan throughout the nation (public water: 204 to 2,213 sites; groundwater: 188 to 1,479 sites) since FY1998. From FY2013 to FY2017, number of monitoring sites for public water and ground-water ranged from 1,442 to 1,537 and from 498 to 556, respectively[17]. Details are shown in Annex H.1.

5.1.4.2 Bottom sediment

Japan is continuously monitoring POPs in the bottom sediment in water throughout the nation since FY2002[16]. Concentrations of following POPs are measured in the monitoring project: aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, HCB, mirex, toxaphene, PCBs, chlordecone, endosulfan, HBB, HBCD, HCHs, PBDEs, PeCBz, PFOS, HCBD, PCA, PCNs, PCP, PFHxS, PFOA and SCCPs. However, chlordecone was not measured from 2013 to 2018. There is another program by Ministry of Environment, Japan which is monitoring PCDD/PCDFs and *dl*-PCBs in bottom sediment in water in Japan throughout the nation (205 to 1,836 sites) since 1998 (for 2013 to 2017, number of monitoring sites ranged from 1,197 to 1,247)[17]. Also, concentrations of chlordane, DDTs, endosulfan, HBCDs, HCHs, PCBs, PBDEs, PCDD/PCDFs, *dl*-PCBs, PFOA and PFOS in sediment from marine environment surrounding Japan is reported[24]. Japan Coast Guard is continuously monitoring PCBs in the bottom sediment marine water in inner bay since 1974[25]. Details are shown in Annex H.2.

5.1.4.3 Soil

Japan is continuously monitoring PCDD/PCDFs and *dl*-PCBs in the soil throughout the nation (286 to 3,735 sites) since 1998 (for 2013 to 2017, number of monitoring sites ranged from 833 to 921) [17]. Details are shown in Annex H.3.

5.1.4.4 Biota

Japan is continuously monitoring POPs concentrations in fish, shellfish, and birds throughout the nation[16]. Concentrations of following POPs are measured in the monitoring project: aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, HCB, mirex, PCBs, toxaphene, chlordecone, endosulfan, HBB, HBCD, HCHs, PBDEs, PeCBz, PFOS, HCBD, dicofol, PCA, PCNs, PCP, PFOA and SCCPs. However, chlordecone was not measured from 2013 to 2018. In addition, concentrations of PCBs, PCDD/PCDFs, and *dl*-PCBs in marine biota (mussels, benthic sharks, squids, cods and crustaceans) are reported since 1998[24]. Details are shown in Annex H.4.

5.1.4.5 Food

Concentrations of dioxins from food, livestock products and marine products in Japan is reported in surveys conducted by Ministry of Environment, Japan[23] and Ministry of Agriculture, Forestry and Fisheries, Japan[26]. In addition, survey on daily intake of dioxins is conducted with grants from Ministry of Health, Labor and Welfare, Japan[27]. Details are shown in Annex H.5.

5.2 Review and discussion

Temporal trend of POPs level is discussed in this section based on the data from 1st to 3rd phase Asia-Pacific Regional Monitoring Report. Generally speaking, concentration of POPs in the environment is expected to decrease after the establishment of relevant regulations. Especially POPs in the ambient air are considered to respond to the change in the primary emission source rather promptly. Their decreasing trends, however, will slow down and eventually be hardly detectable after certain period of time, because released POPs will eventually distribute in various environmental media in equilibrium and circulate among them continuously. For initial POPs, it has been a while since many countries have already regulated its production and use, and the changes in the concentrations in the environment has become smaller. For example, in Japan, use of PCBs has been regulated since 1972, and while its significant reduction tendency was seen in biota from the 1970s to the 1980s, change in concentrations became smaller after the 1990s. On the other hand, for the new POPs, significant change in environmental concentrations is expected to be seen after the implementation of regulation. In this section, based on the data gathered in the 1st, 2nd and 3rd phase of GMP, the result of the analyzed trend will be organized for each core media.

The trend analysis is conducted primarily by the statistical analysis tools equipped in the Data Warehouse of the Stockholm Convention, and the results are summarized below. Typical example with clear tendencies is shown below. In Japanese national POPs monitoring program[16], on the other hand, different statistical analyses have been conducted and reported in recent years to detect significant temporal trends in the data. The analysis employed the following three statistical analyses, i.e., (1) maximum likelihood estimation method based on Akaike's Information Criterion (AIC), (2) test of differences in mean values by bootstrap method, and (3) analysis of inter-annual trends based on detection frequencies. Detailed description of these analytical methods and the criteria to apply either of the three methods to each data are given in Annex I (p. 86~90 in the Annex of the 3rd Regional Monitoring Report). In the result of maximum likelihood estimation method, an estimated half-life and its range is given to the data when a significant temporal trend is detected. In the following section, the results of these statistical analysis to the POPs levels in various environmental media are summarized.

5.2.1 Ambient air

5.2.1.1 Trends at background air monitoring stations in East Asia

There are three background air monitoring stations in the POPsEA project, i.e., Cape Hedo in Okinawa (Japan; FY2009 to FY2018: please note that fiscal year (FY) is from April to next March in Japan), Jeju Island (Republic of Korea; 2009 to 2018), and Fukue in Goto Islands, Nagasaki (Japan; FY2014 to FY2018), where a monthly POPs monitoring by high volume air samplers have been conducted (in Fukue, the monthly monitoring has been conducted only half a year including winter season in recent couple of years).

Outline of trends in the background monitoring stations at Hedo and Fukue are summarized in Table 5.2.1–1. It should be pointed out that the data show fairly large variations, due to seasonal changes of temperatures as well as prevailing wind directions as the result of Asian Monsoon. As a result, small annual trends are modulated with large seasonal variations, and it is not easily extract annual trends. Even in this condition, clear decreasing trends of DDTs had been observed in GMP-2 period from FY2009 to FY2013 at Hedo (2nd Regional Report in 2014). Both total DDTs (sum of all the six isomers/metabolites) and (*p,p'*-DDT+*o,p'*-DDT)/total DDTs showed clear decreasing trends, suggesting the decrease of newly released DDT in the East Asian sub-region. Similar decreasing tendencies of total DDTs as well as isomers and their metabolites are observed in GMP-3 period (FY2014-FY2018) at both Hedo and Fukue, although they are not statistically significant except for *p,p'*-DDE at Hedo and *o,p'*-DDT at Fukue. Decreasing trends of total DDTs as well as the isomers/metabolites at Hedo are judged as statistically significant if all the data until 2018 are analyzed together.

Similarly, all the isomers of HCHs at Hedo showed statistically significant decreasing trends when all the data through GMP-2 and GMP-3 were analyzed. All HCHs at both Hedo and Fukue showed decreasing tendencies within GMP-3 period, although none of them are judged as statistically significant. In addition to DDTs and HCHs, dieldrin also showed statistically significant decreasing trend at Fukue while insignificant decreasing tendency at Hedo. Chlordanes and heptachlors also show generally decreasing tendencies at both Hedo and Fukue, although only *cis*-heptachlor epoxide at both sites and oxychlordane at Hedo were judged as statistically significant.

HCB and PeCBz seem to behave differently between Hedo and Fukue. At Fukue, both HCB and PeCBz seem to decrease (only PeCBz was judged as statistically significant). On the other hand, HCB is rather stable and PeCBz shows increasing tendencies, though not statistically significant at Hedo. Their median levels are similar at both sites. Both PFOS and PFOA do not show clear tendencies at Hedo and Fukue. It should be pointed out that both perfluoro-chemicals behave as if they are volatile, i.e., passing through quartz fiber filter (QFF) and PUF and trapped in ACF (active carbon fiber), and also that their levels at Hedo and Fukue are among the lowest group in all over Japan, suggesting that the data at Hedo and Fukue will represent regional background instead of sum of local emission sources. As for other POPs, tendencies are not clear due to short period of monitoring or too many ND data.

Analysis of newly added POPs, including PBDEs, HBCDs, PCPs and SCCPs, were also started, and the data will be used as baseline data for the assessment of the effectiveness of the Convention in future. Among them, HCBD increased sharply and will be discussed later in this section.

Table 5.2.1–1 Summary of trend analysis for the background air POPs monitoring in Japan

Substance groups	Substances	Hedo, Okinawa			Fukue Goto		
		Data period	Mean (pg/m^3)	Trends	Data Period	Mean (pg/m^3)	Trends
PCBs	Total PCBs	FY2010-2018	49	↑	FY2014-2018	39	
HCB	HCB	FY2009-2018	110	–	FY2014-2018	110	–
Aldrin	Aldrin	*(FY2009-2018)*	*	*	*(FY2014-2018)*	*	*
Dieldrin	Dieldrin	FY2009-2018	1.1	–	FY2014-2018	0.84	↓
Endrin	Endrin	FY2009-2018	0.069	–	FY2014-2018	0.040	–
DDTs	*p,p'*-DDT	FY2009-2018	0.46	↓	FY2014-2018	0.23	–
	p,p'-DDE	FY2009-2018	0.96	↓	FY2014-2018	0.75	–
	p,p'-DDD	FY2009-2018	0.06	↓	FY2014-2018	0.040	–
	o,p'-DDT	FY2009-2018	0.39	↓	FY2014-2018	0.23	↓
	o,p'-DDE	FY2009-2018	0.16	↓	FY2014-2018	0.12	–
	o,p'-DDD	FY2009-2018	0.061	↓	FY2014-2018	0.050	–
Chlordanes	*Cis*-chlordane	FY2009-2018	3.2	–	FY2014-2018	1.7	–
	Trans-chlordane	FY2009-2018	3.3	–	FY2014-2018	1.8	–
	Oxychlordane	FY2009-2018	0.38	↓	FY2014-2018	0.21	–
	Cis-nonachlor	FY2009-2018	0.36	–	FY2014-2018	0.18	–
	Trans-nonachlor	FY2009-2018	2.9	–	FY2014-2018	1.4	–
Heptachlors	Heptachlor	FY2009-2018	0.68	–	FY2014-2018	0.30	–
	Cis-heptachlor epoxide	FY2009-2018	0.42	↓	FY2014-2018	0.31	↓
	Trans-heptachlor epoxide	FY2009-2018	<loq	**	FY2014-2018	<loq	**
Toxaphenes	Parlar-26	FY2009-2018	<loq	**	FY2014-2018	<loq	**
	Parlar-50	FY2009-2018	<loq	**	FY2014-2018	<loq	**
	Parlar-62	FY2009-2018	<loq	**	FY2014-2018	<loq	**
Mirex	Mirex	FY2009-2018	0.14	–	FY2014-2018	0.076	–
HCHs	*α*-HCH	FY2009-2018	9.0	↓	FY2014-2018	5.3	–
	β-HCH	FY2009-2018	0.71	↓	FY2014-2018	0.40	–
	γ-HCH (lindane)	FY2009-2018	1.9	↓	FY2014-2018	1.1	–
PBDEs (Br_4 – Br_{10})	TeBDEs						
	PeBDEs						
	HxBDEs						
	HpBDEs						
	OcBDEs						
	NoBDEs						
	DeBDEs	FY2014-2018	<loq	–	FY2014–2018	4.5	–
PFOS	PFOS	FY2014-2018	5.4	–	FY2014–2018	2.8	–
PFOA	PFOA	FY2014-2018	7.9	–	FY2014–2018	12	–
PeCBz	PeCBz	FY2011-2018	53	–	FY2014–2018	66	↓
Chlordecone	Chlordecone	FY2010-2018		**	FY2014–2018		**
HBCDs	*α*-HBCD	FY2014-2018	0.28	–	FY2014-2018	0.83	–
	β-HBCD	FY2014-2018	<loq	–	FY2014-2018	0.30	–
	γ-HBCD	FY2014-2018	0.35	–	FY2014-2018	0.80	–
Endosulfans	*α*-endosulfan (I)	FY2014-2018	12	–	FY2014-2018	4.8	↓
	β-endosulfan (II)	FY2014-2018	0.85	–	FY2014-2018	0.60	↓
PCPs	PCP	FY2016-2018	0.80	***	FY2016-2018	0.78	***
	PCA	FY2016-2018	6.8	***	FY2016-2018	5.5	***
PCNs	PCNs	FY2016-2018	13	***	FY2016-2018	23	***
HCBD	HCBD	FY2016-2018	3000	***	FY2016-2018	3300	***
SCCPs	SCCPs	FY2017-2018	520	***	FY2017-2018	270	***

*: not reliable due to low recoveries
**: too many ND data to extract trends
***: too short periods to extract trends

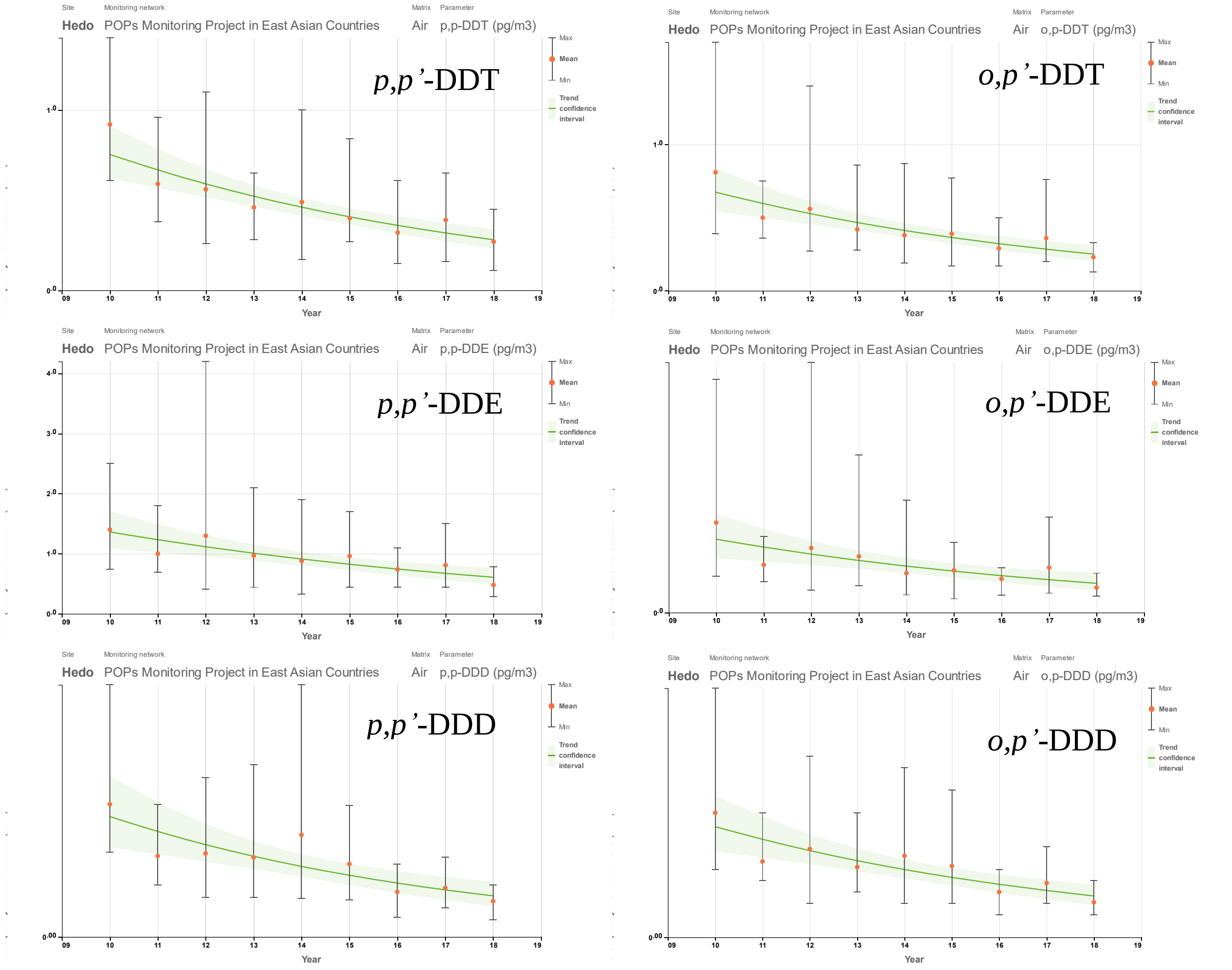


Figure 5.2.1–1 Trends of DDTs at Hedo, Okinawa, Japan.

The data in the first year (2009) was omitted from the analysis because the sampling started in April 2009 according to Japanese fiscal year system (April until next March).

All show statistically significant decreasing trends. For example,

- *p,p'*-DDT Mann-Kendall test: -0.8889 (P=0.0002); Daniels test: -0.9667 (P=0.0002)
- *o,p'*-DDT Mann-Kendall test: -0.8333 (P=0.0009); Daniels test: -0.95 (P=0.0004)

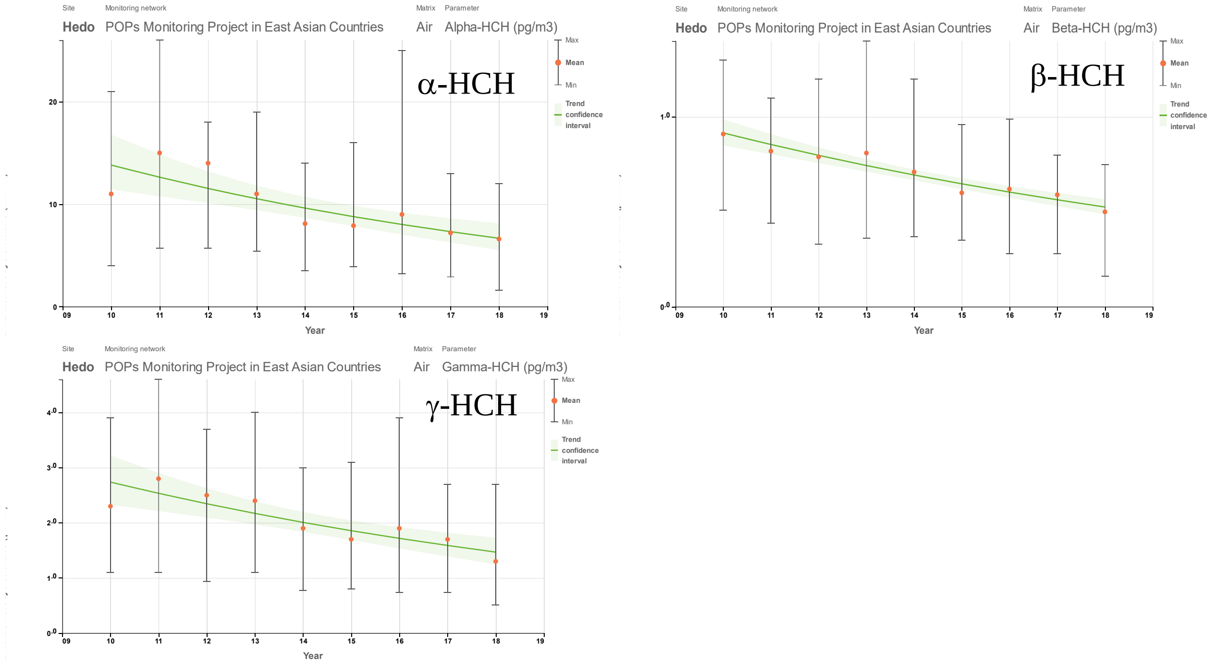


Figure 5.2.1–2 Trends of HCHs at Hedo, Okinawa, Japan, during GMP-2 and GMP-3 periods.

All show statistically significant decreasing trends. For example,

- γ-HCH Mann-Kendall test: -0.7432 (P=0.0061); Daniels test: -0.8572 (P=0.0031)

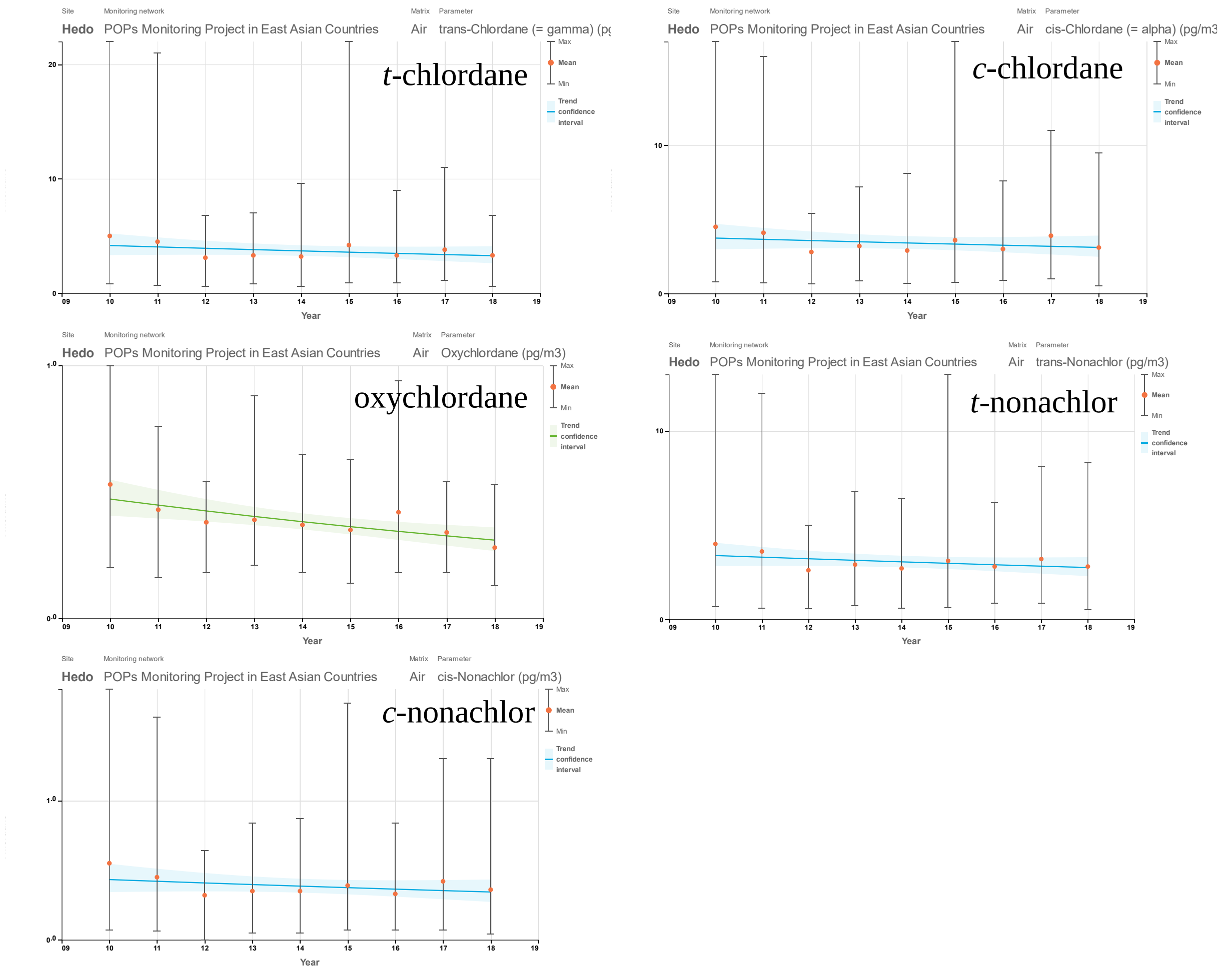


Figure 5.2.1–3 Trends in chlordanes at Hedo, Okinawa, Japan.

Oxychlordane shows statistically significant decrease.

- Oxychlordane Mann-Kendall test: -0.7222 (P=0.0059); Daniels test: -0.8167 (P=0.0108)

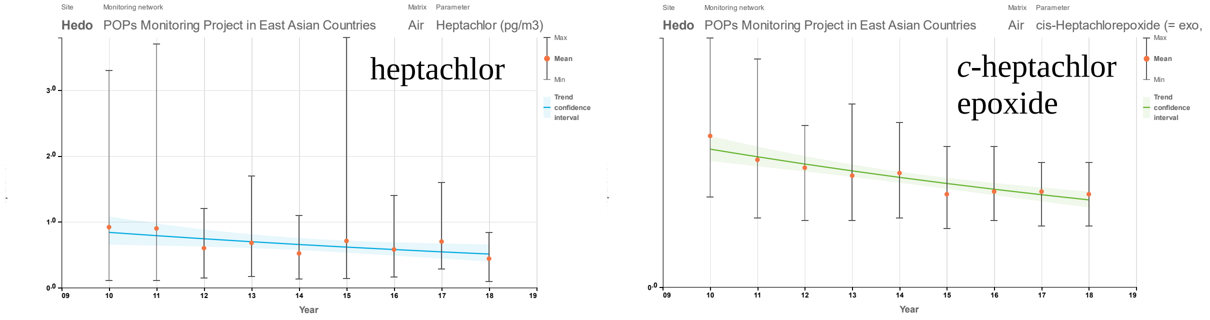


Figure 5.2.1–4 Trends in heptachlors at Hedo, Okinawa, Japan during GMP-2 and GMP-3 periods. *Cis*-heptachlor epoxide shows statistically significant decreasing trends.

- *Cis*-heptachlor epoxide Mann-Kendall test: -0.8003 (P=0.0032); Daniels test: -0.9073 (P=0.0007)

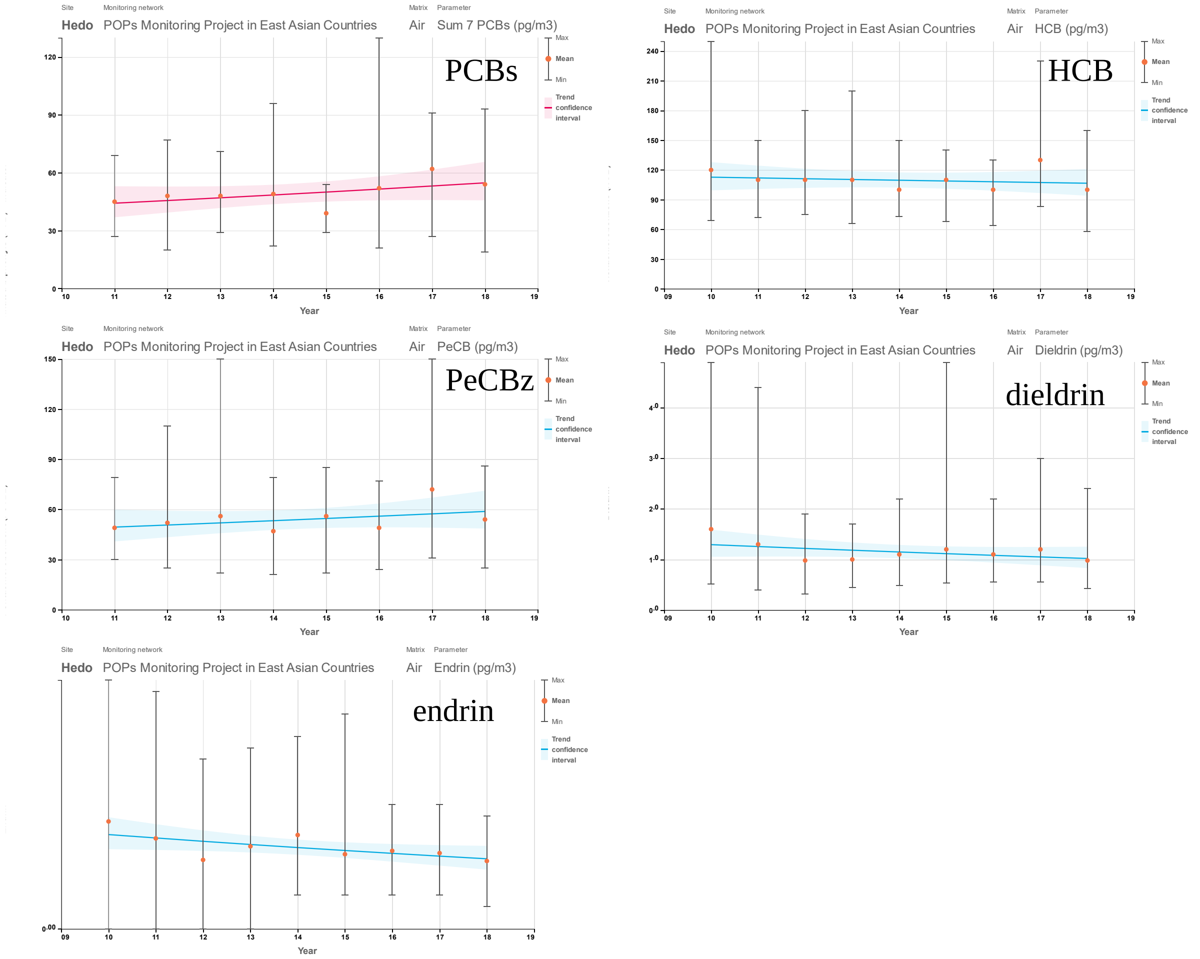


Fig. 5.2.1–5 PCBs, HCB, PeCBz, dieldrin and endrin at Hedo, Okinawa.

PCBs showed statistically significant increasing trends. PeCBz, although not significant, also showed an increasing tendency while dieldrin and endrin decreasing tendencies.

- Total PCBs Mann-Kendall test: 0.6183 (P=0.034); Daniels test: 0.7306 (P=0.0396)

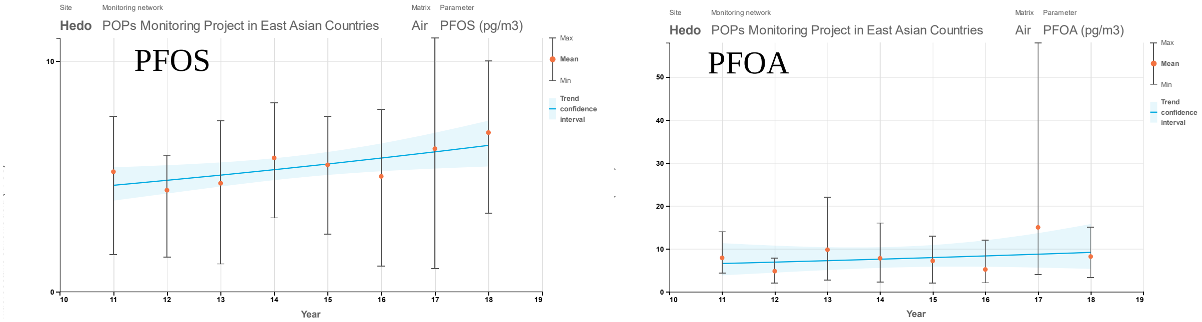


Figure 5.2.1–6 PFOS and PFOA in Hedo, Okinawa.
Although not statistically significant, both seemed to show increasing tendencies in recent years.

HCBDs in Japan

Although the monitoring periods are not long enough for assessing statistical significance of the trend, hexachlorobutadiene (HCBD) levels in the air seem to increase dramatically in recent couple of years. Figure 5.2.1-7 summarizes the available data on HCBD in Japan, including the two background monitoring as well as national monitoring. Black bar with dotted line and additional upper/lower bars represent national monitoring data in each fiscal year (bold bar represents median while thinner bars show maximum and minimum values). Small dots around March 2014, shows additional ambient air data obtained by the same sampling/analytical methods obtained during method development stage. On the other hand, blue open circles show monthly data at Hedo while orange circles at Fukue (only winter seasons). From the data, it seemed that HCBD levels around Japan were 800 to 1,000 pg/m^3 until Spring 2017 when sudden and dramatic increase started at background monitoring stations. Same trends observed in the national monitoring in Japan in FY2017 and FY2018 (both conducted in late Summer to Autumn) as well as in the monthly background monitoring at Hedo and Fukue. Although large variations of data were observed, the median levels seem to be rather similar among the national monitoring and the two background monitoring in each fiscal year, suggesting the occurrence of large-scale emission of HCBD which spreads in wide areas covering the whole Japan islands from Spring 2017 when it was decided at COP-8 to list HCBD in Annex C of the Stockholm Convention.

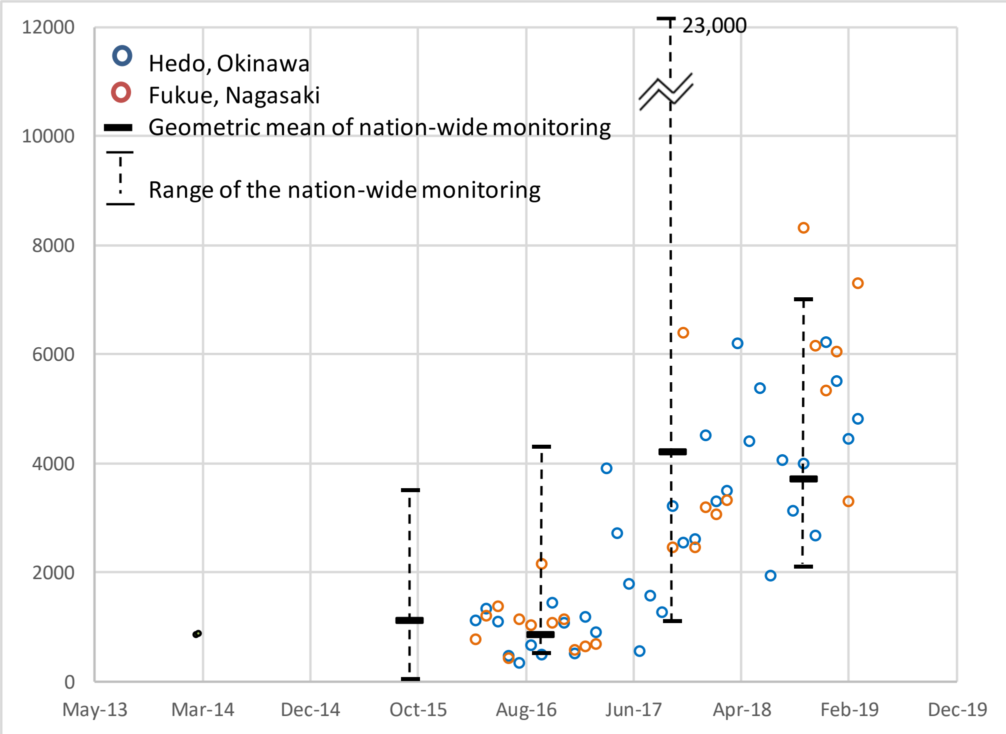


Figure 5.2.1–7 HCBD levels in the nation-wide monitoring and background monitoring stations in Japan.

Note that range of nation-wide monitoring was based on individual data (not three days average) while data in background stations were three days average in each month.

Other POPs levels in Hedo and Fukue are either too small (including many ND data) or too short period to reveal their trends.

5.2.1.2 Temporal trends of POPs levels in the air of Jeju Island, Republic of Korea

Republic of Korea has been conducting monthly background air monitoring at Gosan, Jeju Island. Again, a clear decreasing trends with statistical significance were observed on *p,p'*-DDT and *o,p'*-DDT (Figure 5.2.1–8) as well as some of their metabolites, indicating that input of new DDT in East Asia is decreasing in a recent decade.

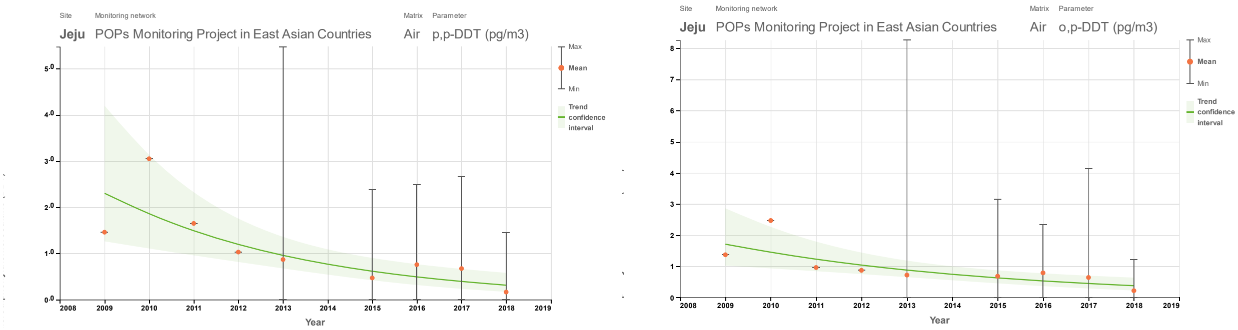


Figure 5.2.1–8 Temporal trends of *p,p'*-DDT (left) and *o,p'*-DDT (right) at Jeju Island, R. Korea.

Chlordanes levels at Jeju Island, on the other hand, seem to be increasing recently.

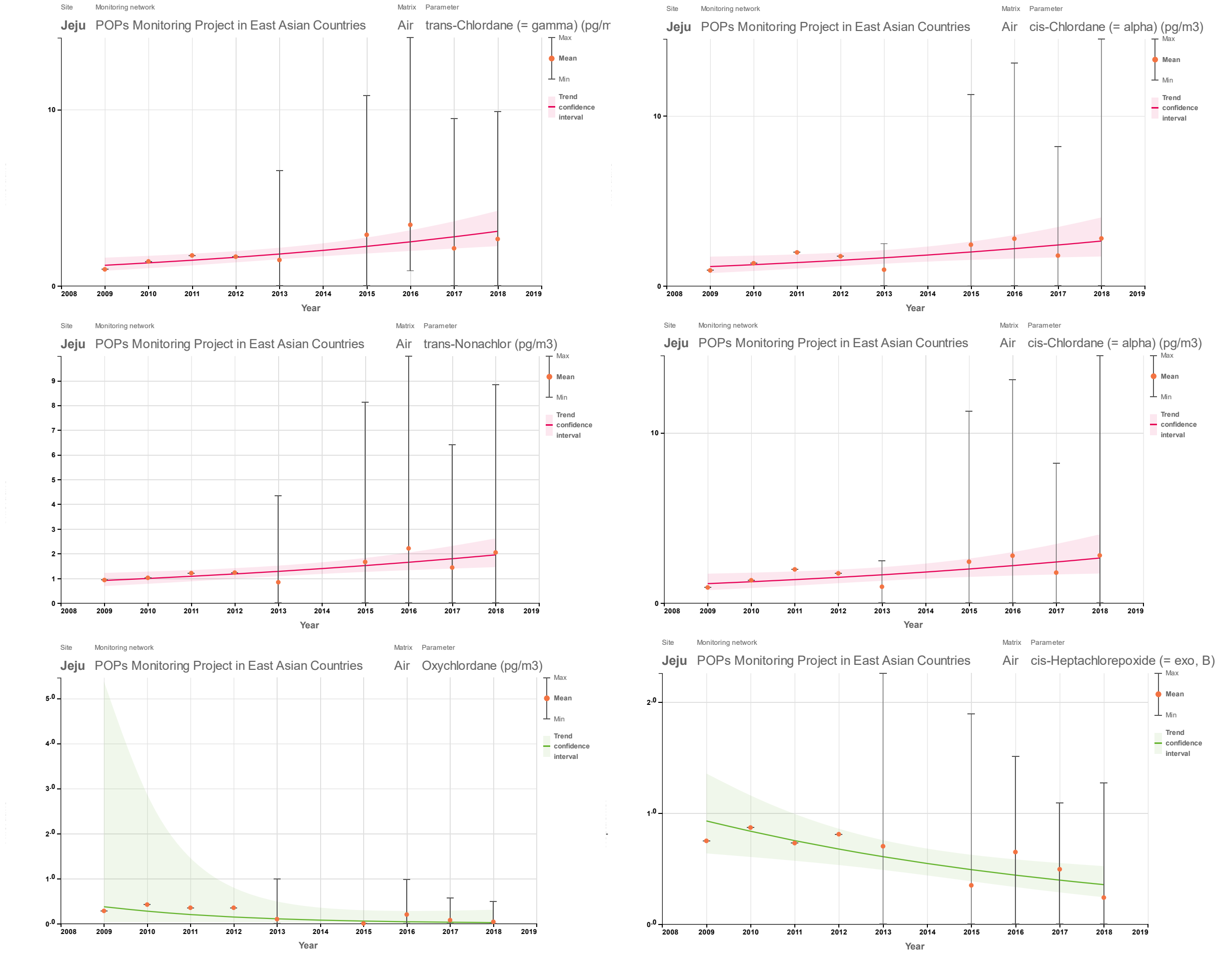


Figure 5.2.1-9 Temporal trends of chlordanes and heptachlors in Jeju Island, R. Korea

Except oxychlordane (lower left), all the other isomers of chlordanes show clear increase. *Cis*-heptachlor epoxide (lower right), on the other hand, shows statistically significant decrease. Heptachlor (not shown) did not show clear trend during the period.

No clear trends were found in PCDD/PCDFs and *dl*-PCBs levels as well as other POPs, including chlordecone, dieldrin, endrin, HCB, mirex and PeCBz. HCHs do not show statistically significant trends, though α-HCH and β-HCH seem to be slightly decreasing. Endosulfan I, endosulfan II and endosulfan show flat or slight decreasing tendency, though not significant. PBDEs, on the other hand, seem to be decreasing. Particularly, BDE-47 and BDE-99, marker isomers of commercial penta-BDE, show statistically significant decrease.

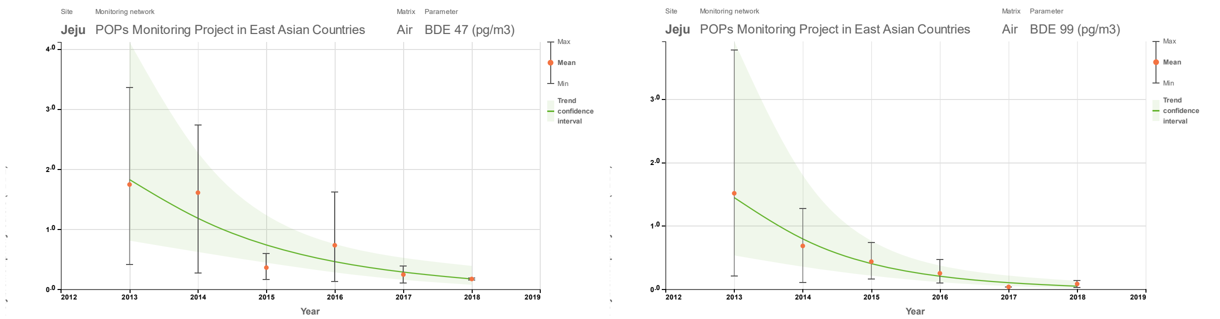


Figure 5.2.1-10 Temporal trends of BDE-47 (left) and BDE-99 (right) in Jeju Island, R. Korea.

5.2.1.3 Temporal Trend of the PCDD/PCDFs and PCBs in the Air of China

The mean concentrations of PCDD/PCDFs in the air in 2014-2019 were 12.2 WHO-TEQ fg/m^3, 85.0 WHO-TEQ fg/m^3, and 25.3 WHO-TEQ fg/m^3 for the air sample from remote, urban and rural sites respectively. The concentrations of PCDD/PCDFs in the air in 2008-2011 were 16.1 fg/m^3, 164 WHO-TEQ fg/m^3, and 22.2 WHO-TEQ fg/m^3 for the air from remote, urban and rural sites respectively. In general, the mean concentrations of PCDD/PCDFs in air declined in China.

The mean concentrations of 12 *dl*-PCBs in the air in China in 2014-2019 were 1.32 WHO-TEQ fg/m^3, 5.28 WHO-TEQ fg/m^3 and 2.16 WHO-TEQ fg/m^3 for the air from remote, urban and rural sites respectively. The mean concentrations of 12 *dl*-PCBs in the air in China in 2008-2011 were 0.82 WHO-TEQ fg/m^3, 10.2 WHO-TEQ fg/m^3 and 2.14 WHO-TEQ fg/m^3 for the air sample from remote, urban and rural sites respectively. Generally, the *dl*-PCBs in urban sites in China all showed a declining trend.

The mean values of the concentrations of 6 indicator PCBs in the air from remote, urban and rural sites in China from 2014 - 2019 were 10.3 pg/m^3, 10.0 pg/m^3, and 6.16 pg/m^3 respectively. The mean values of the concentrations of the indicator PCBs in the air from the remote, urban and rural sites in 2008-2011 were 18.5 pg/m^3, 71.6 pg/m^3 and 7.32 pg/m^3 respectively. The concentrations of indicator PCBs in the air of remote, urban and rural sites showed a declining trend, especially, the concentrations of indicator PCBs in the air of remote sites and urban sites decreased significantly.

China continuously monitored POPs in two remote sites Qinghai Lake and Wuyi Mountain more than once a year since 2008. The results (see Figures 5.2.1-11 and 5.2.1-12) showed the concentrations of the dioxins and *dl*-PCBs in the two remote sites decreased slightly and a low concentration fluctuation was observed.

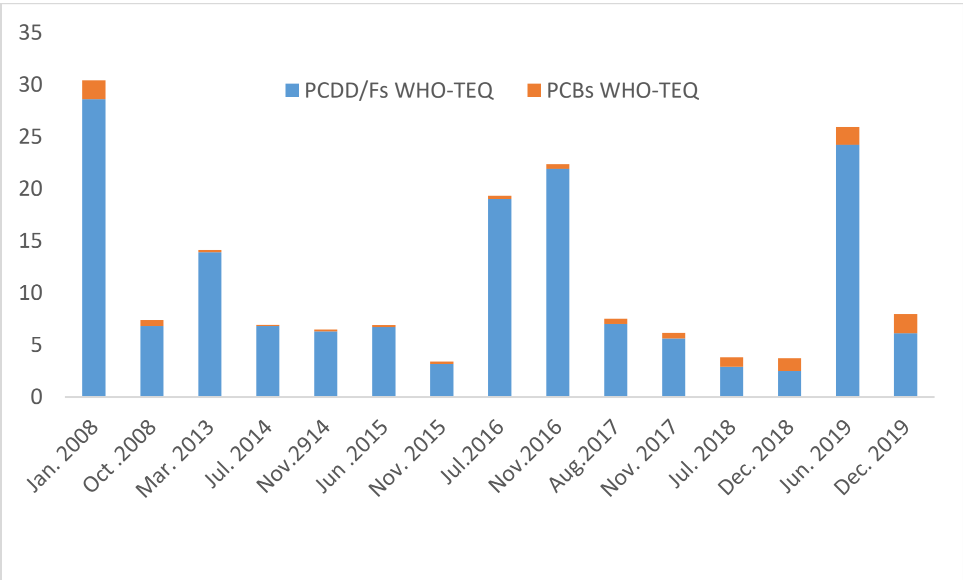
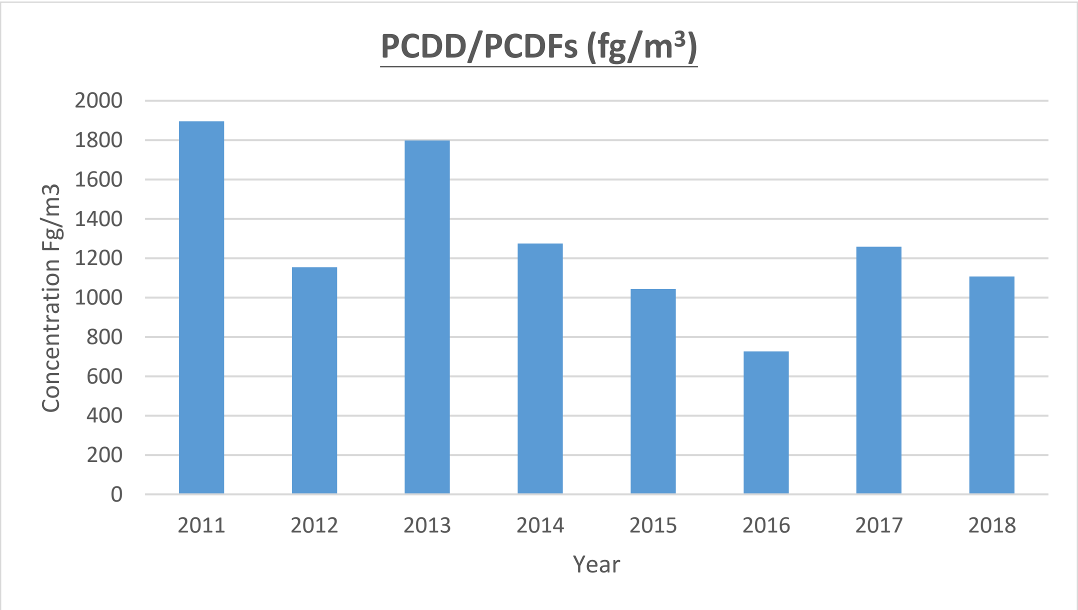


Figure 5.2.1-11 Temporal trends of PCDD/PCDFs and *dl*-PCBs in air from remote area of Qinghai Lake in 2008-2019.

Figure 5.2.1-12 Temporal trends of PCDD/PCDFs and *dl*-PCBs in air from remote area of Wuyi Mountain in 2008-2019.

China continuously monitored POPs in Hong Kong SAR monthly during 2011-2018. The results showed the concentrations of PCDD/PCDFs and PCBs declined. Annual average concentrations of PCDDs/PCDFs and PCBs being monitored from 2011 to 2018 are presented in Figure 5.2.1-13 – Figure 5.2.1–15.



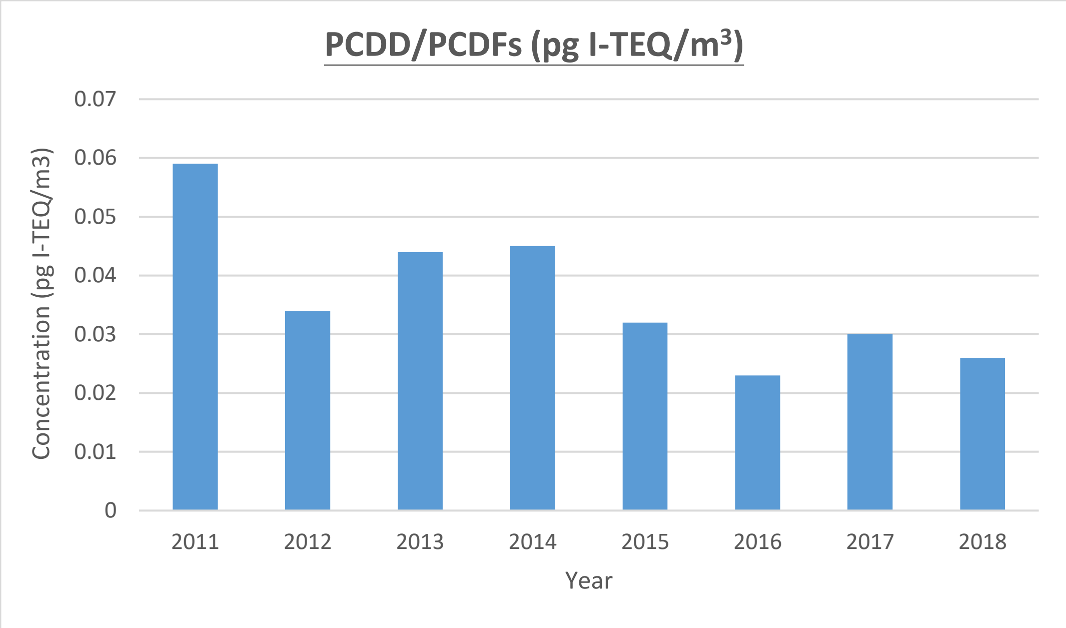
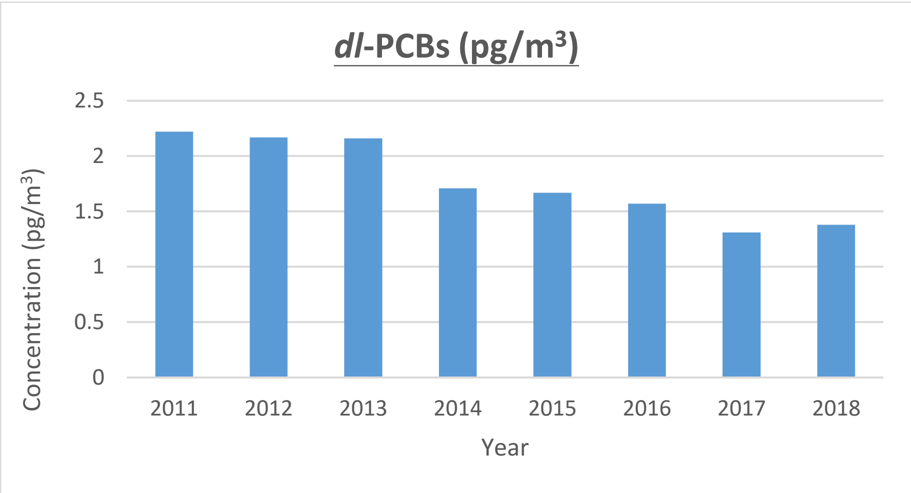


Figure 5.2.1–13 Trend of PCDD/PCDFs in ambient air of Hong Kong SAR, China from 2011 to 2018.



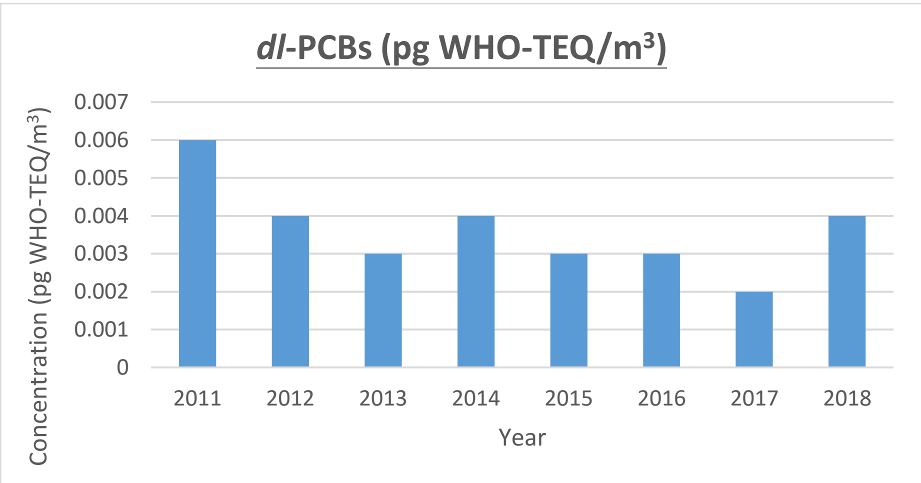


Figure 5.2.1–14 Trend of *dl*-PCBs in ambient air of Hong Kong SAR, China from 2011 to 2018.

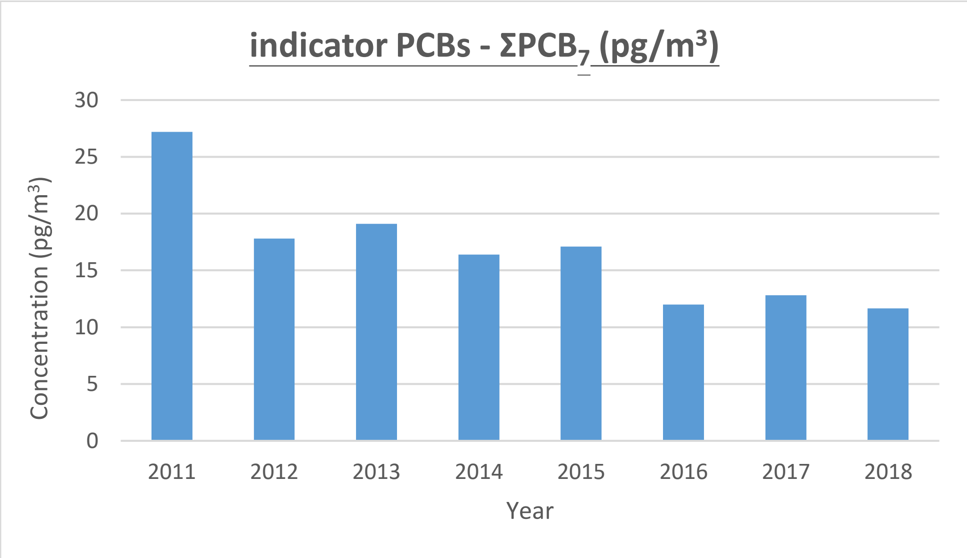


Figure 5.2.1–15 Trend of indicator PCBs (ΣPCB7) in ambient air of Hong Kong SAR, China from 2011 to 2018.

5.2.1.4 Trends at national POPs monitoring in Japan

In the national POPs monitoring in Japan, similar decreasing trends were identified in DDTs, chlordanes, heptachlors and HCHs (Table 5.2.1–2). In addition, PCBs and PFOS are also found to show statistically significant decreasing trends in recent years. Air concentrations of these chemicals in national monitoring, however, are generally higher than those in background sampling at remote islands, possibly reflecting emissions from primary/secondary sources in Japan more strongly. In the case of PCBs, for example, median concentration of PCBs in the national monitoring in FY2018 was 100 pg/m^3 while those in Hedo and Fukue were 54 pg/m^3 and 35 pg/m^3, respectively.

Table 5.2.1–2 Result of trend analysis for Japanese national POPs monitoring program[16]

Substance groups	Substances	Period	Result of Trend analysis (warm season)
PCBs	Total PCBs	FY2003 – 2018	↘ Half-life: 14 years [10-25 years]
HCB	HCB	FY2003 – 2018	–
Aldrin	Aldrin	FY2003 – 2014	X
Dieldrin	Dieldrin	FY2003 – 2014	–
Endrin	Endrin	FY2003 – 2014	–
DDTs	*p,p'*-DDT	FY2003 – 2018	↘ Half-life: 8 years [6-12 years]
	p,p'-DDE	FY2003 – 2018	↘ Half-life: 9 years [7-14 years]
	p,p'-DDD	FY2003 – 2018	– **
	o,p'-DDT	FY2003 – 2018	↘ Half-life: 6 years [4-7 years]
	o,p'-DDE	FY2003 – 2018	↘ Half-life: 5 years [4-6 years]
	o,p'-DDD	FY2003 – 2018	↘
Chlordanes	*Cis*-chlordane	FY2003 – 2016	↘ Half-life: 12 years

Substance groups	Substances	Period	Result of Trend analysis (warm season)
			[10-14 years]
	Trans-chlordane	FY2003 – 2016	–
	Oxychlordane	FY2003 – 2016	↘ Half-life: 19 years [13-43 years]
	Cis-nonachlor	FY2003 – 2016	–
	Trans-nonachlor	FY2003 – 2016	↘ Half-life: 9 years [7-13 years]
Heptachlors	Heptachlor	FY2003 – 2016	↘ Half-life: 9 years [7-13 years]
	Cis-heptachlor epoxide	FY2003 – 2016	↘
	Trans-heptachlor epoxide	FY2003 – 2016	↘
Toxaphenes	Parlar-26	FY2003 – 2018	– **
	Parlar-50	FY2003 – 2018	– **
	Parlar-62	FY2003 – 2018	– **
Mirex	Mirex	FY2003 – 2018	–
HCHs	α-HCH	FY2009 – 2017	–
	β-HCH	FY2009 – 2017	↘ Half-life: 19 years [10-100 years]
	γ-HCH (lindane)	FY2009 – 2017	↘ Half-life: 23 years [18-33 years]
	δ-HCH	FY2009 – 2017	–
Polybromodiphenyl ethers (Br_4 – Br_{10})	Tetrabromodiphenyl ethers	FY2009 – 2018	↘ Half-life: 7 years [5-10 years]
	Pentabromodiphenyl ethers	FY2009 – 2018	– **
	Hexabromodiphenyl ethers	FY2009 – 2018	– **
	Heptabromodiphenyl ethers	FY2009 – 2018	– **
	Octabromodiphenyl ethers	FY2009 – 2018	– **
	Nonabromodiphenyl ethers	FY2009 – 2018	– **
	Decabromodiphenyl ethers	FY2009 – 2018	– **
Perfluorooctane sulfonic acid (PFOS)	PFOS	FY2010 – 2017	↘
Perfluorooctanoic acid (PFOA)	PFOA	FY2010 – 2017	–
Pentachlorobenzene	PeCBz	FY2007 – 2018	–

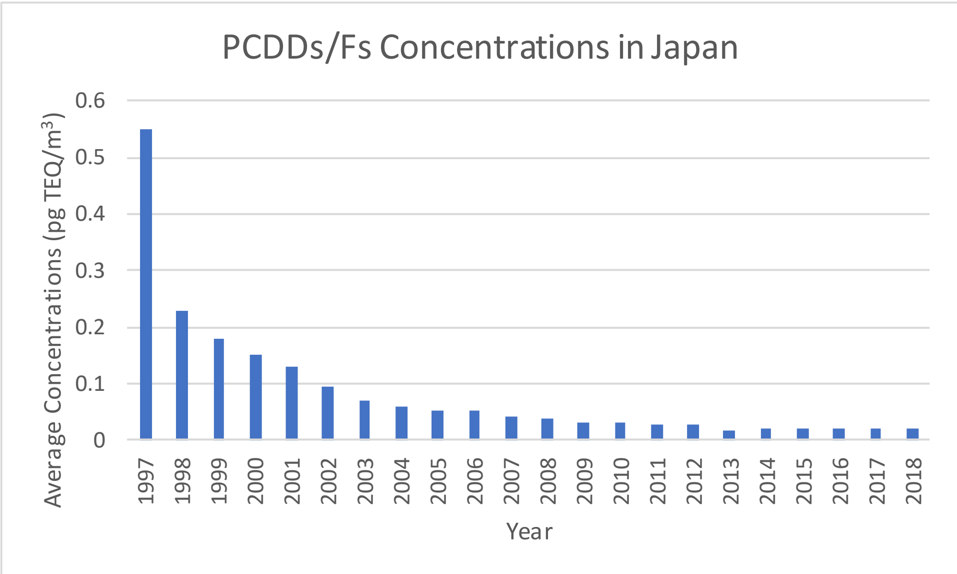
Note 1: When the posteriori probability from AICs was more than 95%, the measurement results were deemed to be in agreement with the simple log-linear regression model.

Note 2: "↘" (arrow) means that "an inter-annual trend of decrease was found".
"–" means that "an inter-annual trend was not found".
"x" means that "this analysis approach was regarded as unsuitable because 'measured concentrations of more than 50% of samples did not reach the detection limit (ND) in an FY or more,' or 'less number of monitoring sites'/'measured concentrations did not show a normal distribution in an FY or more,' 'the number of samples was less than 11 in each FY,' or 'measured concentrations did not show a homoscedasticity in an FY or more.'"
"*" means that "in case of using the bootstrap methods, there was not a significant difference between the values of first-half and second-half periods".
"**" means that "the detection rate was not decreased, there was not a reduction tendency".

Note 3: The half-life describes the half-life in the environment based on the survey results when the decrease tendency continues for 3 years or more by the maximum likelihood estimation that does not assume parametric residual distribution. The results in [] indicate that the values in the 95% confidence interval.

PCDD/PCDFs and *dl*-PCBs in Japan

Contrary to HCBD or other volatile POPs, such as HCB, PeCBz and α-HCH, dioxins tend to attach to particles and are transported mainly in particulate form. As a result, dioxins do not travel for long distance, and its monitoring needs many sampling stations to reveal their major emission sources and to capture their temporal trends properly. In Japan, dioxins monitoring has been conducted in a different program under the Law concerning Special Measures to dioxins at more than 600 air monitoring stations, while the other POPs have been monitored in “Chemicals in the Environment” program where 37 air sampling sites are set covering all over Japan. In 1997, only PCDD and PCDF had been monitored as dioxins and TEQ values were calculated by I-TEF (1988). From 1998, *dl*-PCB were added to total dioxin calculations and the TEQ values were calculated by WHO-TEF (1998). As shown in the figure, overall reduction tendency was observed for the concentrations of dioxins in the ambient air measured throughout Japan. The temporal trends are quite similar to the trends of the estimated unintentional emission of dioxins in the ambient air in Japan (see, FigureB.1–1 in Annex), suggesting the appropriate design of the monitoring which covers majority of dioxins emissions efficiently and captures the dioxin levels properly and quantitatively.



Reference: Ministry of the Environment, Japan[17]

Figure 5.2.1–16 Temporal trends of dioxins concentrations in air in Japan.

5.2.2 Human tissues (milk and/or blood)

5.2.2.1 Data from WHO human breast milk survey

Fiji participated in WHO human breast milk survey for four times (2002, 2006, 2011 and 2019). Although statistically not significant, PCDD/PCDFs, *dl*-PCBs (Figure 5.2.2–1), PCBs (6 isomers) and DDTs (6 isomers) (Figure 5.2.2–2) show more or less decreasing tendencies. *p,p'*-DDT seems to decrease faster than total DDTs, suggesting the stop of release of newly synthesized DDT.

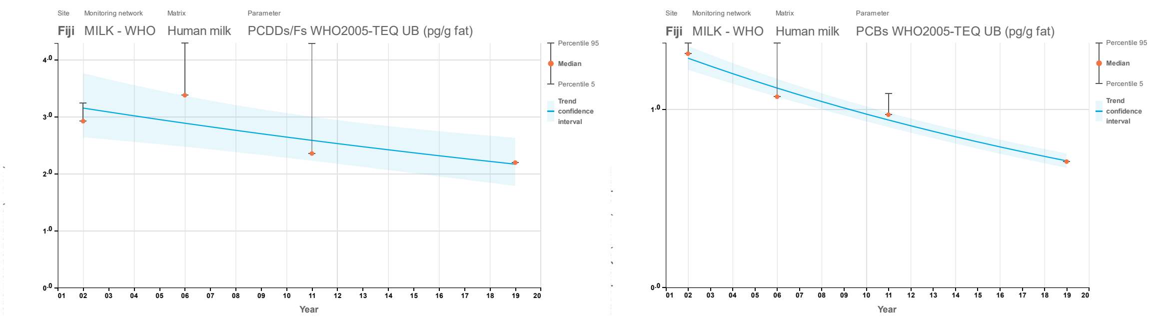


Figure 5.2.2-1 PCDD/PCDFs (left) and *dl*-PCBs (wright) in human breast milk in Fiji.

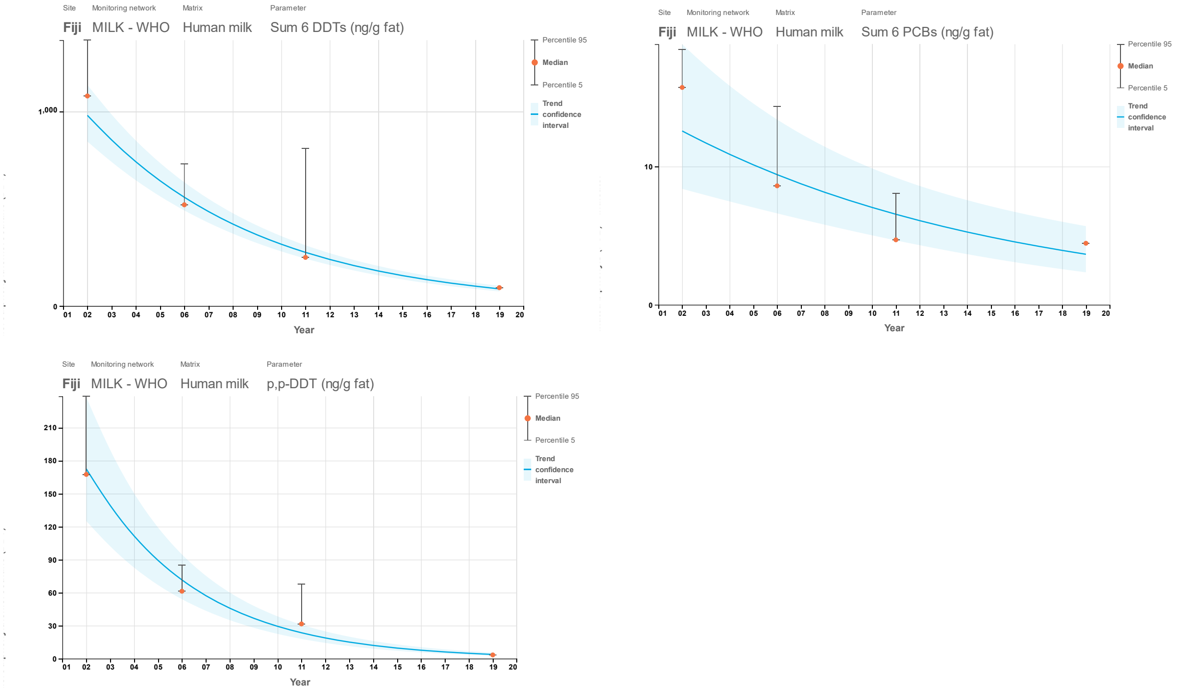


Figure 5.2.2-2 Trends of DDTs (6 isomers), PCBs (6 isomers), and *p,p'*-DDT in human breast milk in Fiji.

In Kiribati, the sampling and analysis of human breast milk was conducted three times (2006, 2011 and 2018). Their POPs trends and levels are similar to Fiji as shown in Figure 5.2.2–3. In the Pacific Islands, several projects on POPs management have been conducted, including "Persistent Organic Pollutants in Pacific Island Countries"[28] supported by the Department of Foreign Affairs and Trade (DFAT) of Australia (formerly AusAID) and "GEFPAS POPs Project" [29] supported by GEF, and the decreasing tendencies of POPs levels in human breast milk in Fiji and Kiribati may be the outcome of these activities.

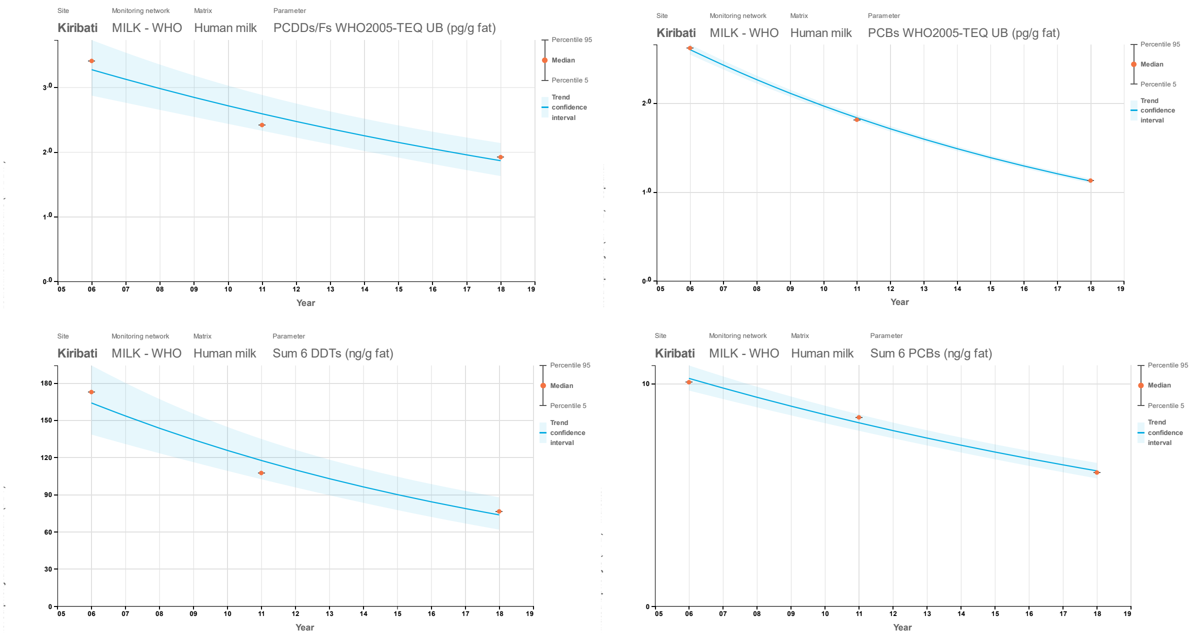


Figure 5.2.2-3 Trends of PCDD/PCDFs (upper left), *dl*-PCBs (upper right), indicator PCBs (lower left), and DDTs (6 isomers; lower right) in human breast milk in Kiribati.

5.2.2.2 Japanese survey data

PCDD/PCDFs and *dl*-PCBs

Total concentrations of PCDD/PCDFs and *dl*-PCBs in human breast milk in Japan tended to decline over time from a peak in 1998 (Figure 5.2.2-4; Ae et al., 2018[30]). The authors reported that decreasing speed of total dioxins slowed down in recent years (2011 – 2015) and individual levels for PCDDs, PCDFs and *dl*-PCBs also followed this trend.

The median concentration of PCDD/PCDFs and *dl*-PCBs in blood[23] in the 2011 – 2016 survey (9.4 pg TEQ/g lipid) was found to have decreased by 41.3 % compared to the 2002 – 2010 surveys (16 pg TEQ/g lipid) in Japan (Muzembo et al. 2019[31]).Although there were some potential limitations on the study design, the measures and actions undertaken in Japan have possibly contributed to the reduction of dioxins in the Japanese population.

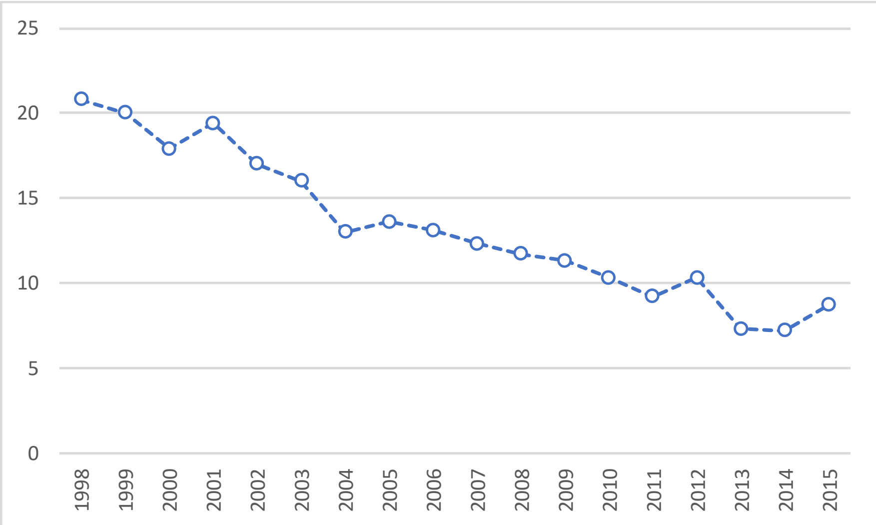


Figure 5.2.2-4 Dioxin levels in human breast milk in Japan[23] (unit: pg TEQ/g fat).
Averages of each year's data are plotted.
Dioxins: sum of PCDDs (7 isomers), PCDFs (10 isomers) and *dl*-PCBs (12 isomers)

PFOS in Japan

Based on the result of trend analysis using GMP Data Warehouse, statistically significant decreasing trend was observed for PFOS concentrations in blood during FY2008 and FY2016 in Japan[23]($p<0.05$; Figure 5.2.2–5).

PFOA in Japan

Based on the result of trend analysis using GMP Data Warehouse, statistically significant decreasing trend was not observed for PFOA concentrations in blood during FY2008 and FY2016 in Japan[23] (Figure 5.2.2–5).

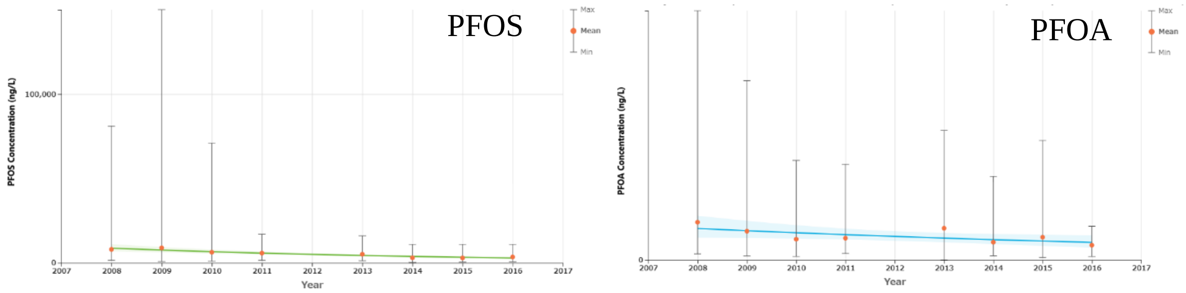


Figure 5.2.2–5 Temporal trends of PFOS and PFOA in blood in Japan.

5.2.3 Water

5.2.3.1 Temporal Trend of PFOS in the Water of China

The PFOS concentration from Taihu Lake was 31.0-32.9 ng/L in 2013 and 11-13 ng/L in 2019. The PFOS concentration in water from Taihu Lake decreased significantly[14].

5.2.3.2 Temporal trends of PFOS and PFOA in Japan

In Japan, as results of the inter-annual trend analysis from FY2009 to FY2018 throughout the nation, reduction tendency in specimens from lake areas was identified as statistically significant for PFOS[16]. In addition, reduction tendency in specimens from river mouth areas was identified as statistically significant for PFOA[16].

Table 5.2.3 – 1 Result of trend analysis for Japanese national POPs monitoring program (surface water) [16]

Substances	Period	Result of trend analysis (surface water)				
			River area	Lake area	River mouth area	Sea area
Perfluorooctane sulfonic acid (PFOS)	FY2009 – 2018	–	–	↘ Half-life: 10 years [6-22 years]	–	–
Perfluorooctanoic acid (PFOA)	FY2009 – 2018	–	–	–	↘ Half-life: 9 years [7-14 years]	–

Note 1: When the posteriori probability from AICs was more than 95%, the measurement results were deemed to be in agreement with the simple log-linear regression model.

Note 2: "↘" means "an inter-annual trend of decrease was found".
"–" means "an inter-annual trend was not found".

Note 3: The half-life describes the half-life in the environment based on the survey results when the decrease tendency continues for 3 years or more by the maximum likelihood estimation that does not assume parametric residual distribution. The results in [] indicate that the values in the 95% confidence interval.

5.2.4 Other media

In Japan, sediment and biota are also target medium in national POPs monitoring program for more than a decade[16]. The results of the inter-annual trend analysis from FY2002 to FY2018 for surface water (except for PFOS and PFOA), sediment and biota are shown briefly in Table 5.2.4 – 1 and Table 5.2.4 – 2. Details are shown in Annex I.

Table 5.2.4 – 1 Result of trend analysis for Japanese national POPs monitoring program (surface water and sediment) [16]

Substance groups	Substances	Surface water		Sediment	
		Period	Trend analysis	Period	Trend analysis
PCBs	Total PCBs	FY2002 – 2018	↘ Half-life: 7 years [6-10 years]	FY2002 – 2018	↘ Half-life: 17 years [12-30 years]
HCB	HCB	FY2002 – 2018	↘ Half-life: 14 years [10-20 years]	FY2002 – 2018	↘ Half-life: 17 years [11-33 years]
Aldrin	Aldrin	FY2002 – 2009	–	FY2002 – 2018	↘
Dieldrin	Dieldrin	FY2002 – 2014	–	FY2002 – 2018	↘
Endrin	Endrin	FY2002 – 2014	–	FY2002 – 2018	–
DDTs	*p,p'*-DDT	FY2002 – 2014	↘	FY2002 – 2014	–
	p,p'-DDE	FY2002 – 2014	–	FY2002 – 2014	–
	p,p'-DDD	FY2002 – 2014	–	FY2002 – 2014	–
	o,p'-DDT	FY2002 – 2014	↘	FY2002 – 2014	–
	o,p'-DDE	FY2002 – 2014	‾|_	FY2002 – 2014	–
	o,p'-DDD	FY2002 – 2014	–	FY2002 – 2014	–
Chlordanes	*Cis*-chlordane	FY2002 – 2017	↘	FY2002 – 2017	↘ Half-life: 8 years [7-12 years]
	Trans-chlordane	FY2002 – 2017	–	FY2002 – 2017	–
	Oxychlordane	FY2002 – 2017	x	FY2002 – 2017	‾|_
	Cis-nonachlor	FY2002 – 2017	–	FY2002 – 2017	↘
	Trans-nonachlor	FY2002 – 2017	–	FY2002 – 2017	↘ Half-life: 12 years [9-19 years]
Heptachlors	Heptachlor	FY2002 – 2017	x	FY2002 – 2017	⇘
	Cis-heptachlor epoxide	FY2002 – 2017	↘	FY2002 – 2017	‾|_
	Trans-heptachlor epoxide	FY2002 – 2017	x	FY2002 – 2017	X
Toxaphenes	Parlar-26	FY2002 – 2018	– **	FY2002 – 2018	– **
	Parlar-50	FY2002 – 2018	– **	FY2002 – 2018	– **
	Parlar-62	FY2002 – 2018	– **	FY2002 – 2018	– **
Mirex	Mirex	FY2002 – 2018	– **	FY2002 – 2018	– **
HCHs	*α*-HCH	FY2002 – 2017	↘ Half-life: 11 years [8-16 years]	FY2002 – 2017	↘
	β-HCH	FY2002 – 2017	↘ Half-life: 13 years [10-20 years]	FY2002 – 2017	–
	γ-HCH (lindane)	FY2002 – 2017	↘ Half-life: 6 years	FY2002 – 2017	↘

Substance groups	Substances	Surface water		Sediment	
		Period	Trend analysis	Period	Trend analysis
			[5-7 years]		
	δ-HCH	FY2002 – 2017	– *	FY2002 – 2017	↘
Polybromodiphenyl ethers (Br_4 – Br_{10})	Tetrabromodiphenyl ethers	FY2009 – 2018	– **	FY2009 – 2018	– *
	Pentabromodiphenyl ethers	FY2009 – 2018	⇘	FY2009 – 2018	– *
	Hexabromodiphenyl ethers	FY2009 – 2018	– **	FY2009 – 2018	– *
	Heptabromodiphenyl ethers	FY2009 – 2018	– **	FY2009 – 2018	⏋
	Octabromodiphenyl ethers	FY2009 – 2018	– **	FY2009 – 2018	– *
	Nonabromodiphenyl ethers	FY2009 – 2018	– *	FY2009 – 2018	–
	Decabromodiphenyl ethers	FY2009 – 2018	– *	FY2009 – 2018	–
Perfluorooctane sulfonic acid (PFOS)	PFOS	FY2009 – 2018	–	FY2009 – 2018	–
Perfluorooctanoic acid (PFOA)	PFOA	FY2009 – 2018	–	FY2009 – 2018	–
Pentachlorobenzene (PeCBz)	PeCBz	FY2007 – 2018	–	FY2007 – 2018	–

Note 1: When the posteriori probability from AICs was more than 95%, the measurement results were deemed to be in agreement with the simple log-linear regression model.

Note 2: "↘" (arrow) means that "an inter-annual trend of decrease was found".
"⏋" means that "statistically significant differences between the first-half and second-half periods were found".
" – " means that "an inter-annual trend was not found".
"⇘" (dotted arrow) means that "although the number of detections was small, the detection rate was decreased, it suggested a reduction tendency".
"x" means that "this analysis approach was regarded as unsuitable because 'measured concentrations of more than 50% of samples did not reach the detection limit (ND) in an FY or more,' or 'less number of monitoring sites'/'measured concentrations did not show a normal distribution in an FY or more,' 'the number of samples was less than 11 in each FY,' or 'measured concentrations did not show a homoscedasticity in an FY or more.'"
"*" means that "in case of using the bootstrap methods, there was not a significant difference between the values of first-half and second-half periods".
"**" means that "the detection rate was not decreased, there was not a reduction tendency".

Note 3: The half-life describes the half-life in the environment based on the survey results when the decrease tendency continues for 3 years or more by the maximum likelihood estimation that does not assume parametric residual distribution. The results in [] indicate that the values in the 95% confidence interval.

Table 5.2.4 – 2 Result of trend analysis for Japanese national POPs monitoring program (biota) [16]

Substance groups	Substances	Period	Result of trend analysis (biota)	
			Bivalves	Fish
PCBs	Total PCBs	FY2002 – 2018	↘	–
HCB	HCB	FY2002 – 2018	–	–
Aldrin	Aldrin	FY2002 – 2014	x	X
Dieldrin	Dieldrin	FY2002 – 2014	–	–
Endrin	Endrin	FY2002 – 2014	–	– *
DDTs	*p,p'*-DDT	FY2002 – 2018	–	↘
	p,p'-DDE	FY2002 – 2018	–	–
	p,p'-DDD	FY2002 – 2018	↘	–
	o,p'-DDT	FY2002 – 2018	↘	↘ Half-life: 7 years [5-11 years]
	o,p'-DDE	FY2002 – 2018	↘ Half-life: 5 years [4-7 years]	↘ Half-life: 11 years [8-18 years]

Substance groups	Substances	Period	Result of trend analysis (biota)	
			Bivalves	Fish
	o,p'-DDD	FY2002 – 2018	↘	–
Chlordanes	*Cis*-chlordane	FY2002 – 2016	–	–
	Trans-chlordane	FY2002 – 2016	–	–
	Oxychlordane	FY2002 – 2016	–	–
	Cis-nonachlor	FY2002 – 2016	–	–
	Trans-nonachlor	FY2002 – 2016	–	–
Heptachlors	Heptachlor	FY2002 – 2016	x	X
	Cis-heptachlor epoxide	FY2003 – 2016	–	–
	Trans-heptachlor epoxide	FY2003 – 2016	x	X
Toxaphenes	Parlar-26	FY2002 – 2018	–	– *
	Parlar-50	FY2002 – 2018	–	–
	Parlar-62	FY2002 – 2018	– **	– **
Mirex	Mirex	FY2002 – 2018	–	–
HCHs	*α*-HCH	FY2002 – 2017	↘ Half-life: 10 years [7-18 years]	–
	β-HCH	FY2002 – 2017	–	–
	γ-HCH (lindane)	FY2002 – 2017	↘	┐└
	δ-HCH	FY2002 – 2017	x	┐└
Polybromodiphenyl ethers (Br_4 – Br_{10})	Tetrabromodiphenyl ethers	FY2008 – 2018	↘ Half-life: 7 years [6-9 years]	–
	Pentabromodiphenyl ethers	FY2008 – 2018	–	–
	Hexabromodiphenyl ethers	FY2008 – 2018	– **	–
	Heptabromodiphenyl ethers	FY2008 – 2018	– **	– **
	Octabromodiphenyl ethers	FY2008 – 2018	– **	– **
	Nonabromodiphenyl ethers	FY2008 – 2018	– **	– **
	Decabromodiphenyl ethers	FY2008 – 2018	– **	– **
Perfluorooctane sulfonic acid (PFOS)	PFOS	FY2009 – 2017	x	–
Perfluorooctanoic acid (PFOA)	PFOA	FY2009 – 2017	x	X
Pentachlorobenzene (PeCBz)	PeCBz	FY2010 – 2018	– **	– *
1,2,5,6,9,10-Hexabromo cyclododecanes (HBCD)	*α*-HBCD	FY2011 – 2018	↘	↘
	β-HBCD	FY2011 – 2018	– **	– **
	γ-HBCD	FY2011 – 2018	↘	– *

Note 1: When the posteriori probability from AICs was more than 95%, the measurement results were deemed to be in agreement with the simple log-linear regression model.

Note 2: "↘" (arrow) means that "an inter-annual trend of decrease was found".
"┐└" means that "statistically significant differences between the first-half and second-half periods were found".
" – " means that "an inter-annual trend was not found".
"↘" (dotted arrow) means that "although the number of detections was small, the detection rate was decreased, it suggested a reduction tendency".
"x" means that "this analysis approach was regarded as unsuitable because 'measured concentrations of more than 50% of samples did not reach the detection limit (ND) in an FY or more,' or 'less number of monitoring sites'/'measured concentrations did not show a normal distribution in an FY or more,' 'the number of samples was less than 11 in each FY,' or 'measured concentrations did not show a homoscedasticity in an FY or more.'"
"*" means that "in case of using the bootstrap methods, there was not a significant difference between the values of first-half and second-half periods".
"**" means that "the detection rate was not decreased, there was not a reduction tendency".

Note 3: The half-life describes the half-life in the environment based on the survey results when the decrease tendency continues for 3 years or more by the maximum likelihood estimation that does not assume parametric residual distribution. The results in [] indicate that the values in the 95% confidence interval.

5.2.5 Summary of temporal trends of POPs in Asia-Pacific region

Background air monitoring data in the region show generally decreasing trends of many of POPs in the atmosphere. Particularly evident is a continuous decrease of input of newly synthesized DDT in the East Asia, which was also detected and reported in the 2nd regional report. The clear decreasing trends of DDTs were observed in the two background monitoring stations, Hedo, Okinawa and Gosan, Jeju. In addition to DDTs, decreasing trends of other POPs, including chlordanes (Okinawa), HCHs (Okinawa and Jeju), tetra or pentaBDEs (Jeju and Japanese national monitoring), PCDD/PCDFs and/or *dl*-PCBs (national monitoring in China and Japan), and PCBs (national monitoring of Japan) were observed. Although the latter group might reflect local emission changes rather than transboundary transport, these data generally support the view that POPs emissions in the region is generally decreasing. There is continuous input of air monitoring data from East Asian countries under the POPsEA project, and another data by passive samplers under UNEP/GEF GMP2 project will be submitted in near future. The latter data will come from Pacific Islands, too. Analysis of these data together with the monthly monitoring data and the national data will provide us with better view of the trends of POPs in East Asian countries.

A clear decreasing trends of DDTs are observed in human breast milk in Fiji and Kiribati where milk analysis has been conducted three times or more. Similarly, PCDD/PCDFs and *dl*-PCBs levels in human milk or bloods are continuously decreasing in Fiji, Kiribati and Japan. PFOS levels in bloods seem to be decreasing in Japan. Although the amount of human data is not enough compared with air data, these information also seem to support general decline of some of POPs in the region.

Information on PFOS in water environment is also increasing. Chinese national monitoring program showed decrease of PFOS in Taihu Lake.Japanese national monitoring show statistically significant decrease of PFOS in lakes and PFOA in river mouth region, but further analysis of data will give us better understanding of the current situation. In Japanese national monitoring, statistically significant decreasing trends are reported on other media; for example, total PCBs, HCB and dieldrin in sediments in general, tetra- and pentaBDEs in river sediments, PFOS in marine sediments, PFOA in river and river mouth sediments; PCBs, some of DDTs, tetraBDE and α-/γ-HBCDs in bivalves, and some of DDTs and α-HBCD in fishes.

Clearly more data are needed to reveal current pollution status and their temporal trends in regional scale. Capacity building/enhancing activities are needed particularly in south-, west- and middle Asia, and establishment of long-term environmental monitoring activities as well as their networking will farther support the implementation of the Convention.

5.3 Long-range transport (LRT) of POPs in Asia/Pacific

5.3.1 General considerations on LRTs

5.3.1.1 Key properties of POPs for considering LRTs

All POPs (12 initial POPs and new POPs) listed in Annex A, B and/or C under the Stockholm Convention possess potential for long range transport. The substances released in the Asia-Pacific Region may be transported via air or water and reach far away from the emission source to remote areas such as Arctic or in high altitude areas. There are some ways to understand the environmental movement of the listed chemicals, and examples are described in Guidance on the Global Monitoring Plan for Persistent Organic Pollutants[13]. These include:

- GMP data can be assessed using information on long-range transport potential (LRTP, e.g., characteristic transport distances (CTD) values) for the various POPs. CTD for some POPs discharged in air and water are described in Table 5.3.1–1. According to the CTD values, majority of substances are mainly transported by air (the “flyers”) while a few by water (the “swimmers”).

- Back trajectory analysis is relatively simple in terms of data and infrastructure support. This can be extended to generate probability density maps for better interpretation of trend data with respect to advection inputs for GMP sites.

- Regional- and global-scale models are more complex and demanding in terms of input data, although a range of models are available. GMP data can be used to initialize models and evaluate transport pathways on a regional and trans-regional (trans-continental) scale. This is a specialized and resource demanding technique that may be difficult to implement.

- As a further option the regional organization groups could set up a small team of experts to prepare a report or reports, based upon published literature and/or the data derived from the air monitoring component of the GMP. With this approach, interpretive techniques such as modelling and back trajectory analysis would be a part of the reports reviewed by the experts, and not directly a component of the GMP.

Table 5.3.1–1 Characteristic travel distances (CTDs, km) for air and water for selected POPs[13]

Chemical	CTD (air)	CTD (water)
Hexachlorobenzene	230,000	700
Pentachlorobenzene	120,000	200
Octabrominated Diphenyl ethers	22,000	360
PCB (tetra homolog)	17,000	340
α-HCH	7,800	830
PCB (tri homolog)	5,100	190
γ-HCH	4,200	220
BDE-99	3,700	540
DDT	3,600	490
β-HCH	3,100	430
Hexabromobiphenyl	3,000	540
Toxaphene	2,800	1,600
Short-chain chlorinated paraffins	1,800	230
2,3,7,8-TCDD	1,600	130
Dieldrin	1,100	580
Chlordane	1,100	300
Chlordecone	710	1,700
Aldrin	100	130
PFOS	10	63,000

It should be pointed out that CTD is calculated under a hypothetical situation, and thus represents relative tendencies, not the real distance, of transport of chemicals in the environment. It should also be pointed out that the calculation may not be properly conducted in some of the POPs, particularly PFOS, which is a surfactant, fully fluorinated with unusual water and oil repelling properties, and behaves differently from other POPs. In fact, the above CTD of PFOS is calculated based on the assumption that PFOS is not volatile at all[13], but in the ambient air considerable amounts of PFOS is detected in various places, including background sites. In addition, in a high-volume air sampling, PFOS behaves as if it is a volatile chemical; i.e., it passes through QFF (quartz fiber filter) and PUF (polyurethane foam plug), and is trapped in ACF (active carbon fiber felt). Although more research may be needed to establish proper theoretical treatment of PFOS and some other POPs, CTD values are generally useful to recognize the differences in the environmental behaviors of POPs and to design proper POPs monitoring system.

5.3.1.2 POPs in chemical partitioning space

Characteristic properties of POPs include not only long-range transport potential through air or water as represented by CTDs, but also potential to deposit on the surfaces in a remote area by dry/wet deposition, and potential to contaminate the ecosystem, i.e., bioconcentration/bioaccumulation/biomagnification potential. In equilibrium, these behaviors are represented by the partition between air, water and soil/organisms (considered as hydrophobic materials) in the environment, and are represented by the two chemical properties, log K_{OA} (octanol-air partition coefficient) and log K_{WA} (water-air partition coefficient). In general, chemicals with negative log K_{WA} go to gas phase while those with positive log K_{WA} dissolve in water. In both cases, however, chemicals with higher log K_{OA} tend to be absorbed/accumulated in organic phase of solid materials, such as soils, sediments, particles and organisms, and thus stay or move with these solid materials (Figure 5.3.1–1).

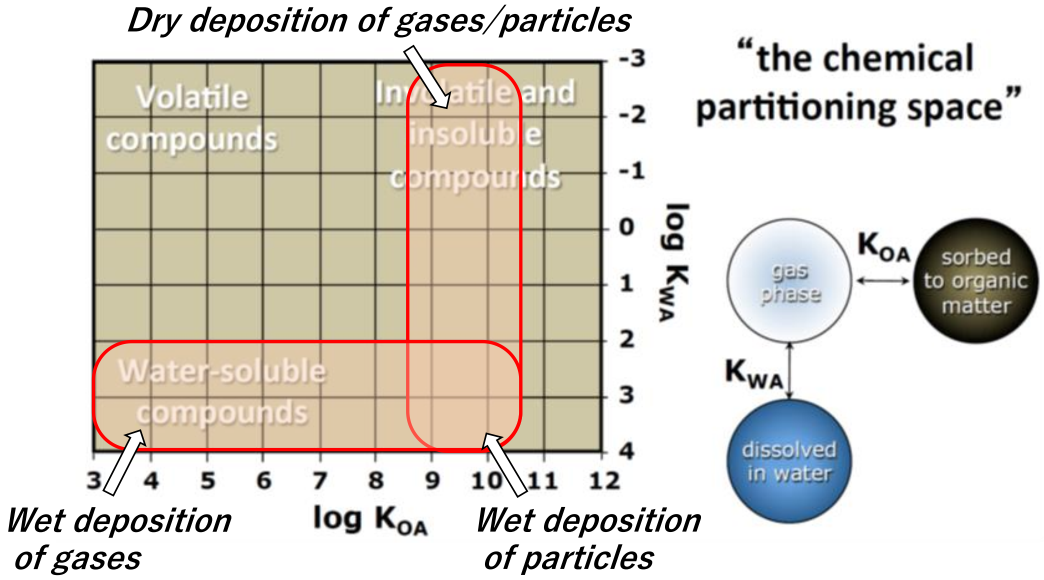


Figure 5.3.1–1 Characteristics of chemicals in the chemical partitioning space (log K_{WA} vs log K_{OA}) (modified from ref 32).

In both Arctic and Mountain contamination cases, chemicals evaporate into air at warmer source region in lowland areas, are transported through air, and deposit in colder and frequently higher precipitation environment through dry or wet deposition. Major differences between source and deposition areas lie in their temperatures as well as precipitation. When considering dry deposition, temperature dependence of partition between organic phase and air (K_{OA}) is a key to define contamination potential. Chemicals with smaller K_{OA} tend to be transported for long distance without deposition to the surface while those with larger K_{OA} tend to deposit earlier before reaching to the target areas. As a result, chemicals with particular K_{OA} range show higher tendency to deposit to the target area, and the optimum K_{OA} is dependent on the distance between the source and the deposition areas as well as temperature in target area. Wet deposition tendency, on the other hand, is dependent mainly on K_{WA}, and optimum K_{WA} range is dependent on the climate condition of target area. As a result, chemicals with high deposition potentials to a target area will distribute as a mirrored "L" shape in the chemical partition space (Figure 5.3.1–1). Compared with the hemispheric transport to Arctic (or Antarctic) area, chemicals transported to nearby mountains generally show higher K_{OA} (stronger attachment to particles, soils and vegetation) and higher K_{WA} (more water soluble and higher wet deposition rate) to some extent.

Bioconcentration properties, BCFs, on the other hand, is basically dependent on Kow = K_{OA}/K_{WA}. It is generally assumed that chemicals with higher log Kow show higher bioaccumulation potential; in fact, log Kow = 5 or higher is a criterion to identify a chemical as POPs under the Stockholm

Convention. There are, however, continuing debates on the hydrophobicity cut-off, above which bioaccumulation potential start to decrease again[33,34]. Presence of cut-off is also assumed in molecular weight/size of chemicals. High molecular weight chemicals, such as those having molecular weight heavier than 800 daltons or molecular size larger than 1.5 nm, are reported to show lower bioaccumulation potential in general because of their difficulties to pass through biomembranes[35,36]. In addition to BCF, other factors, such as BAF (bioaccumulation factors), BMF (biomagnification factors) and TMF (trophic magnification factors), have been used as indicators showing properties to accumulate chemicals within bodies of wildlife or humans through food web[37]. TMF plays a key role to comply with Water Framework Directive in European Union by checking the status of clearance of environmental quality standards for biota (EQS_{biota}), and studies have been conducted to determine TMF experimentally or estimate them theoretically[38].

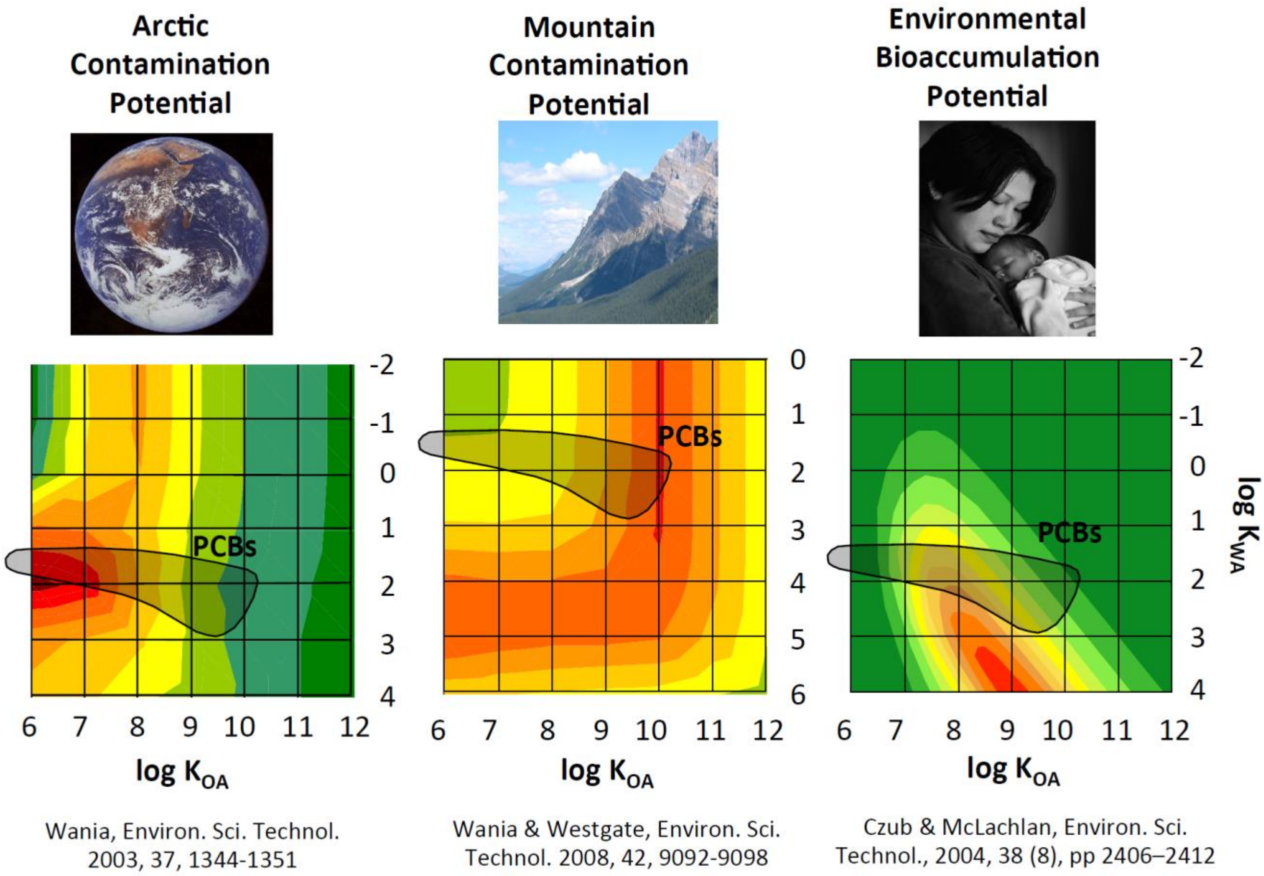


Figure 5.3.1–2 Properties of chemicals and specific amplification processes**Error! Bookmark not defined.**.

Figure 5.3.1–2 shows bioaccumulation potential of chemicals in chemical partition space. A major group of chemicals of regional concern, with higher potential to cause adverse effects to ecosystem or human beings in Asia-Pacific, are those with both high mountain contamination potential and high bioaccumulation potential, and their characteristic properties are plotted on the chemical partition space as the product of the two potentials. Another group of chemicals of regional concern is those contaminating the coastal environment and foods derived from the environment. We will first discuss on the atmospheric transport of former chemicals, and then the latter transport briefly.

5.3.1.3 POPs transport in Asia-Pacific

The regional and global circulation of air is a primary driver of long-range atmospheric transport of chemicals. As described in Chapter 1, Asia-Pacific region is under the control of the Hadley cell (low latitude area) and the Ferrel cell (middle latitude area). In equatorial area, surface is heated by the sun and produces ascending air flow. Near the equator, surface winds always move toward the equator in both hemispheres (trade winds) and converge to make Intertropical Convergence Zone (ITCZ), where air is ascending and causing condensation of humidity, thus making clouds and providing huge precipitation in the zone. ITCZ moves seasonally between 15 degrees North (Summer) and 15 degrees South (Winter), thus the prevailing wind direction also changes seasonally in tropical area. The ascending dry air at ITCZ is moving in the high altitude of troposphere towards north or south, descends to the surface to make arid area around 30 degrees, and goes back to the ITCZ by absorbing humidity from the sea surface. The Ferrel cell, on the other hand, is in fact a frontal zone between the equatorial hot air mass and polar cold air mass, where heat exchange process constantly occurs as cyclones. Cyclones are developed on the front and eventually pinched off from the front, and carry hot air mass towards poles to transfer heat, while they are constantly moving on the westerly wind; i.e., in the middle latitude area, chemicals are transported from west to east with gradual shift to higher latitude.

This general circulation pattern, however, is modulated by the strong land-sea interaction, a so-called "Asian Monsoon", i.e., seasonal change of prevailing surface winds between ocean (from Arabian, Indian, and western Pacific oceans) and Asian continent. In boreal summer season, ascending air flows develop on the warm continent and make cyclones, and surface air flow prevails from ocean to Asian continent. Chemicals tend to be transported from coastal lowland area to inland mountains and partly deposited on the mountains by cold trapping or precipitation. Rest of the chemicals are brought further by ascending air flow, which then spread in high altitude to other places and descend to surfaces through anticyclone activities. In winter season, on the other hand, a strong anticyclone develops on colder continent due to descending air flow, which pushes pollutants in the surface air towards the ocean. Continuous monitoring data of mercury at Hedo, Okinawa, captures this phenomenon clearly[39]. Due to its long half-life, gaseous elementary mercury (GEM) circulates on the globe and distributes nearly evenly; thus, it is always observed almost in the same level around 1.5 ng/m^3 in northern hemisphere. A temporal rise of GEM, however, is occasionally observed in winter season in Hedo when a cyclone passes along the southern coast of mainland Japan and its cold front passes at Hedo. Cyclone drags on its northern side a cold surface air which contains GEM emitted from coal combustion for heating. In fact, GEM variation at Hedo showed a beautiful positive correlation with CO, a combustion marker[39].

In addition to the tropospheric transport mechanisms, there are two additional mechanisms of long-range transport to transfer air from troposphere to stratosphere in Asia-Pacific; i.e., one in ITCZ area (The Brewer-Dobson circulation[40]) and the other around Tibetan Plateau where part of ascending air driven by summer Monsoon will reach to stratosphere[41]. Occurrence of these two mechanisms were noted by the anomaly of ozone as well as humidity in upper troposphere – lower stratosphere. It is also argued that global warming will accelerate~2.0–3.2% per decade of the global mass circulation of tropospheric air through stratosphere[40]. However, the quantitative significance of chemical transport through stratosphere have not been clarified yet. POPs will be transported for long distances on the movement of cyclones, seasonal monsoon-driven winds, hemispheric scale circulation like Hadley and Ferrel cells, and through the lower stratospheric air circulations. Such large scale movement of chemicals will be clarified and understood well with the help of reliable model studies as well as extensive monitoring to assess and improve models. So far in Asia-Pacific Region, particular attention has been given on the chemicals having high mountain contamination potential as for long range transport of POPs. There are several studies on model development in national as well as in regional scales[42,43,44,45,46,47,48,49], and on the monitoring of long-range transport of POPs and other chemicals to highly elevated areas, such as Himalaya and Tibetan plateau[50,51,52,53,54].

In tropical areas, such as Pacific Islands and many of East Asian countries, "cold trapping mechanism" does not work. On the other hand, tropical areas in Asia-Pacific include the heaviest precipitation areas, and water solubility (or wash-out potential) of chemicals may affect their fate and significance in the region. The major mechanism to contaminate the ecosystem and human beings are bioaccumulation through food web, particularly in the coastal environment where land-based marine pollution by human activities occur most severely. Pest control both for food production by the agricultural activity and to protect human health from various diseases is in high demands and particularly active in tropical areas. As a result, coastal pollution by various bioactive chemicals, such as pesticides, have occurred in the region. Furthermore, fringing coral reefs surrounding the tropical islands limit water exchange and keep the pollutants in coastal water and promote contamination in the coastal ecosystem. POPs used in the islands are biomagnified through coastal food web and are eventually back to human body through their foods. Huge amount of plastics recently increasing in coastal environment of the area may work as adsorbents and carriers for POPs and may contribute to the progression of coastal POPs pollution further.

In a regional scale, understanding of ocean currents as well as major terrestrial river systems are important to recognize POPs movements in the hydrosphere. Major ocean currents in Asia-Pacific include; in Pacific ocean, north and south equatorial currents and equatorial counter current, Kuroshio current and its branch (Tsushima current), Kuroshio extension, and Oyashio current; in Indian ocean, south equatorial current, equatorial counter current, and Indian Monsoon current (eastward in summer, westward in winter). A clockwise flow of surface sea water, i.e., North Pacific subtropical gyre, dominates in north Pacific, and transports various materials from Asian side to islands such as Hawaii or even North American coast, including wrecked ships and crews[55,56], and debris after the East Japan Earthquake and Tsunami in 2011[57]. Plastics and POPs will also be transported through the current. Major river systems include (from west); Tigris, Euphrates, Indus, Ganges, Brahmaputra, Salween, Chao Phraya, Mekong, Hong, Xi Jiang, Chang Jiang, Huang He, Amur. Large cities/industrial complexes/agricultural farmlands are developed along the major rivers as well as coastal areas, and POPs and other chemicals flow through rivers/ground water/sewage systems to coastal ocean. Due to geological activities in a long history of the earth, a series of marginal seas and gulfs are developed along the coastline of Asia, i.e., Red Sea, Gulf of Aden, Persian Gulf, Andaman Sea, Gulf of Thailand, Java Sea, Banda Sea, Celebes Sea, Sulu Sea, South China Sea, East China Sea, Yellow Sea, Bohai Sea, Sea of Japan, and Sea of Okhotsk. Land-based marine pollution through water in Asia, therefore, will occur, first of all, in these marginal seas/gulfs. The environmental monitoring in these marginal seas/gulfs, although outside of the scope of the current GMP, will play important roles to understand the current pollution and food contamination status, to evaluate their risks, to prioritize regulatory action, and to assess the effectiveness of political actions. Some of information on the marine environmental monitoring activities are summarized in the Annex. Related information is compiled in the report “Regional overview of PTS and POPs issues of ecological concern in the NOWPAP region”[58] and others[49,59,60].

Contrary to the Arctic region[61], the activities on the screening of chemicals having specific potential to contaminate hot-spots in Asia-Pacific is scarce, and further research activities are needed to fill gaps and to prioritize chemicals of concern in the region. More researches will also be needed to identify tropical area-specific POPs pollution and to assess their impact to human beings and ecosystem in the region. Deposition monitoring of POPs will be needed to understand their environmental behavior and characteristics. Also, marine environment, particularly in coastal region, needs more attention because it is a major source of foods and thus plays a key role for POPs exposure to human beings in many counties. Like in the case of air monitoring, passive sampling of POPs in water has been developed as a simple, reliable and useful monitoring method[62], and marine monitoring data will provide useful information to further support implementation of the Stockholm Convention.

5.3.2 Some trends observed in the monitoring data in Asia-Pacific

As already explained in the previous section, in POPsEA project, high frequency air monitoring of POPs in background stations have been conducted at the three islands, Okinawa, Jeju, and Fukue, in the Asia-Pacific region. In this section, a preliminary analysis of Okinawa data for LRTs of POPs in East Asian region is outlined.

In Hedo, Okinawa, 24 hrs sampling by high volume sampler (or a low volume sampler with an adsorbent Tenax TA for HCBD) is conducted in a consecutive three days in each month, and POPs levels are determined for each 24 hrs sampling. The data were averaged for each month and reported in the Data Warehouse of the Stockholm Convention as yearly aggregated data (maximum, minimum, mean, median). As explained in Section 5.2.1.1, these aggregated data of some of POPs, including DDTs and HCHs, showed decreasing trends at Hedo in a recent decade, while others do not show clear changes (like HCB). A few of POPs showed rather increasing tendencies (PCBs and PFOS, for example). While the trends are not judged significant due to short monitoring period, HCBD data showed a clear increase after Spring 2017 (Figure 5.2.1–7).

In Jeju Island, R. Korea, background monitoring showed statistically significant decreasing trends in some of DDTs including *p,p'*-DDT and *o,p'*-DDT, oxychlordane, *cis*-heptachlor epoxide, and BDE-47and BDE-99 (Figure 5.2.1–8 and Figure 5.2.1–10). Other chlordanes, including *trans*-/*cis*-chlordane and *trans*-/*cis*-nonachlor, on the other hand, show statistically significant increasing trends as shown in Figure 5.2.1–8. No clear trends were found in PCDD/PCDFs and *dl*-PCBs, chlordecone, dieldrin, endrin, HCB, HCHs, and mirex. Although statistically not significant, endosulfan I, endosulfan II and endosulfan showed flat or slight decreasing tendency, while PeCBz a slight increasing tendency.

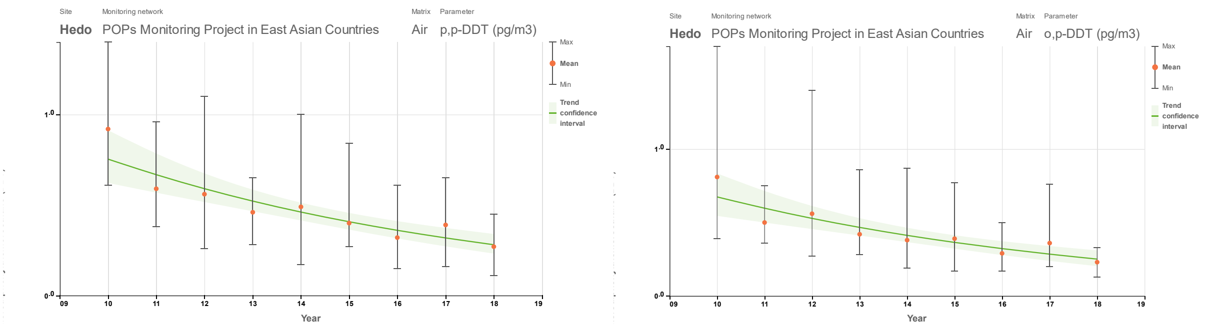


Figure 5.3.2–1 Temporal trends of *p,p'*-DDT and *o,p'*-DDT at Hedo, Okinawa (reproduced from Figure 5.2.1–1).

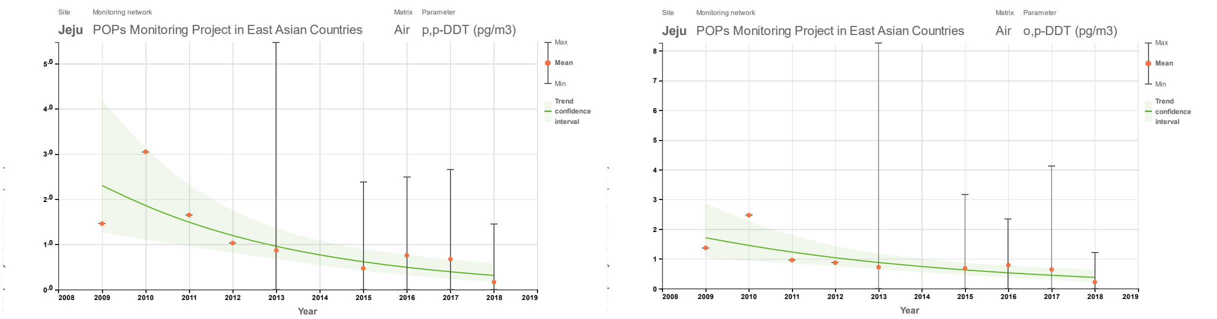


Figure 5.3.2–2 Temporal trends of *p,p'*-DDT and *o,p'*-DDT at Jeju Island, R. Korea (reproduced from Figure 5.2.1-7).

The data of these background sites (Figure 5.3.2–1 and Figure 5.3.2–2) clearly indicated that input of newly synthesized DDTs in East Asian environment is decreasing in a recent decade, and that majority of POPs levels are also decreasing or flat conditions recently, suggesting general decreasing trends of POPs in this sub-region. However, there are some data suggesting the increase of some of POPs in the sub-region (or in local scale) as described in the previous section, and more careful monitoring as well as efforts to identify the reason and emission sources to cause these increases are necessary.

In order to get insight into the major cause of variations of POPs levels in the atmosphere and their possible relationship with LRTs, a simple correlation analysis was conducted on the monthly average data of POPs for 9 years in Hedo (except those having many ND data) together with a number as a proxy of temperatures in the area. A number from -2 to 2 is assigned in each month as a proxy of temperature: i.e., 2 for Jul-Sep; 1 for Jun-Oct; 0 for May-Nov; -1 for Apr-Dec; and -2 for Jan-Mar. Note that the numbers are not assigned as a quantitative value to represent exact averaged temperatures but rather as a simple proxy, and further detailed researches are clearly needed. It should also be pointed out that the island is under Asian Monsoon climate, i.e., south eastern wind from Pacific Ocean prevails during summer while north western wind from the continent in winter. So, the above numbers are also considered as a proxy of the prevailing wind directions.

The result of the correlation analysis between this number (temperature proxy) and the concentrations of variety of POPs in Hedo is shown in Figure 5.3.2–3. The correlation coefficients are plotted in Y axis.

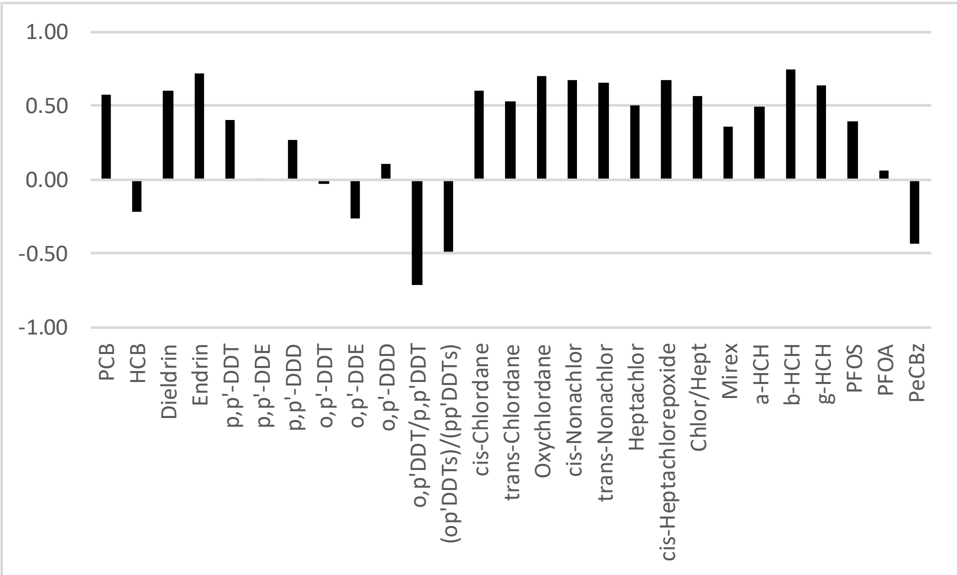


Figure 5.3.2–3 Correlations between "temperature proxy" and monthly averaged POPs at Hedo. Correlation coefficients are plotted against each POPs.

As shown in the above figure, majority of POPs levels show positive correlations with this number, i.e., high in summer and low in winter. This may reflect the general property of chemicals, i.e., they tend to be more volatile under higher temperature in summer. Interestingly, however, *o,p'*-DDT/*p,p'*-DDT ratios showed a clear negative correlation with this proxy. In addition, HCB, PeCBz, *o,p'*-DDE and (*o,p'*-DDT+*o,p'*-DDE+*o,p'*-DDD)/(*p,p'*-DDT+*p,p'*-DDE+*p,p'*-DDD) ratios also show weak negative correlations. Previously, it was reported that *o,p'*-DDT/*p,p'*-DDT ratios at Hedo showed clear seasonal variations, i.e., higher in winter and lower in summer[63]. Although the reason was not clarified, a possible explanation reported in the reference[63] was that the high *o,p'*-DDT/*p,p'*-DDT ratios in winter at Hedo might reflect the dominant winter air flow from the continent where air DDT compositions were affected by the spray of dicofol, which contained unreacted, *o,p'*-rich, DDT[64]. This tendency, i.e., high in winter and low in summer, still continues as shown in Figure 5.3.2–4. It should be pointed out that all DDTs levels show clear decreasing trends in recent years at Hedo and Jeju (Figures 5.2.1–1, 5.3.2–1, 5.3.2–2), supporting the effectiveness of the Convention.

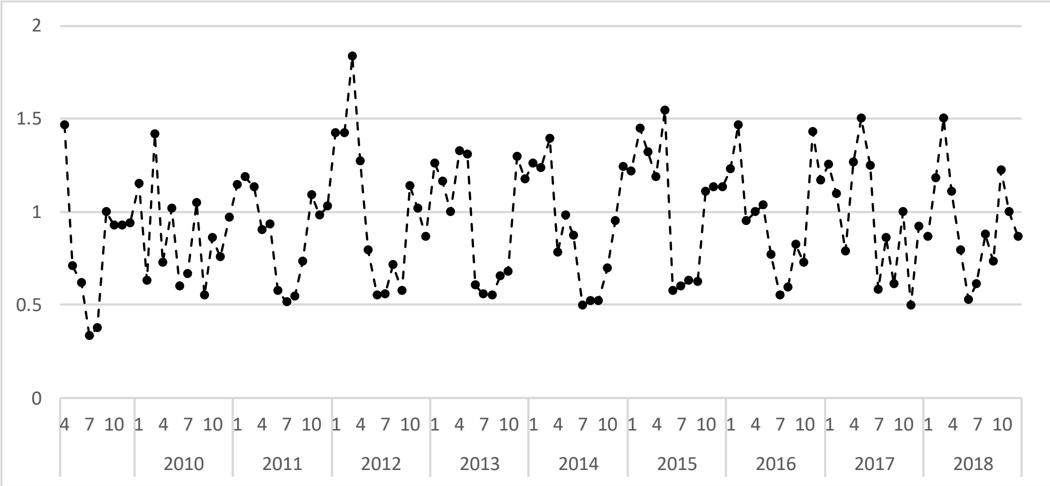


Figure 5.3.2–4 *o,p'*-DDT/*p,p'*-DDT ratios at Hedo.

HCB and PeCBz, on the other hand, show the longest CTDs among POPs (Table 5.3.1–1) and thus may travel long distance before coming to Hedo. Therefore, their levels in Hedo may reflect both the emission levels in the hemispheric or global scale and the effects from nearby sources. They have both intentional and unintentional emission sources and their levels do not show clear temporal trends recently in both Hedo, Okinawa and Gosan, Jeju. It seems reasonable at Hedo that their levels in winter is higher than summer, for in winter the wind comes from Eurasia continent where so many human activities are conducted while in summer the wind from Pacific Ocean where virtually no human activity is present. In fact, their seasonal variations are not clearly sinusoidal or biphasic; apparently HCB levels are almost always low in summer (July) and high in winter to early spring (Jan to Apr), but also frequently high in autumn (around Oct). Spring and autumn data did not affect the above correlation analysis strongly because only small or zero proxy values were assigned in the seasons. Again, more detailed researches, including back trajectory analysis and/or model studies as well as compilation of the emission source information, will be needed to analyze their trend data and to clarify their long-range transport and possible source regions. In Hedo, monthly HCB and PeCBz data correlates very well each other with correlation coefficient of 0.90, suggesting the effect of common sources in Hedo. Interestingly PeCBz showed, although not statistically significant, a slight increasing tendency in both Hedo, Okinawa and Gosan, Jeju (Figure 5.3.2–5), supporting further research needs of these high CTD substances in a global scale.

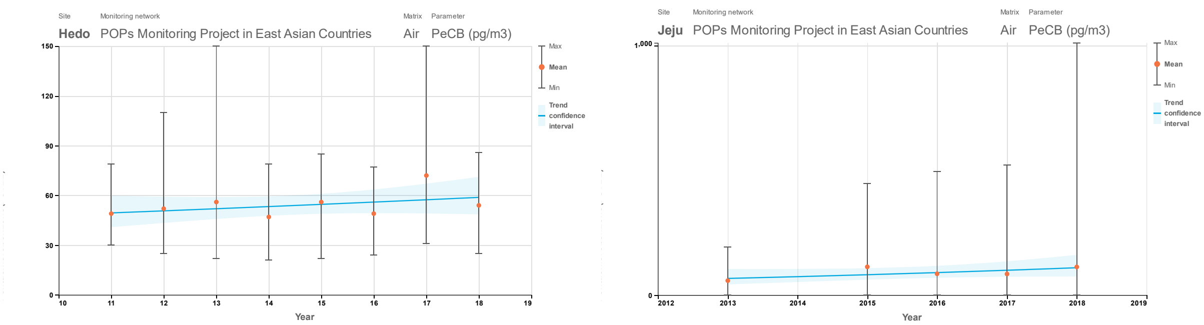


Figure 5.3.2–5Temporal trends of PeCBz in Hedo (left) and Jeju (right).

5.3.3 Long range transport of HCBD

As described in Figure 5.2.1-7, HCBD levels in East Asian sub-region showed a dramatic increase in recent couple of years. So far, the highest levels of HCBD, 20,000 to 23,000 pg/m^3, were observed on 19-20 and 20-21 September 2017 at Hagi, in the western edge of the main island, Honshu. HCBD is known to be produced as by-product during the synthesis of organochlorine solvents, such as trichloroethylene, tetrachloroethylene and carbon tetrachloride, and also produced unintentionally during magnesium production and incineration process. There are no big facilities of related activities around Hagi sampling site. Back trajectory analysis during the sampling period at the sampling sites, Hagi, were summarized in Figure 5.3.3–1. On the two days when highest HCBD levels were observed, westerly wind coming from Asia continent through Tsushima Strait was prevailing, suggesting the effect of transboundary transport.

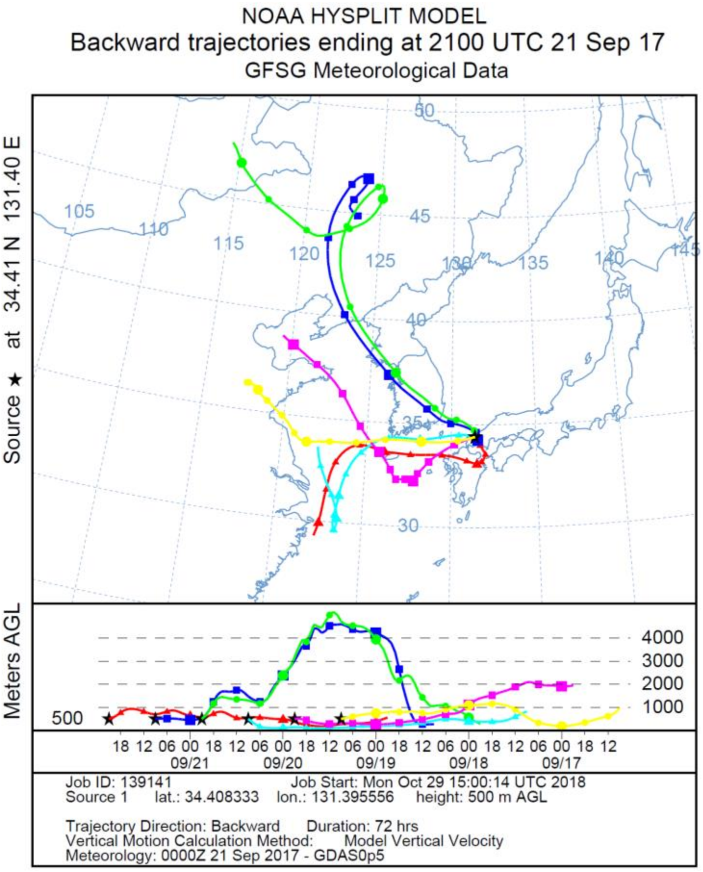


Figure 5.3.3–1Backtrajectory analysis of air flow at Hagi during the sampling in 2017.
Calculation was conducted by HYSPLIT, NOAA, USA.
Note that HCBD levels were high in the first and the second days (back trajectories; yellow, pink, light blue and green) but low in the third day (dark blue and red).

5.3.4 Summary of long-range transport of POPs

As described above, background air monitoring stations in East Asia captured several interesting trends and transport related information, particularly decreasing trends of DDTs and commercial pentaBDEs, and increasing trends of HCBD. Although these background stations were carefully selected by establishing selection criteria, small scale industries, traffics and agricultural activities are present in each of the islands and it is not easy to identify which is the effect of long-range transport and which come from local source(s). At this moment a simple criterion of the effect of long-range transport is the identification of similar trends in different monitoring. In the case of HCBD, similar levels of its drastic increases are observed not only in Hedo, Okinawa, but also in Fukue, Nagasaki and in the Japanese national monitoring program in a same period in 2017. Similarly a clear decreasing trend of DDTs, particularly *p,p'*-DDT and *o,p'*-DDT, are observed in Hedo, Okinawa and Gosan, Jeju as well as in Japanese national monitoring. These observations support the view that the temporal trends in HCBD and DDTs are the result of long-range transport, rather than the local effects (although national monitoring may also be affected by the local effects). Particularly HCBD is volatile and belong to the highest CTD group among all the POPs, and comparison of the observed data with other regions will provide us with more insight into the potential sources and their global transport.

Currently monitoring data are available only in East Asia and Pacific Islands. There is a strong need to establish environmental monitoring in south, west and middle Asia, and thus to expand monitoring network to cover all the Asia-Pacific region. Further capacity building/enhancement activities in these regions as well as networking of existing monitoring activities will farther support the implementation of the Convention.

6 CONCLUSIONS AND RECOMMENDATIONS

Highlights of collected regional data on POPs levels in air and human milk/blood

In the Asia-Pacific Region, several international and national POPs monitoring programs on air and human milk/blood are available. For the air, passive sampling was conducted in the POPs Global Monitoring Plan in Asia and Pacific sub-regions. In POPs Monitoring Project in East Asian (POPsEA), active sampling was operated in seven countries (Japan, Republic of Korea, Cambodia, Indonesia, Lao PDR, Malaysia, and Thailand). In China and Japan, national POPs monitoring programs in ambient air are performed. For human milk, a regional POPs monitoring program was carried out in East Asian and Pacific Islands Region including Cambodia, Mongolia, Thailand, Vietnam, Fiji, Kiribati, Marshall Islands, Niue, Palau, Samoa, Solomon Islands, and Vanuatu. China and Japan also conducted national POPs monitoring programs to analyze the level of POPs in human milk. Only Japan have conducted monitoring programs to investigate the level of POPs in human blood.

China has been performed a relatively wide scope of analysis of POPs in the ambient air from 2007 to 2019. Ambient air samples were collected over the nation including Hong Kong SAR and Macao SAR, while human milk samples were collected from Macao SAR for the investigation of the concentrations of POPs.

For the air, Japan has monitored POPs by high volume sampler throughout the nation since 1997 for dioxins, and since 2002 for other POPs. Air sample is collected and analyzed at Cape Hedo (Okinawa Island) and Fukue (Goto Islands), which are background sites, since 2009 and 2014, respectively. Republic of Korea conducted background air monitoring at a regional background site, Jeju Island, every month from 2009 to 2018 (except 2014). The POPs Monitoring Project in East Asian Countries has also monitored POPs in the air by high volume sampler in Cambodia, Indonesia, Lao PDR, Malaysia and Thailand during 2014-2017.

For many countries in the Region, there is generally less information available on the levels of POPs in the human tissues than those of air. As part of the UNEP/GEF GMP2 capacity building program in East Asian and Pacific Islands, human breast milk sampling was conducted in twelve countries, and pooled samples in each country was analyzed of both original and newly added POPs. POPs concentrations in human milk in Japan were reported by the research supported by a governmental research grant from 2013 to 2018.In the Asia-Pacific Region, however, limited POPs monitoring programs on human blood are available. In Japan, a project conducted by the Ministry of Environment monitored POPs in human blood since 2002. From 2013 to 2016, the project targeted PCDDs, PCDFs, *dl*-PCBs, PFOS, PFOA and PFHxS.

However, no or limited data and information are available from South and West Asian sub-regions. Furthermore, studies on POPs in human tissues are mainly limited to human milk. There is very limited data of human blood lacking over the region, primarily due to the poor availability of analytical facilities.

Monitoring data of POPs were reported by some countries in Asia-Pacific Region. In general, POPs levels in ambient air vary from country to country, from site to site. However, some of the POPs have not been quantitated in studies. It might be due to the analytical methods to analyze POPs were not sensitive enough to detect ultra-trace level of contaminants, and hence it is difficult for further comparison. Snapshot samples were collected in a random time of year. It is encouraged that more data (higher sampling frequencies and more sampling points) should be gathered on the basis of the discussion of long-range transport and temporal trend of POPs.

It should be noted that only a few countries in the Region reported the POPs data. Some countries have been collecting POPs data for longer and more intensively than others, but most countries have not.

Highlights of evidence of temporal trends and long-range transport of POPs

Temporal trend of POPs level is based on the data collected over the period between 2014 and 2019, compared to those gathered in the 1st and 2nd Asia-Pacific Regional Monitoring Reports. The levels of initial POPs are reducing, but not as significant as before. Only few data are focused on the levels of new POPs in the region. The significant change on the levels will be seen after a certain period of time since the implementation of regulations in the Parties.

Background air monitoring data in the region show generally decreasing trends of many of POPs in the atmosphere. Particularly evident is a continuous decrease of input of newly synthesized DDT in the East Asia, which was also detected and reported in the 2nd regional report. The clear decreasing trends of DDTs were observed in the two background monitoring stations, Hedo, Okinawa and Gosan, Jeju. In addition to DDTs, decreasing trends of other POPs, including chlordanes (Okinawa), HCHs (Okinawa and Jeju), tetra or pentaBDEs (Jeju and Japanese national monitoring), PCDD/PCDFs and/or *dl*-PCBs (national monitoring in China and Japan), and PCBs (national monitoring of Japan) were observed. Although the latter group might reflect local emission changes rather than transboundary transport, these data generally support the view that POPs emissions in the region is generally decreasing. On the other hand, a sudden increase of HCBD in the air was observed in the background sampling sites in Okinawa and Fukue as well as national monitoring in Japan after Spring 2017. HCBD is among the POPs showing highest CTD in the air, and its simultaneous increase in several sampling sites suggest the occurrence of large-scale emission and long range transport of HCBD instead of the effect of nearby local source. So far, the data is limited in a narrow area in East Asia, and more monitoring data for long term and in different locations will be needed to reveal the source and the scale of this increase.

There is continuous input of air monitoring data from East Asian countries under the POPsEA project, and another data by passive samplers under UNEP/GEF GMP2 project will be submitted in near future. The latter data will come from Pacific Islands, too, and will be compared with the previous GMP-1 data in the islands. Analysis of these data together with the monthly monitoring data and the national data will provide us with better view of the trends of POPs in East Asian countries.

A clear decreasing trends of DDTs are observed in human breast milk in Fiji and Kiribati where milk analysis has been conducted three times or more. PCDD/PCDFs and *dl*-PCBs levels in human milk or bloods are continuously decreasing in Fiji, Kiribati and Japan. PFOS levels in bloods seem to be decreasing in Japan. Although the amount of human data is not enough compared with air data, these data also seem to support general decline of some of POPs in the region.

Number of data on PFOS in water environment is also increasing. Japanese national monitoring showed the statistically significant decrease of PFOS in lakes and PFOA in river mouth region, but further analysis of increasing data will give us better understanding of the current situation. In Japanese national monitoring, statistically significant decreasing trends are reported on other media; for example, total PCBs, HCB and dieldrin in sediments in general, tetra- and pentaBDEs in river sediments, PFOS in marine sediments, PFOA in river and river mouth sediments; PCBs, some of DDTs, tetraBDE and α-/γ-HBCDs in bivalves, and some of DDTs and α-HBCD in fishes.

Clearly, more data are needed to reveal current pollution status and their temporal trends in regional scale. Capacity building/enhancing activities are needed particularly in south-, west- and middle Asia, and establishment of long-term environmental monitoring activities as well as their networking will farther support the implementation of the Convention.

Highlights of participations in POPs monitoring programs

As part of the UNEP/GEF GMP2 capacity building program in East Asia and Pacific Islands, human breast milk sampling was conducted in several countries and regions. Also, monitoring data on ambient air for the effectiveness evaluation of POPs levels in the East Asian and Pacific sub-regions were obtained from East Asian POPs Monitoring Programme. It is important to keep the monitoring programs continued for future evaluation. More countries and regions should be encouraged to participate in the monitoring programs.

The UNEP-coordinated interlaboratory assessment programs provide significant impact on training and comparison to Asia-Pacific laboratories. Thirteen countries in this region have participated in rounds of 2016/2017 and 2018/2019 rounds of POPs interlaboratory assessment coordinated by UN-Environment. For core matrix of “human milk”, OCPs, PCBs and PFASs were analyzed under the collaboration of WHO and UNEP. For the matrix of “water”, only PFASs were analyzed. For core matrix of “ambient air with passive samplers”, all POPs were included in the analysis.

In POPsEA project, capacity building/enhancement activities have been being conducted by Japan for POPs air sampling and by R. Korea for sample clean-up and analysis. Japan and R. Korea have also been conducting a bilateral program on the harmonization of analytical methods of POPs. Furthermore, efforts have been conducted to share information and to improve harmonization between POPsEA project and UNEP/GEF GMP2 program in East Asia by organizing the meetings back-to-back and participating core members to the related meetings. United Nations University and Shimadzu Corp. conducted another capacity building/enhancement program on the management of POPs in water until 2018, in which sampling and analysis of POPs, including PFOS and PFOA in water, were trained and conducted.

Nearly two decades have passed after the adoption of the Stockholm Convention. During the period, several countries in East Asian region, including China, Japan and R. Korea, conducted POPs monitoring and reported the data to GMP DWH, while other countries, including Philippines, Thailand and Vietnam, established advanced analytical laboratories for dioxins and/or other POPs analysis. Some other countries have also arranged instruments for the analysis of some of POPs. The number of countries having capacity to analysis POPs is increasing in East Asia.

It should be pointed out, however, that most countries/sub-regions in Asia-Pacific Region currently do not have analytical facilities/capacity particularly for new POPs. While training and collaboration have been provided to some countries and regions, even with the provisions of sampling equipment and consumables, laboratories analysis were conducted outside Asia-Pacific Region through collaborations. For example, no operational POPs laboratory was built in Pacific Island countries during project implementation period on PFASs.

Existing barriers and recommendations

In Asia-Pacific Region, many countries do not have enough funding for the technology development and transfer. Therefore, facilities for POPs analysis and monitoring are limited. In addition, the techniques and knowledge of many of the specialists in the region may need further enhancement to reach/surpass the standard levels to produce qualified POPs data. In some cases, there is also insufficient monitoring of POPs, lack of programs on the emission control and lack of quality control. The current monitoring data are mostly available in East Asian and Pacific Islands. There is a strong need to establish environmental monitoring in the south, west and the middle Asia, and thus to expand monitoring network to cover all Asia-Pacific regions.

Only some trends were studied due to the insufficient number of long-term regional monitoring programs or studies on POPs. Therefore, comprehensive determination of long-range transportation and its impact is difficult. Nevertheless, the back trajectory results of air monitoring data obtained from the East Asian Monitoring Programme provided some interesting trends and transport related information. It is recommended that comparison of the observed data with other regions can be conducted because it may provide us with more insight into the potential sources and their global transport. In addition, it is strongly recommended to establish environmental monitoring in the south, west and the middle Asia, in order to cover all Asia-Pacific regions for trends and transport investigations.

Except for China, Japan, Republic of Korea and Singapore that have well established POPs monitoring systems, the capacity lack is identified in many of other countries in the region. There is still a long way to achieve an Asia-Pacific Monitoring System to provide timely and reliable data for GMPs. The difficulties involved in the lack of POPs monitoring capacity for most countries within the Region include lack of funds and advanced technology as well as insufficient knowledge and training of technical groups. In particular, more resources are necessary for improving the analytical facilities and methods for the determination of POPs. In addition to analytical facilities and methods, more trained personnel should be employed for the daily operation of the instruments. To maintain or improve the analytical capability for POPs needs, good QA/QC among laboratories, including the regular use of reference standards and/or certified reference materials, training programs, inter-laboratory comparison exercise, and the identification of reference laboratories within the region for specific POPs, should be achieved.

Regional POPs monitoring programs should be continued for regional comparison and temporal trend analysis. UNEP/GEF GMP-1 and GMP-2 programs together with WHO human breast milk analysis have been playing key roles to conduct capacity building/enhancement and to support production of POPs monitoring data in East Asia and Pacific Islands. Particularly noteworthy is the observation of clear decreasing trends of some of POPs in human breast milk in Pacific Islands, which provide indispensable information to assess the effectiveness of the political actions taken by the countries to manage POPs properly. In order to have a better evaluation on the POPs level in the future, continuation of the existing programs, such as POPs Monitoring Project in East Asia and UNEP/GEF POPs Global Monitoring Plan in East Asia and in the Pacific Islands, as well as establishment of more regional/sub-regional programs are needed. The following areas are the key elements for the capacity building for the development of POPs analysis: human capacity, inter-calibration tests, strengthening skills for sampling and analysis infrastructure strengthening of existing laboratories for analyzing the core media, QA/QC, and financial assistance to establish long-term, self-sufficient laboratories.

POPs analysis laboratories within Asia-Pacific Region should implement robust and validated methods according to international scientific standards. By adopting the suitable analytical method to their circumstances and prove the capabilities with successful participation in international comparison studies. Therefore, capacity building has to be set as the top priorities for establishing new POPs laboratories and for improving the capabilities of most existing laboratories in the region. Countries in the region should be encouraged to participate in ongoing programs to promote the implementation of the Convention. In particular, countries in the region should be encouraged to participate in the inventory activities. Analytical capability for the POPs monitoring may be enhanced through existing mechanisms of collaborations and with seeking funds from national and international organizations. In addition, projects to harmonize analytical methods among monitoring programs in the region should be continuously conducted.

We hope the regional centers in Asia/Pacific, including the Stockholm Convention Regional Centers for capacity building and the transfer of technology (SCRC China, India, Indonesia, Iran and Kuwait), will play roles in POPs monitoring in the future. However, further capacity building/program enhancement in Asia-Pacific Region are necessary for the implementation of the Convention.

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