Ministry of Environment

National Implementation Plan for the Stockholm Convention

Republic of Korea

Updated in 2019

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1. Introduction

1.1 Stockholm Convention on Persistent Organic Pollutants

The Stockholm Convention on Persistent Organic Pollutants (hereinafter referred to as the “Convention”) is a global convention, whose objective is to protect human health and the environment from persistent organic pollutants (POPs) by eliminating or reducing the releases of POPs. POPs are the chemical substances with characteristics of environmental persistency and bioaccumulation, posing a risk that may lead to adverse health effects. These pollutants also transport in long range across international boundaries. The Convention was adopted on 22 May 2001 and entered into force on 17 May 2004.

At the beginning, the Convention had initial 12 POPs such as PCBs, organochlorine pesticides (OCPs) and dioxins/furans were listed in Annex A, B and C. As of April 2019, 14 new POPs were added to the Convention: 9 POPs including PFOS were listed in 2009; endosulfans in 2011; HBCD and PCP in 2013; HCBD and PCN in 2015; and SCCPs and deca-BDE in 2017. Consequently, a total of 28 POPs are now listed on the Convention (Table 1).

Under the Convention, the Parties shall take measures: ban or restriction on production, import/export and use of intentional POPs, reduction of unintentional release of POPs, environmentally sound management of stockpiles and wastes consisting of, containing or contaminated with POPs, submission of the National Implementation Plan, reporting, monitoring and research, etc.

1.2 POPs control of the ROK before the Convention

POPs control in the Republic of Korea (ROK) began in 1969 with the revised the Pesticide Control Act, which mandated “toxic pesticides go through a permission process before their sale or use”, to prevent indiscreet use of toxic and bioaccumulative chemicals such as Chlordane and DDT. In 1990, the Toxic Chemicals Control Act started to ban or restrict the manufacture, import/export and use of such chemicals for purposes other than pesticides.

Table 1. POPs listed on the Stockholm Convention

Chemical	CAS No.	Listed in Annex			Category		
					Pesticide	Industrial Chemical	byproduct
Aldrin	309-00-2	A			P		
Chlordane	57-74-9	A			P		
DDT	50-29-3		B		P		
Dieldrin	60-57-1	A			P		
Endrin	72-20-8	A			P		
Heptachlor	76-44-8	A			P		
Hexachlorobenzene(HCB)	118-74-1	A		C	P	I	U
Mirex	2385-85-5	A			P		
Toxaphene	8001-35-2	A			P		
Polychlorinated biphenyls (PCB)		A		C		I	U
Dioxins (PCDD)				C			U
Furans (PCDF)				C			U
Pentachlorobenzene (PeCB)	608-93-5	A		C	P	I	U
Alpha-hexachlorocyclohexane (α-HCH)	319-84-6	A			P		
Beta-hexachlorocyclohexane (β-HCH)	319-85-7	A			P		
Chlordecone	143-50-0	A			P		
Lindane (γ-HCH)	58-89-9	A			P		
Tetra- and pentabromodiphenyl ether (4,5-BDE)	5436-43-1, etc.	A				I	
Hexa- and heptabromodiphenyl ether (6,7-BDE)	68631-49-2,etc.	A				I	
Hexabromodiphenyl(HBB)	36355-01-8	A				I	
PFOS, its salts and PFOS-F	1763-23-1, etc.		B			I	
Endosulfan	115-29-7, etc.	A			P		
Hexabromocyclododecane (HBCD)	25637-99-4,etc.	A				I	
Pentachlorophenol (PCP)	87-86-5, etc.	A			P		
Polychlorinated naphtalens (PCN)	70776-03-3,etc.	A		C		I	U
Hexachlorobutadiene (HCBD)	87-68-3	A		C		I	U
Decabromodiphenyl ether (deca-BDE)	1163-19-5	A				I	
Short-chain chlorinated paraffins (SCCP)	85535-84-8,etc.	A				I	

PCBs have been widely used in insulating oil for transformers and condensers due to its chemical stability and insulating property. However, as their environmental pollution and risks were reported, Korea banned the use of PCBs in accordance with the Electric Utility Act in 1979 and classified waste containing PCBs as designated hazardous industrial waste under the Wastes Control Act in 1991 for its environmentally sound management. In July 2004, the Ministry of Environment, civic groups and power generators signed the “Voluntary Agreement to Eliminate PCBs.” The countermeasure against environmental pollution of PCBs and road map to eliminate PCBs were developed in 2005 and 2006, respectively.

In the 1990s, dioxin was firstly detected from waste incinerators in the country, which raised an environmental issue and led to the amendment of the Wastes Control Act in 1997 that adopted the emission limits of dioxin from waste incinerators. In addition, a dioxin monitoring project began from 2001 to measure their levels in industrial facilities. In July 2005, the Ministry of Environment and the industries emitting high amount of dioxin signed the “Voluntary Agreement to Reduce Dioxin Emission” to induce their voluntary emission reductions. Environmental monitoring on POPs in the air, water, soil and sediment was started in 1999 to assess the status of environmental pollution.

After signing the Stockholm Convention in Oct. 2001, the ROK ratified the Convention in January 2007. Under the Article 25 (4) of the Convention, the Korea as a country separately ratifying the amendment of its Annex, is regularly amending the Act to add newly listed substances and implement its obligations.

To implement the Convention, the ROK enacted and promulgated the POPs Control Act in January 2007 (became effective in January 2008), starting to control dioxin emission on industrial facilities and integrated the existing POPs control systems. The national POPs monitoring network was started to monitor POPs in the environmental media since 2008 under the Act.

1.3 Overview: National Implementation Plan

According to the Article 7 of the Convention, each party shall develop a national implementation plan (NIP) to fulfill its obligations under the Convention and transmit the NIP to the Conference of Parties within two years of the date on which the Convention enters into force for it. According to the Decision SC-1/12, the parties also have to review and update the NIP when any change occurs in its obligations.

The ROK prepared and submitted the first Korean NIP in April 2009 after the ratification in 2007, and its 1st update in December 2011.

This NIP as the 2nd update describes the national implementation status and plan regarding five new POPs such as endosulfan, HBCD, HCBD, PCP and PCN listed from 2011 to 2015 (Table 2).

Table 2. New POPs added to the 2nd update of the NIP

Chemical	Description of Listing	Year of Listing	National Regulation
Technical endosulfan and its related isomer	**[Prohibition]** Specific exemptions of production and use as an insecticide for 17 crops listed in the Annex	2011	· Completely banned in 2010 under the Pesticides Control Act · Added to the POPs Control Act in Mar. 2015 and entered into effect in Oct. 2015. · No specific exemption
HBCD	**[Prohibition]** Specific exemptions of production·use for expanded polystyrene and extruded polystyrene in buildings	2013	· Added to the POPs Control Act in Mar. 2015 and entered into effect in Oct. 2015. · Specific exemptions expired in Oct. 2020
PCP	**[Prohibition]** Specific exemptions of production·use for utility poles and cross-arms	2015	· Added to the POPs Control Act in Mar. 2017 and entered into effect in Oct. 2018. · No specific exemption
HCBD	**[Prohibition]** No specific exemption	2015	· Added to the POPs Control Act in Mar. 2017 and entered into effect in Oct. 2018.
PCNs	**[Prohibition]** Specific exemptions for production use as an intermediate in the production of polyfluorinated naphthalenes including octafluoronaphthalene **[Unintentional production]** Emission source control and emission reduction measures	2015	· Added to the POPs Control Act in Mar. 2017 and entered into effect in Oct. 2018. · No specific exemption

2. POPs Control Status of the ROK

2.1 The ROK and POPs

2.1.1 General Profile of the ROK

The ROK is located in Northeast Asia, at the latitude of 33 °N ~ 43 °N and the longitude of 124 °E ~ 132 °E, with an area of 99,700 ㎢. Geographically, the ROK is in the mid-latitude temperate zone, with four distinctive seasons. The annual average temperature is 10℃ ~ 15℃ and the average temperature in the hottest month of August is 23℃ ~ 26℃ while that in the coldest month of January is -6℃ ~ 3℃. Annual precipitation is about 1000 ~ 1900 mm and observed 50 ~ 60% of rain falls in the summer.

The ROK is a country where separating its powers into legislative, administrative and judicial powers and has a presidential government system. Its administration consists of 18 ministries, 5 ministry agencies, and 17 administrations (Figure 1).

2.1.2 ROK's POPs Management System

The POPs management of the ROK is mainly involved with seven related ministries: Ministry of Environment, Ministry of Oceans and Fisheries, Ministry of Agriculture, Food and Rural Affairs, Rural Development Administration, Ministry of Food and Drug Safety, Ministry of Trade, Industry and Energy, and Ministry of Science, ICT and Future Planning (Figure 2).

The Ministry of Environment manages the overall works related to the Convention and the POPs Control Act: It sets environmental POPs criteria; bans or restricts their production, import/export and use; operates the national POPs monitoring network; investigates emission sources, sets release limits and develops emission inventory; and manages stockpiles and wastes consisting of, containing and contaminated with POPs.

The Ministry of Oceans and Fisheries investigates POPs in the marine ecosystem, sets goals to manage marine sediment and develop pollution reduction measures, and

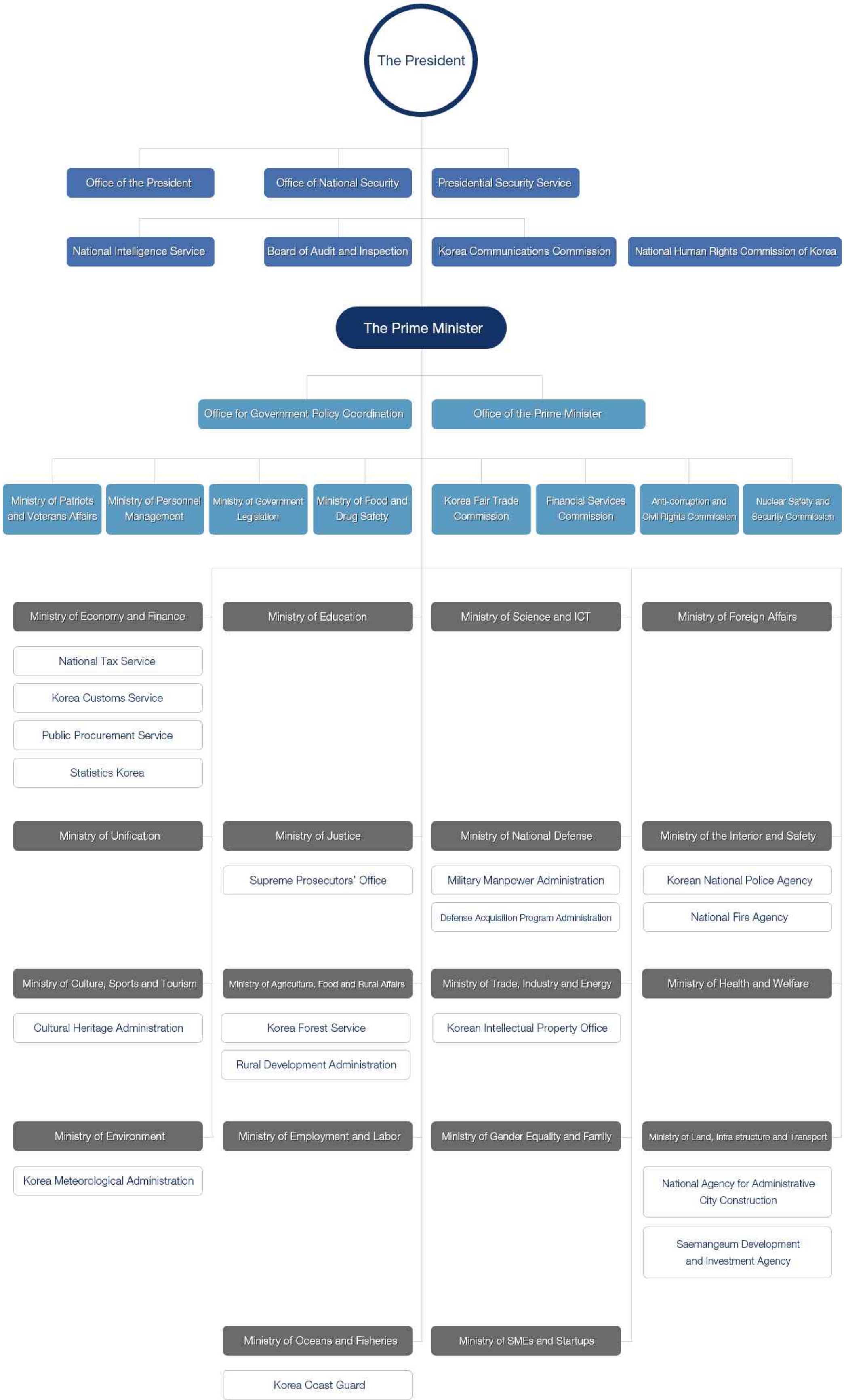

Figure 1. Organizational Chart of the ROK Government.

develops the marine environmental standard in accordance with the Marine Environment Management Act.

The Rural Development Administration is in charge of controlling pesticide POPs by prohibiting their production, import/export and use under the Pesticides Control Act.

The Ministry of Food and Drug Safety conducts monitoring and risk assessment on POPs mainly in food based on the Food Sanitation Act and the Pharmaceutical Affairs Act. It also conducts a human bio-monitoring program to identify POPs exposure and establishes daily intake criteria of POPs like dioxin, PCBs, PFOS and PFOA.

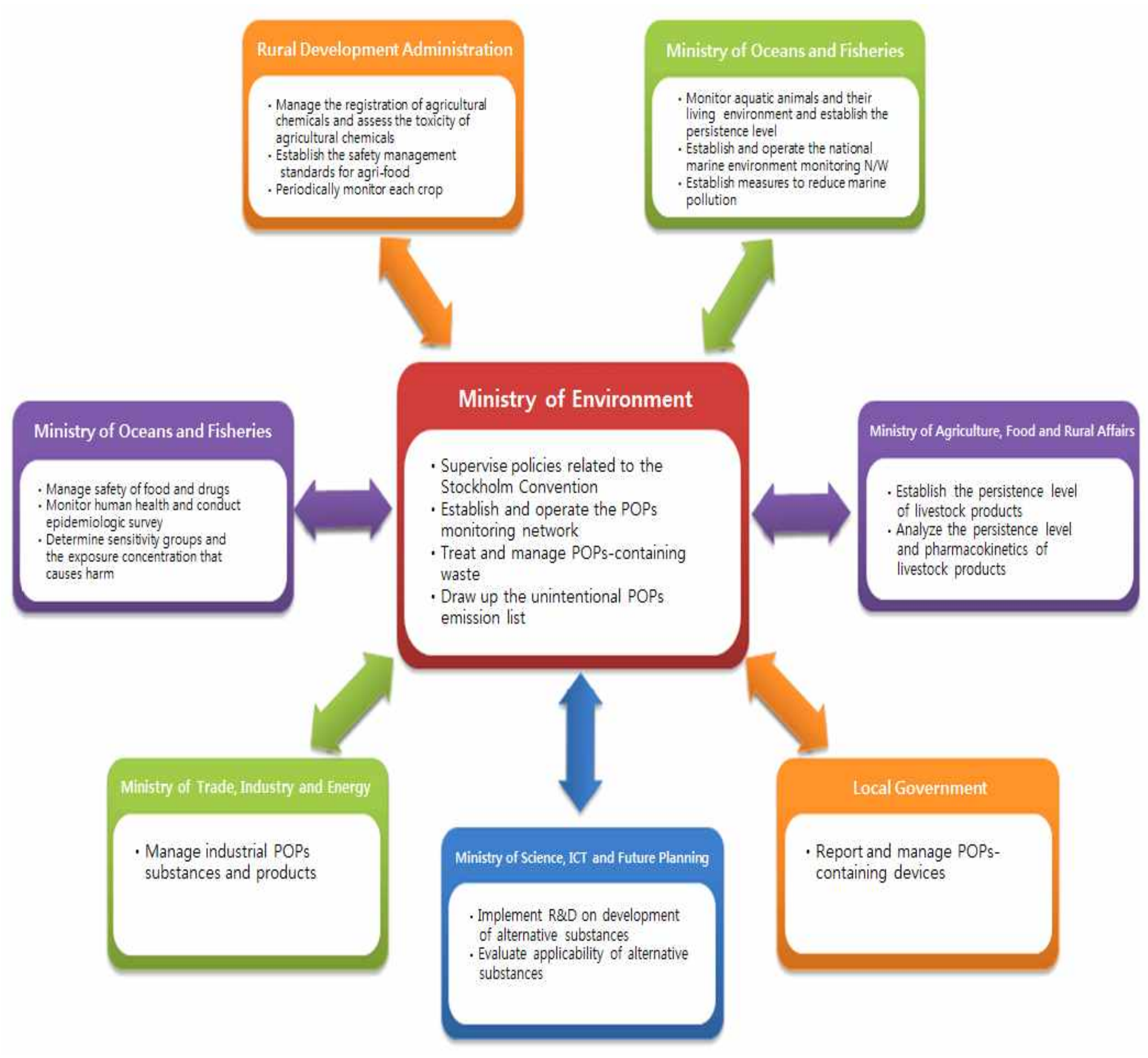

Figure 2. Relevant Ministries and Their POPs Control Works.

The Ministry of Agriculture, Food and Rural Affairs examines residue levels of hazardous substances and assesses their safety in livestock products. Since 2000, it has investigated dioxin levels in livestock products.

2.2 Status of Intentional POPs Control

2.2.1 Pesticide POPs

Pesticide POPs listed under the Convention are 15 OCPs (organochlorine pesticides): Aldrin, dieldrin, endrin, chlordane, heptachlor, hexachlorobenzene (HCB), mirex, toxaphene, chlordecone, α-HCH, β-HCH, lindane, pentachlorobenzene (PeCB) and endosulfan in Annex A, and DDT in Annex B.

2.2.1.1 Control System for Pesticide POPs

The ROK’s POPs management began with the pesticide management. In the past, the pesticide management policy focused on preventing damage to agricultural products rather than protecting the environment and human health. In 1969, however, the Ministry of Agriculture and Forestry revised the Pesticides Control Act to require getting permission for sale and use of toxic agricultural chemicals and to prevent careless use of the chemicals such as DDT. Currently, a person who intends to use pesticide in the country shall register it in accordance with the Pesticides Control Act. Besides, those already registered shall be registered again every 10 years and their registration can be cancelled by authority of the Administrator of the Rural Development Administration, if necessary. With the current system, the ROK can prevent the pesticide POPs under the Convention from entering the Korean market.

Some pesticide POPs such as mirex, HCB, chlordecone and PeCB have never been produced and used in the country and their distributions are also banned by the POPs Control Act (Table 4). The pesticide POPs that had been used in the country are 11 substances, including aldrin, dieldrin, endrin, chlordane, heptachlor, toxaphene, DDT, α-HCH, β-HCH, lindane and endosulfan. Their registrations were banned and revoked forty or fifty years ago in accordance with the Pesticides Control Act, except endosulfan. Especially, the registrations of α-HCH, β-HCH and lindane, which are also listed under the Rotterdam Convention, were revoked in 1979 and they were included in the list of non-importation in 2009 pursuant to the Approval Standard on Import/Export for Agricultural Chemicals (Public Notice No.2009-4 of the Rural Development Administration). However, lindane was distributed until 2015 as pharmaceutical product, not as agricultural substance. Its specific exemption was registered for medical use against head lice and scabies and was ended in 2015.

Endosulfan

Endosulfan was produced firstly in Germany in 1956 and sold as product name of “Thiolix” in the ROK. It was used nationwide as an insecticide for food crops such as tobacco, chinese cabbage and mulberry.

Endosulfan was listed in Annex A (Elimination) of the Convention at the COP5 in 2011. The ROK completely prohibited its use on food crops from 2004 by embracing it into the scope of the Pesticides Control Act. The registration of endosulfan was prohibited as a technical concentrate of pesticide in 2010 and its registration as an existing agricultural chemical was also canceled in 2011 under the Pesticides Control Act. Therefore, production, import and use of endosulfan as an agricultural chemical have been totally banned since 2012, and its production and use have also been prohibited under the POPs Control Act from Dec. 2014.

Table 3. Control Status of Pesticide POPs

Chemicals	Year of listing	Domestic Control	
		Pesticides Control Act	POPs Control Act
Aldrin	2005	Cancellation of registration/Prohibition(1972)	Total ban (2008)
Endrin,	2005	Cancellation of registration/Prohibition(1970)	Total ban (2008)
Dieldrin	2005	Cancellation of registration/Prohibition(1970)	Total ban (2008)
Toxaphene	2005	Cancellation of registration/Prohibition(1983)	Total ban (2008)
Chlordane	2005	Cancellation of registration/Prohibition(1969)	Total ban (2008)
Heptachlor	2005	Cancellation of registration/Prohibition(1979)	Total ban (2008)
Mirex	2005	No domestic distribution (unregistered as a pesticide)	Total ban (2008)
Hexachlorobenzene	2005	No domestic distribution (unregistered as a pesticide)	Total ban (2008)
DDT	2005	Cancellation of registration/Prohibition(1971)	Total ban (2008)
Chlordecone	2005	No domestic distribution (unregistered as a pesticide)	Total ban (2011)
Lindane	2009	Cancellation of registration/Prohibition(1979), Nonimportation(2009)	Total ban except specific exemption (2011)
α-HCH	2009	Cancellation of registration/Prohibition(1979), Nonimportation (2009)	Total ban (2011)
β-HCH	2009	Cancellation of registration/Prohibition(1979), Nonimportation(2009)	Total ban (2011)
Pentachlorobenzene	2009	No domestic distribution (unregistered as a pesticide)	Total ban (2011)
Endosulfan	2011	Cancellation of registration/Prohibition(2011) Nonimportation(2012)	Total ban (2015)

2.2.1.2 Monitoring Status of Pesticide POPs

(1) Pesticide POPs in the Environment

The environmental pollution caused by pesticide POPs have been monitored by the national POPs monitoring network of the Ministry of Environment. The network has been in operation since 2008. As of 2018, monitoring activity is performed at 171 sites (air: 38 sites, water: 36, soil: 61 and sediment: 36): twice a year for air (spring and fall) and once a year (spring) for other environmental media. Since 2017, different monitoring cycle (e.g. once in three years) has been applied for pesticide POPs with a low detection rate.

According to the results of the national POPs monitoring network from 2014 to 2016 (MOE, 2017), annual average concentrations in the atmosphere were as follows: drins[1)] was ranging from lower than MDL (method detection of limits) to 4.745 pg/S㎥; heptachlors[2)] 0.393 ~ 0.428 pg/S㎥; chlordanes[3)] 1.822 ~ 3.013 pg/S㎥; DDTs[4)] 2.555 ~ 3.908 pg/S㎥; HCHs[5)] 22.474 ~ 34.487 pg/S㎥; and endosulfans[6)] was 66.401 ~ 128.604 pg/S㎥. The annual average concentration of PeCB in the air was 91.210~136.887 pg/m^3 and that of HCB was 187.087 ~ 223.412 pg/m^3. The concentrations of both substances in the air were high in summer, and the highest detection sites were mostly located in the industrial area or the metropolitan area adjacent to industrial areas.

In case of HCB and PeCB detected in high concentrations in the air, they are assumed to be emitted unintentionally since they have never been distributed or used as pesticides in Korea. Endosulfans that had been used until most recently shows a higher concentration than other pesticide POPs.

The concentrations of OCPs in soil were under or a little over MDL. By substance, average of drins was in the range of 0.003 ~ 0.009 ng/g; heptachlors 0.007 ~ 0.018 ng/g; chlordanes 0.021 ~ 0.037 ng/g; DDTs 0.678 ~ 2.098 ng/g; HCHs 0.055 ~ 0.182 ng/g; and endosulfans 0.567 ~ 1.047 ng/g. The average concentration of PeCB was 0.115~0.228 ng/g, and that of HCB was 0.176 ~ 0.269 ng/g, relatively high in industrial areas.

Most of pesticide POPs in rivers and lakes were under MDL. The average concentration of HCHs was 0.153 ~ 0.311 ng/L and that of endosulfans was 2.050 ~ 4.743 ng/L. Average concentration of PeCB in sediment was 0.050 ~ 0.110 ng/g, and that of HCB was 0.082 ~ 0.160 ng/g.

As mentioned earlier, other pesticide POPs are strictly controlled by banning their use forty or fifty years ago or with other measures. Hence, their residue levels are insignificant. But DDTs continue to be detected though a small amount, and

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1) Sum of aldrin, dieldrin, and endrin
2) Sum of heptachlor, and heptachlor epoxide
3) Sum of *trans*-chlordane, *cis*-chlordane, *trans*-nonachlor, *cis*-nonachlor, and oxychlordane
4) Sum of *p.p'*-DDE, *o.p'*-DDE, *p.p'*-DDD, *o.p'*-DDD, *p.p'*-DDT, and *o.p'*-DDT
5) Sum of α-HCH, β-HCH, and lindane (γ-HCH)
6) Sum of endosulfan-α, endosulfan-β, and endosulfan sulfate

especially in 2017, DDTs was found in eggs produced from some farms where DDT was detected in ground soil, becoming a social issue in the country. The detected amounts of DDTs in soil from poultry farms and adjacent the farming land were ranging from 0.046 to 0.539 mg/kg but DDTs was not found from crops cultivated in contaminated soil.

Besides, the ROK participates in the East Asian POPs monitoring program as the Global Monitoring Plan (GMP) to contribute to effective evaluation of the Convention. OCPs in the air have been monitored every month since 2009 in Jeju Island as a national background site (measured every 24 hours for three consecutive days, using a high-volume air sampler). From the results of the GMP monitoring between 2009 and 2018, atmospheric concentrations were found high for these OCP substances: HCB (171 ± 84 pg/m^3), endosulfans (108 ± 139 pg/m^3), PeCB (106 ± 76 pg/m^3), ΣHCHs (28.21 ± 62.20 pg/m^3), and ΣDDTs (6.46 ± 7.01 pg/m^3).

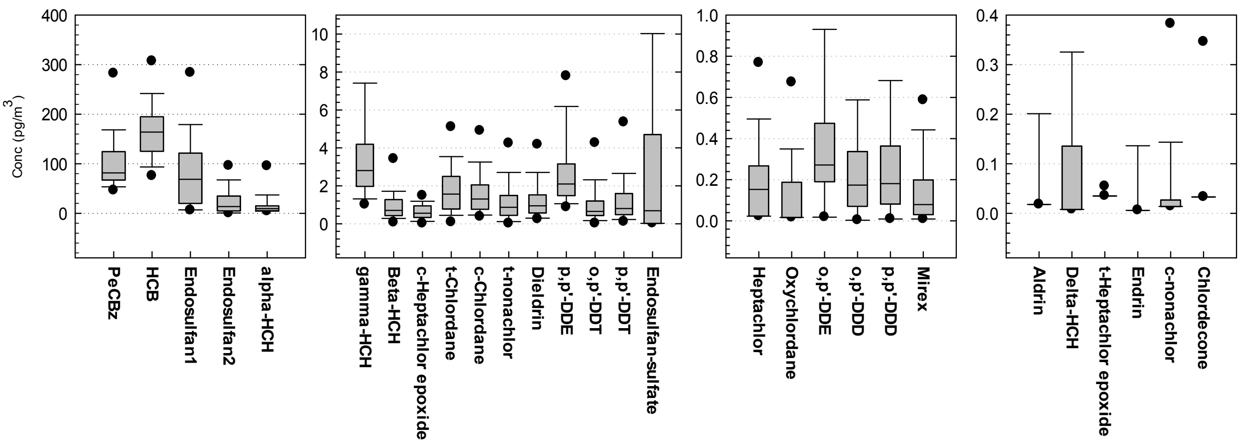

Figure 3. Distribution of OCPs concentrations in the air at the GMP Site (Jeju Island, 2009 - 2017)

(2) Pesticide POPs in the Marine Environment

The Ministry of Oceans and Fisheries (MOF) investigated POPs in the marine environment by collecting marine sediment and living organisms like oysters or mussels at 50 examination sites (as of 2017) across the country under the marine environment monitoring network. DDTs[7], HCHs[8], and chlordanes[9] were subject to the investigation (MOF, 2018).

The average concentrations in the marine sediment were: DDTs 1.42±1.71 ng/g dw, HCHs N.D (not detected), and chlordanes 0.09±0.16 ng/g dw. For living organism, the average concentration of DDTs was 6.36±9.40 ng/g dw, HCH N.D, and chlordanes 1.19±0.90 ng/g dw. DDTs recorded a higher concentration than other pesticide POPs. The ratio of p,p'-DDD and p,p'-DDE with total DDTs were high and the ratio of p,p'-DDT with total DDTs was low. This result implied that there is no new DDT flowed into the marine environment after the banning of DDT in 1970s. According to the survey results so far, DDTs show relatively high detection rates and high concentrations compared to other pesticide POPs, and there is no distinctive increasing or decreasing trend in their concentrations.

(3) Pesticide POPs in Food

The Ministry of Food and Drug Safety (MFDS) has conducted the Monitoring Project on Persistent Agricultural Chemicals in food since 1968 to secure safety of crops distributed across the country. It also sets and manages allowable residue levels in food regarding pesticide POPs. The allowable residue levels in foods as follows: Aldrin and dieldrin are in the range of 0.004 ~ 0.007 mg/kg for cereals; Endosulfans is 0.01 ~ 2.67 mg/kg in aster scaber; Heptachlor is 0.00 ~ 0.99 mg/kg for potatoes. According to the project, residue levels in most foods were under the allowable levels based on risk assessment method pursuant to the Food Sanitation Act, or not detected.

(4) Pesticide POPs in Human

The National Institute of Food and Drug Safety Evaluation under the MFDS carried out the "4th WHO POPs Monitoring Project in Breast Milk" in 2008 and reported the result to WHO. Also, monitoring data on human exposure to POPs are generated for risk assessment of POPs, with ordinary group and sensitive groups such as infants and pregnant women.

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7) Sum of *p.p'*-DDE, *o.p'*-DDE, *p.p'*-DDD, *o.p'*-DDD, *p.p'*-DDT, and *o.p'*-DDT
8) Sum of α-HCH, β-HCH, and lindane (γ-HCH)
9) Sum of *trans*-chlordane, *cis*-chlordane, *trans*-nonachlor, *cis*-nonachlor, and oxychlordane

2.2.2 Industrial POPs

Among intentional POPs listed in Annex A and B under the Convention, POPs such as PFOS, 4,5-BDEs, 6,7-BDEs, HBB, HBCD, PCPs, HCBD, PCNs and PCBs, except pesticide POPs, are classified and under control as industrial POPs. Of those industrial POPs, more information on PCBs are described in section 2.2.3.

2.2.2.1 Control System of Industrial POPs

In the ROK, the POPs Control Act bans or restricts production, import/export and use of industrial POPs except acceptable purpose and specific exemption for the ROK under the Convention. Moreover, even when using them for the acceptable purpose or specific exemption, it is required to comply with control measures according to the national regulations such as information labeling, safety requirements and accident-preventive measures. When exporting POPs for the allowable purpose under the Convention, an application for export approval shall be submitted to the Minister of Environment beforehand and the export is permitted only with the consent of the importing country. Out of industrial POPs, PFOS, HBCD, 4,5-BDEs, 6,7-BDEs, and PCBs are controlled, in line with acceptable purposes or specific exemptions, in accordance with the POPs Control Act.

Table 4. Acceptable Purposes of PFOS of the ROK

Chemical	Control under the Convention (Year of Listing)	Enforcement Date of the Rep. of Korea	Acceptable Purposes
PFOS, its salts and PFOSF (CAS No.: 1763-23-1, 307-35-7, 2795-39-3, 29457-72-5, 29081-56-9, 70225-14-8, 56773-42-3, 251099-16-8)	Restriction (2009)	5 April 2011	- **(Use)** For the following acceptable purposes, or as an intermediate in the production of chemicals with the following acceptable purposes: · Photo-imaging · Photo-resist and anti-reflective coatings for semiconductors · Etching agent for compound semiconductors 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

Table 5. Specific Exemptions of Industrial POPs of the ROK

Chemical	Control under the Convention (Year of Listing)	Enforcement Date of Korea	Specific Exemptions
PCBs (all PCBs)	Prohibition/ unintentional emission (2005)	27 Jan. 2008	- **(Use)** Equipment using PCBs (transformers, condensers, etc.) * No specific exemption for production - **(Exemption expiration)** 31 Dec. 2025
6,7-BDEs (CAS No. 68631-49-2, 207122-15-4, 446255-22-7, 207122-16-5, including commercial use)	Prohibition (2009)	5 April 2011	- **(Use)** Article manufactured with recycled materials including or likely to include this substance (only for green recycling and treatment) * No specific exemption for production - **(Exemption expiration)** 31 Dec. 2030
4,5-BDEs (CAS No. 5436-43-1, 60348-60-9, including commercial use)	Prohibition (2009)	5 April 2011	- **(Use)** Article manufactured with recycled materials including or likely to include the same substance (only for green recycling and treatment) * No specific exemption for production - **(Exemption expiration)** 31 Dec. 2030
HBCD (CAS No. 25637-99-4, 3194-55-6, 134237-50-6, 134237-51-7, 134237-52-8)	Prohibition (2013)	24 March 2015	- **(Production·Use)** Expanded polystyrene and extruded polystyrene in buildings - **(Exemption expiration)** 27 Oct. 2020

Perfluorooctane Sulfonic Acid (PFOS)

In 2009, the COP4 adopted a decision to list PFOS, its salts and PFOSF in Annex B of the Convention. This came into effect in Korea in April 2011 by amending the POPs Control Act. The ROK has registered specific exemptions for PFOS, except insect bait to control leaf-cutter ants.

PFOS were widely used in semiconductor manufacturing process, surfactant and fire-fighting foam in the country but after introduction of PFOS control measures, the amount of use reduced significantly. According to the Statistical Survey on Chemicals by the Ministry of Environment, 495 kg of PFOS was used in 2014 for photos-resist coatings and metal plating gas prevention agents, decreasing up to 18 kg in 2016 that was used only for hard metal plating as acceptable purpose of the Convention. In case of fire-fighting foam, the National Fire Agency prohibited the use of PFOS, its salts and PFOSF for fire-fighting form in February 2012 (detection limit of 1 ppm) according to the Public Notice on Technical Criteria for Approval and Inspection of Fire-Fighting Foam under the Act on Fire Prevention and Installation, Maintenance, and Safety Control of Fire-Fighting Systems. Relevant regulation took effect from 2013 after a year of grace period.

The National Fire Agency started voluntary replacement of PFOS-containing foam stored in fire fighting stations from 2011 and almost completed it until 2016. On the contrary, stockpiles of the foam purchased and stored by private facilities before the prohibition of PFOS may still exist since its shelf life is more than 20 years. The National Fire Agency has informed relevant stockholders of environmental hazards of PFOS-containing fire-fighting foam, and recommended to replace them in the near future.

Polybrominated Diphenylethers (PBDE) & Hexabromobiphenyl (HBB)

Polybrominated diphenylethers (PBDE), one of the most well-known brominated flame retardants, were mainly used for polyurethane foam in household goods, vehicles and airplane, epoxy and phenol resin, and construction materials. For polybrominated biphenyl (PBB), hexa-, octa- and deca-biphenyl were mainly produced for flame retardant in anti-lock break system (ABS), thermoplastic resin, polyurethane foam and electronic products.

At the COP4 in 2009, tetra-/penta bromodiphenyl ether (hereafter tetra-/penta-BDE) and hexa-/hepta bromodiphenyl ether (hereafter hexa-/hepta-BDE) of PBDE, and hexa bromobiphenyl (hereafter HBB) of PBB were newly listed in Annex A. Accordingly, Korea banned production, import/export and use of tetra/penta-BDEs, hexa/hepta-BDEs, and HBB pursuant to the POPs Control Act since 2011, except recycling exemption of tetra-/penta-BDE and hexa-/hepta-BDE for products in use.

In addition, the ROK has controlled uses of such substances in accordance with the Act on Resource Circulation of Electrical and Electronic Equipment and Vehicles in which the PBDE and HBB content of electrical/electronic products shall be less than 0.1% by weight. The Electrical Appliances and Consumer Products Safety Control Act also prohibits the use of PBDE as a flame resistant for underwear, clothes and bed linen.

Hexabromocyclododecane (HBCD)

Hexabromocyclododecanes (HBCD), which are alicyclic brominated flame retardants (BFRs), was generally used in expanded polystyrene foam (EPS) and extruded polystyrene foam (XPS), and fiber materials for home furniture and car seat covers, and high impact polystyrene (HIPS) for electrical/electronic products. In the ROK, two types of HBCDs are used (CAS No: 3194-55-6, 25637-99-4) for electrical/electronic products, and construction materials especially for EPS and XPS insulation. In 2013, 92% of the total use took for EPS and XPS insulation and 6.3% (97 tons) for car seats and door trims. In 2016, HBCD was distributed 4,568 tons and was used as flame retardants in EPS and XPS only.

As HBCD was listed at the COP6 in 2013, HBCD was also added to the POPs Control Act 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.

Pentachlorophenol (PCP)

Pentachlorophenol (PCP), including its salts and esters was listed in Annex A of the Convention in 2015, and then it was added into the POPs Control Act in 2017. PCP is mainly used for wood preservative. 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 2016 survey.

Hexachlorobutadiene (HCBD)

HCBD is used as an organochlorine solvent and may be also released unintentionally from industrial facilities, particularly during the production of organochlorine solvents like perchloroethylene, trichloroethylene and carbon tetrachloride. Therefore, HCBD was listed in Annex A and C in 2015 and 2017, respectively, and 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.

Polychlorinated naphthalenes (PCN)

Polychlorinated naphthalenes (PCN) had been produced and used in large amounts from 1910 for insulation coating agent of electric wires, wood preservative, rubber and plastic additives, and lubricant. However, as their potential risk began to be revealed, their production and use have reduced since the end of 1970s. PCN is known to be generated as a byproduct in a thermal process with presence of chlorine, and released with dioxin and/or PCBs. Due to potential risks, PCN was listed in Annex A and C in 2015. The scope of listed PCN isomers covers from dichlorinated naphthalenes to octachlorinated naphthalene due to their toxic properties. They 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.

2.2.2.2 Monitoring Status of Industrial POPs

(1) Industrial POPs in the Environment

PFOS and PBDEs are monitored under the national POPs monitoring network of the Ministry of Environment. As of 2018, they has been monitored from 171 sites (air 38, water 36, soil 61 and sediment 36) since 2013: twice a year for air (spring and fall); once a year (spring) for other environmental media. Although PFOA is not listed yet in the Convention, the ROK also has been monitoring PFOA with PFOS since 2015.

PFOS

According to the national POPs monitoring network from 2014 to 2016 (MOE, 2017), PFOS and PFOA were not detected in the air. PFOA level was relatively higher than PFOS in some water systems and soil/sediment. Based on several previous studies in Korea, average concentrations in river water of the two substances were below 10 ng/L. But downstream water affected by urban sewage treatment plants shows average concentrations of dozens of ng/L. Especially, PFOA was detected in the range of dozens or hundreds of ng/L in some areas influenced by waste water discharged from industrial complex.

As high concentrations of PFASs were detected in water treatment plants in 2017, the Ministry of Environment conducted a wide range of monitoring on rivers and water treatment plants, and enhanced supervision for sewage and waste water treatment plants nationwide. The ROK developed PFASs limits in drinking water as 70 ng/L for PFOS and PFOA as a sum, and 480 ng/L for PFHxS to reduce exposure to PFASs.

PBDE & HBB

4,5-BDEs, 6,7-BDEs and HBB were added into the national POPs monitoring network in 2013. From 2014 to 2016, the average concentration of 4,5-BDEs in air was 0.20 ~ 195 pg/㎥, and that of 6,7-BDEs was N.D ~ 15.46 pg/㎥. In soil, the average concentration of ΣPBDEs excluding deca-BDSEs was 1.161 ~ 1.865 ng/g and 0.018 ~ 0.055 ng/L in rivers and lakes, and 0.186 ~ 0.475 ng/g in sediment. HBB was detected as being below detection limit at all monitoring sites and media (MOE, 2017).

HBCD

The atmospheric concentrations of HBCDs[10] were found in the range of N.D ~ 55.54 pg/m^3 in residential and background areas, and N.D ~ 505.35 pg/m^3 in industrial complexes in 2015. Among the HBCD isomers, γ-HBCD was detected in higher concentration than other isomers in the air (NIER, 2015).

The concentrations of HBCDs collected from 10 sites of major rivers in Korea were N.D ~ 0.35 ng/L, and γ-HBCD was detected at the highest rate among the isomers of HBCD since γ-HBCD is a major isomer contained in technical HBCD.

10) Sum of α-HBCD, β-HBCD, and γ-HBCD

There was no trend in concentration based on sampling sites. The average concentration of sediment at the same sites with water was 2.83 ng/g dw in 2015, and 4.61 ng/g dw in 2016. In the sediment, as shown in river water, γ-HBCD was detected as most prevailing among the isomers of HBCD (NIER, 2016a).

The average concentration of HBCDs in carp muscles collected in major rivers was 0.38 ng/g ww, and that in the whole body of minnow was 1.91 ng/g ww in 2015, and 4.18 ng/g ww in 2016. The α-HBCD was detected in higher concentrations than other isomers since α-HBCD isomer is transformed from β-, γ-HBCD in biota (NIER, 2016a).

PCP

In the background areas, the atmospheric PCP was not detected but pentachloroanisole (PCA) was detected in the range of N.D ~ 67.07 pg/m^3 in 2016. Whereas, in industrial complexes, the atmospheric concentration of PCP was N.D ~ 184.34 pg/$m^{3,}$ and that of PCA was N.D ~ 127.20 pg/m^3. In river water, soil and sediment samples, PCP and PCA were not detected from all sites (NIER, 2016b, 2017a).

HCBD

The atmospheric concentration of HCBD was detected in the range of 23.9 ~ 626.0 pg/m^3 in the background areas in 2015 and 175.6 ~ 2181.7 pg/m^3 in industrial complexes in 2016. In river water, soil and sediment samples, it was not detected from all sites (NIER, 2016b, 2017a).

PCN

The atmospheric concentration of PCN[11)] was 4.155 ~ 127.598 pg/m^3 in industrial complexes and 5.099~80.705 pg/m^3 in background areas in 2017 (NIER, 2017b).

(2) Industrial POPs in the Marine Environment

11) 16 PCNs (sum of 16 congers of 5,3,24,13,27,42,52,53,66/67,68,69,71/72,73,75)

PFOS

The average concentration of PFASs[12)] at 50 sites (as of 2017) on 36 coastal areas nationwide was 7.40±7.93 ng/L in sea water, 0.51±0.48 ng/g dw in marine sediment, and 9.63±5.69 ng/g dw in living organisms. In sea water, the PFAS concentrations of Incheon, Asan and Gunsan sites were the highest among the sites. For the marine sediment, that of Asan showed the highest, which means that the west coast of the Korea showed high PFASs concentrations both in seawater and marine sediment. Whereas, the east coast showed high concentration of PFASs in living organisms. In case of the PFASs composition ratio in the marine environment, short chain C6 PFASs (PFHxS and PFHxA) as well as C8 PFASs (PFOA and PFOS) prevailed in sea water whereas long-chain PFASs such as PFUnDA and PFTrDA as well as PFOS and PFOA were found as high in the marine sediment (MOF, 2018).

PBDE

The average concentration of PBDEs[13)] at 50 sites (as of 2017) on 36 coastal areas nationwide was 6.66±9.14 ng/g dw in the marine sediment and 1.24±1.58 ng/g dw in living organisms. In general, the concentration was high in an area where industrial complexes are gathered and port activities are thriving. When it comes to the composition ratio of PBDEs in the marine sediment, BDE 209 was mainly prevailing because it was the main substance of commercial deca-BDE mixture. For the composition ratio of PBDEs, the proportion of brominated compounds with low bromine substitution (e.g. BDE 47, 99, 100) was higher in the marine living organisms than in the marine sediment (MOF, 2018).

HBCD

The average concentration of HBCDs at 50 sites (as of 2017) on 36 coastal areas nationwide was 4.93±9.40 ng/g dw for the marine sediment and 126±611 ng/g (40.1±92.7 ng/g dw, when excluding Yeong-il site) for living organisms. In case of the isomer composition ratio, γ-HBCD in the marine sediment and α-HBCD in

12) 16 PFASs (sum of 16 PFAS such as PFBS, PFHS, PFOS, PFDS, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA, PFHxDA, PFOcDA)

13) 22 PBDEs (sum of 22 congeners of 17, 28, 47, 49, 66, 71, 77, 85, 99, 100, 119, 126, 138, 153, 154, 156, 183, 184, 191, 196, 197, 206, 207, 209)

living organisms were most prevailing (MOF, 2018).

(3) Industrial POPs in Food

PFOS

The MFDS set TDI (Tolerable Daily Intake) of PFOS as 0.15 ㎍/kg·bw/day and TDI of PFOA as 1.0 ㎍/kg·bw/day in 2014. In the ROK, the result of food monitoring from 2012 to 2014 showed that the amount of PFOA and PFOS was "N.D" or "very low." PFOA and PFOS were found in the range of N.D ~ 1.83 ng/g and N.D ~ 0.93 ng/g in fish and shellfish, N.D ~ 0.15 ng/g and N.D ~ 0.12 ng/g in meat, and N.D ~ 0.16 ng/g and N.D ~ 0.63 ng/g in crops, respectively. In case of daily exposure, the exposure to PFOS was 1.52 ng/kg·bw/day or took 1% of TDI (0.15 ㎍/kg bw/day) while PFOA was 2.7 ng/kg·bw/day or 0.27% of TDI (1.0 ㎍/kg·bw/day) (MFDS, 2015a).

The MFDS measured the amount of PFASs transferred from cookware and food packaging to food in usual cooking condition to assess the status of PFASs exposure from them. The daily intake based on detected amounts of PFOA in food was estimated to be 3.2 x 10^{-5} ㎍/kg·bw/day, which was 0.003% of health-based guidance value for PFOA (MFDS, 2014a).

HBCD

To monitor HBCDs levels in food, 301 food samples of 30 food categories were tested. HBCDs were detected in 167 samples with 55.48% of the detection rate, and α-HBCD was the prevalent isomer in biota samples. Among them, Spanish mackerel showed the highest concentration of 2.705 ng/g ww (MFDS, 2016).

(4) Industrial POPs in Human

PFOS

Various monitoring studies on PFASs showed that the blood level of PFOS was 13.1 ng/mL for Korean adults (n = 1,874, 2010 ~ 2012), 3.57 ng/mL for adolescents, 6.58 ng/mL for children, gradually increasing after 20s. From the results of the blood monitoring, the exposure amount of PFOA was estimated as 6.42 ng/kg·bw/day and 10.2 ng/kg·bw/day for PFOS. The exposure amounts took up less than 10% of TDIs of PFOA and PFOS, thus their exposure levels were considered as safe (MFDS, 2015a). For PFASs concentrations in breast milk of four regions in Korea, PFOS was 0.08±0.29 ng/mL, and PFOA was 0.10±0.12 ng/mL. (MFDS, 2013)

Table 6. PFOS and PFOA Concentrations in Blood of Koreans (unit: ng/mL)

Group	Children 6y-12y[14)	Adolescents 13y-19y[15)	20s	30s	40s	50s	60s	Ave. Adult [16)
N	120	300	247	413	456	433	325	1,874
PFOA	5.15	2.82	3.43	3.27	4.24	4.87	4.58	4.12
PFOS	6.58	3.57	7.56	9.69	12.61	16.97	17.16	13.1

PBDE

Many studies showed that, for the PBDE concentrations in blood serum of children and adolescents, BDE 47 showed the highest detection rate (78.7%) and the highest concentration (median: 0.010 ng/mL) among other congeners. Congeners of BDE 99 and BDE 153 were also found in high concentrations with decreasing trends since 2001. (MOE, 2016a).

According to the risk assessment of four main congeners (47, 99, 153, 209) considering multimedia and multiple paths, a congener with the highest exposure was BDE 47, and age group with the highest exposure was infants (max. 96.9 ug/kg-day). The group with relatively higher potential risk was the infant, and their main exposure paths were the intakes of breast milk and house dust (NIER, 2013).

2.2.3 PCBs as Industrial POPs

14) MFDS, 2012
15) MFDS, 2014b
16) MFDS, 2010, data source for those in 20s~60s

2.2.3.1 PCBs Control System

Since polychlorinated biphenyls (PCBs) started to be commercially produced in 1929, 1.3 million tons of PCBs were manufactured in the product name of Aroclor, Clophen, Phenoclor and Kaneclor from the 1930s to the 1970s before their production ceased. As PCBs are chemically stable and have excellent insulating properties, they have been used in a wide range of fields as insulating oil for transformers and batteries, lubricants, plasticizers and flame retardant for paints.

However, as their environmental pollution and toxicity to human body were reported in late 1960s, developed countries started to ban their production and use. In the ROK, use of PCBs was restricted in 1979 by the Electric Utility Act and their distribution control started in 1996 under the Toxic Chemicals Control Act. Now PCBs and the mixtures containing more than 0.005% of PCBs are designated as a prohibited substance under the Chemicals Control Act.

PCBs was listed in Annex A of the Convention at COP1 and PCBs-containing equipments in use are subject to specific exemptions. However, the equipments or articles containing PCBs over 50 ppm must be disposed in an environmentally sound manner by 2028 according to Part Ⅱ of Annex A.

The Ministry of Environment defines the PCBs-containing equipments under control such as transformers, condensers and metering outfits so that their owners shall report manufacturer, date of manufacture, volume, total weight, change of insulating oil, contents of PCBs (only for transformers) and so on. The owners shall report details of installation, sale or disposal of such equipment, and change of insulating oil to the relevant authorities within 30 days. Provided that, when such equipment was made after Jan. 27, 2008 and has less than 0.05 mg/L of PCBs in insulating oil, it is excluded from the obligation of reporting. In addition, the Ministry of Environment strictly manages the equipments containing more than 50 mg/L of PCBs by classifying them as a contaminated equipment and taking control measures such as labelling requirement and waste treatment measures as priscribed in the POPs Control Act.

2.2.3.2 Monitoring Status of PCBs

(1) PCBs in the Environment

According to the national POPs monitoring network, the annual average concentration of co-PCBs[17)] in the air from 2014 to 2016 was 0.002 ~ 0.004 pg WHO-TEQ/m^3. The co-PCBs concentration in soil samples was 0.192 ~ 0.270 pg WHO-TEQ/g and indicator PCBs[18)] was not detected from all samples. The average concentration of co-PCBs was 0.0001 ~ 0.0006 pg WHO-TEQ/L in the rivers and lakes and 0.013 ~ 0.083 pg WHO-TEQ/g in the sediment (MOE, 2017).

(2) PCBs in the Marine Environment

The survey conducted at 50 sites (as of 2017) on 36 coastal areas nationwide revealed that the average concentration of PCBs[19)] in the marine sediment was 1.55 ± 2.26 ng/g dw (N.D ~ 10.5 ng/g dw) and showed the highest in the southern coast of the East Sea and the eastern coast of the South Sea. The average concentration of PCBs in living organisms was 10.5 ± 18.6 ng/g dw (0.54 ~ 86.7 ng/g dw), highest in Ulsan and Busan, and represented similar spatial distribution to the marine sediment. In both sediment and marine living organisms, PCB 153, PCB 138, and PCB 187 were predominant congeners (MOF, 2018).

(3) PCBs in Food

The MFDS published the Re-assessment Report of Dioxins and PCBs Standards for Food, using PCBs monitoring data in food collected from 2012 to 2017. According to the report, a survey (2,882 samples on 284 items of 94 food types) showed that the PCBs contamination level was 0.570 ng/g in average and high in the order of marine products, animal products, processed products and agricultural products. The items with high contamination levels were mostly the marine products and, among eggs, the duck eggs. In detail, PCB contamination levels decrease in the order of whale, duck eggs, gizzard, baby octopus, herring, conch, sandfish and carp.

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17) Sum of 12 co-PCBs (77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, 189)
18) Sum of 7 indicator PCBs (28, 52, 101, 118, 138, 153, 180)
19) Sum of 22 PCBs (8, 18, 28, 29, 44, 52, 87, 101, 105, 110, 118, 128, 138, 153, 170, 180, 187, 194, 195, 200, 205, 206)

The detection rate of PCBs in food was 56.9% on average and those in the animal products and the marine products were high due to accumulative properties of PCBs in lipid. Among the animal products, the detection rates for meat and poultry were 73.9% and 64.7%, respectively. Out of the marine products, fish showed a high detection rate of 83.1%.

The average daily exposure of PCBs was 2.346 ng/kg·bw in 2017, decreasing from 4.022 ng/kg·bw in 2010. That may be mainly due to the reduced PCBs contamination level in food. Though PCBs level of the marine products decreased, PCBs exposure from the marine products increased due to the increase of consumption, along with the increase of exposure share of the marine products from 17.3% in 2010 to 31.6% in 2017. The average daily exposure level and exposure share (6.8% in 2010 → 15.8% in 2017) of PCBs from the animal products increased due to the increase of PCB contamination but were still lower than the marine products.

Compared with TDI (360 ng/kg·bw/day) of PCBs, the average risk for all age groups was 0.7%, and that for person with extreme intake stood at 2.0%, which means no need to concern. However, food uptake by infants should be cautious since the infant is much dependent on a single food item. Risks from uptake of food groups were high in the order of agricultural products (0.7 ~ 2.5%), marine products (0.7 ~ 1.4%), processed products (0.5 ~ 2.4%) and animal products (0.4 ~ 1.0%).

(4) PCBs in Human

MDFS had conducted an adult cohort study from 2004 to 2008 to identify the relation between diseases and POPs exposure, with 19 OCPs and 32 PCBs congeners (n = 1,530). Of those POPs studied, nine POPs were detected in blood serum from more than 80% of samples. The positive correlations between these POPs concentrations in blood serum and prostate cancer was found among other various diseases monitored such as breast cancer, prostate cancer, heart disease and colon cancer (MFDS, 2015b).

2.2.3.3 Stockpiles and Wastes Consisting of/Containing PCB - Management Status

The POPs Control Act stipulates the limit for PCBs contents in equipments and wastes consisting of and containing PCBs, and the management criteria for collection, transport, storage and disposal of the wastes. The Act prohibits equipments over 2 mg/L of PCB to be recycled and ensures that they are treated at authorized waste treatment facility to meet the criteria defined by the POPs Control Act and the Wastes Control Act. The waste with PCBs content over 0.05 mg/L in liquid state shall also comply with disposal criteria for designated hazardous wastes under the Wastes Control Act.

The export of PCBs-containing wastes was banned for all purposes and the PCBs wastes are currently disposed at three high temperature incineration plants, and 11 waste treatment plants with chemical treatment technologies as of December 2018 in the ROK.

2.3 Control System of Unintentional POPs

Seven unintentional POPs are listed in Annex C under the Convention currently: dioxins; furans; PCBs; HCB; PeCB; PCN; and HCBD. Korea investigates the emission sources and conducts monitoring on emissions of four unintentional POPs such as dioxins, furans, co-PCB, and HCB since 2001. The emission monitoring of PeCB was started from 2014 to set up emission factors. With regard to dioxins including furans, Korea manages them by defining the emission facilities and setting the emission limits under the POPs Control Act. The environmental distributions of HCB and PeCB are prescribed in section 2.2.1 and those of PCBs in section 2.2.3.

2.3.1 Emission Sources & Emission Inventory

Control of Dioxin Emission Facilities

The POPs Control Act stipulates that waste incinerators and other dioxin emission facilities shall comply with the emission limits, and requires self-monitoring obligation at the interval of 6 months to 2 years by business type and size. The Act also stipulates that large facilities shall carry out environmental impact assessment on adjacent areas every three years. Different emission limits are applied to the facilities, depending on when they are established and what prevention technologies they have. Therefore, existing facilities are applied more relaxed standards compared to new facilities. Currently, the emission limits for other facilities except waste incinerators have become stronger gradually, so existing facilities are also required to meet the rigid limits (See Table 7 ~ 11).

According to revised the POPs Control Act, from December 13, 2018, when the facility exceeds the dioxin emission limit, the government ensures that the facility stops operating and takes actions to reduce emissions, except for minor violation.

Table 7. Emission Limit of Dioxin in Emission Gas from Waste Incinerator

Category	New Facility (ng I-TEQ/Sm³)	Existing Facility (ng I-TEQ/Sm³)
Hourly treatment capacity ≥ 4 tons	0.1	1
2 tons ≤ Hourly treatment capacity < 4 tons	1	5
25 kg ≤ Hourly treatment capacity < 2 tons	5	10

※ Note: Medical waste incinerator is excluded. 0.1 ng I-TEQ/Sm³ is applied to municipal waste incinerator with more than 2 tons of hourly treatment capacity. 12% of the standard oxygen concentration is applied.

Table 8. Emission Limit of Dioxin in Emission Gas from Medical Waste Incinerator

Classification of facility / Treatment capacity per hr	Facility (ng I-TEQ/Sm³)		
	New Facility	Facility Built between Jan 1, 2001 and Jul 20, 2004	Facility Built before Jan 1, 2001
Capacity ≤ 4 tons	0.1	0.1	1
2 tons ≤ Capacity < 4 tons	1	1	5
1 ton ≤ Capacity < 2 tons	1	1	5
200 kg ≤ Capacity < 1 ton	5	5	5
25 kg ≤ Capacity < 200 kg	5	10	10

※ Note: 12% of the standard oxygen concentration is applied.

Table 9. Emission Limit of Dioxin in Emission Gas from Industrial Facility

Iron & Steel/Aluminum Manufacturing Facility	New Facility	Existing Facility (ng I-TEQ/Sm³)		
		By Dec 31, 2010	Jan 1, 2011 ~ Dec 31, 2014	After Jan 1, 2015
Steel sintering furnace	0.5	1.0	0.5	0.5
Steel electric arc furnace	0.5	1.0	0.7	0.5
Aluminum manufacturing facility	0.5	1.0	0.5	0.5
Copper/Cement Manufacturing Facility	New Facility	Jan 1, 2009~ Dec 31, 2011	After Jan 1, 2012	
Cement kiln	0.1	0.1	0.1	
Copper manufacturing facility	1	10	1.0	

※ Note: Steel sintering furnaces are subject to 15% of the standard oxygen concentration, while cement kilns are subject to 13% of the standard oxygen concentration.

Table 10. Discharge Limit of Dioxin in Waste Water

<table>
<tr><th>Target Facility</th><th colspan="3">Discharge Limit (Unit: pg I-TEQ/L)</th></tr>
<tr><td>Iron & Steel/Aluminum manufacturing facility</td><td colspan="3">10</td></tr>
<tr><td>Copper/Cement manufacturing facility</td><td colspan="3">10</td></tr>
<tr><td>Incinerator</td><td colspan="3">10</td></tr>
<tr><th rowspan="2">Petrochemical basic substance manufacturing facility</th><th rowspan="2">New Facility</th><th colspan="2">Existing Facility</th></tr>
<tr><th>Jan 1, 2009 ~ Dec 31, 2012</th><th>After Jan 1, 2013</th></tr>
<tr><td>Ethylene dichloride/ vinyl chloride manufacturing facility</td><td>50</td><td>300</td><td>50</td></tr>
</table>

Table 11. Facility that Requires Environmental Impact Assessment of Dioxin on Neighboring Areas

Target Facility	Steel sintering furnace	Steel electric arc furnace	Cement kiln	Copper rolling/ extrusion/ drawing
Capacity (Maximum daily production or daily processing capacity)	More than 5,000T/day	More than 3,000T/day	More than 12,000T/ day	More than 50T/day

National Investigation of Dioxin Emission Sources and Emission Estimates [20)]

The national survey on dioxin emission for waste incinerators was performed on about 570 facilities across the country by classifying them into incinerators for municipal wastes, general industrial wastes, designated hazardous industrial wastes, and medical wastes. For industrial facilities (those except incinerators) that release dioxin unintentionally in the process of industrial activity, 1,300 facilities were targeted for the survey by classifying them into iron and steel manufacturing, non-ferrous metal, nonmetal, chemical, energy generation facilities or crematoriums.

The stack monitoring on dioxin emission is carried out for 180 facilities every year to estimate their emissions and emission factors on each emission facility category. To select the facilities for stack monitoring among 1,870 dioxin emission sources,

20) MOE 2016c

the priority is placed on the facility where dioxin emission may be changed significantly compared to the previous year. The priority is also given to the facilities with more stringent emission limit, facilities where reported large emissions in the previous year, and waste incinerators where has large uncertainty of emission factors.

National dioxin emission is estimated by sum of emissions of each categories. Emission of each category is a sum of emissions of each facility, which are calculated by using emission factor of each facility category with annual activity data of each facility.

Table 12. Dioxin Emissions from 2001 to 2015 (unit: g I-TEQ/yr)

Category	Emission Source	2001	2003	2005	2007	2009	2011	2013	2015
Incinerator	Municipal wastes	155.1	37.5	39.5	5.2	4.5	2.6	1.9	2.0
	General industrial wastes	649.3	138.2	111.2	63.2	40.3	37.9	35.1	19.0
	Hazardous industrial wastes	73.4	11.8	11.9	2.7	2.1	1.5	1.9	1.6
	Medical wastes	2.4	5.7	10.9	4.6	1.0	0.8	1.3	1.6
	Subtotal	880.2 (87.7%)	193.2 (62.1%)	173.5 (64.5%)	75.7 (46.0%)	47.9 (37.9%)	42.8 (35.4%)	40.2 (36.1%)	24.2 (25.9%)
Industrial facility	Steel industry	90.3	81.7	60.5	45.5	41.7	44.5	40.6	43.1
	Non-ferrous metal industry	15.6	16.8	18.1	22.7	15.9	12.2	7.5	8.5
	Nonmetal industry	6.8	7.4	2.4	8.4	5.8	6.7	5.4	4.9
	Chemical industry	1.1	1.2	1.2	0.5	0.9	0.7	1.9	1.1
	Energy industry	8.5	8.4	10.4	9.2	12.8	12.2	13.4	9.9
	Crematorium	1.5	2.5	2.8	2.5	1.5	1.9	2.5	1.8
	Subtotal	123.8 (12.3%)	118.0 (37.9%)	95.4 (35.5%)	88.8 (54.0%)	78.6 (62.1%)	78.1 (64.6%)	71.3 (63.9%)	69.3 (74.1%)
Total		1004.0	311.2	268.9	164.5	126.5	120.9	111.5	93.5

For wastes incinerator, the dioxin emission in 2015 was 24.2 g I-TEQ/yr which is

25.9% of the total emission. The emission in 2015 showed a sharp decrease compared to previous year, which is only 2.7% of emission in 2001 (880.2 g-TEQ/yr in 2001), and 39.8% in 2013. This large emission decrease attributed to the increase of the number of facilities under the national control in 2001 (targeted incinerators: 50 tons/day → 0.2 tons/hr), the strengthened dioxin emission limit in 2006 (emission limit for the facility with 2 tons/hr of capacity: 40 ng-TEQ/㎥ → 10 ng-TEQ/㎥), and the closure of small incinerators (272 → 155 incinerators) in 2008.

Figure 4. Comparison of Dioxin Emissions between 2013 and 2015

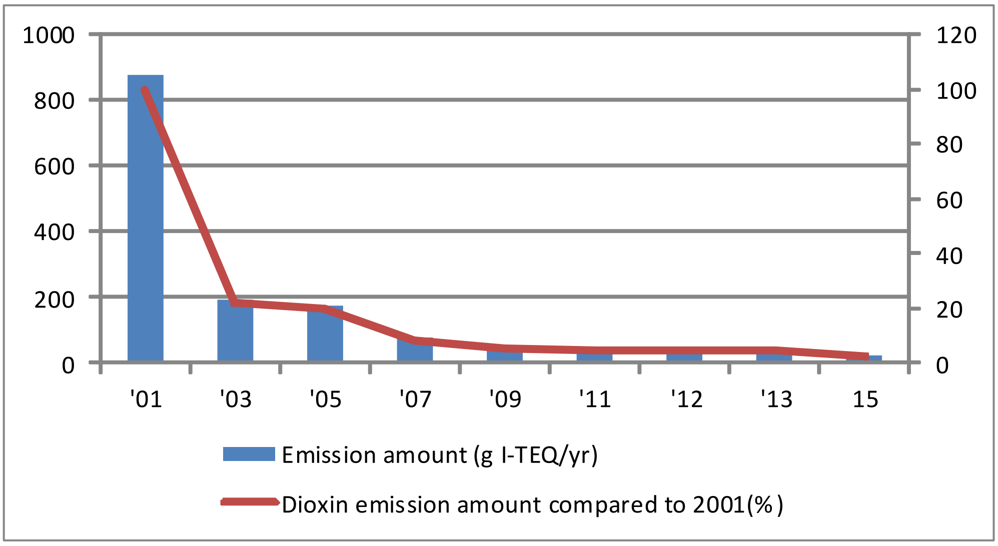

Figure 5. Changes of Dioxin Emissions from Incinerators

In case of dioxin emission from the industrial sector except waste incineration, the emission in 2015 was 69.3 g I-TEQ/yr, which takes up 74.1% of the total emission. The emission in 2015 is 56% decrease compared to 123.8 g I-TEQ/yr in 2001, but only 2.7% decrease from 71.3 g I-TEQ/yr in 2013. The small decrease of dioxin emission in the industrial sectors is attributed to the smaller changes of emissions from each industrial source due to steady emission factors compared to the incineration sector.

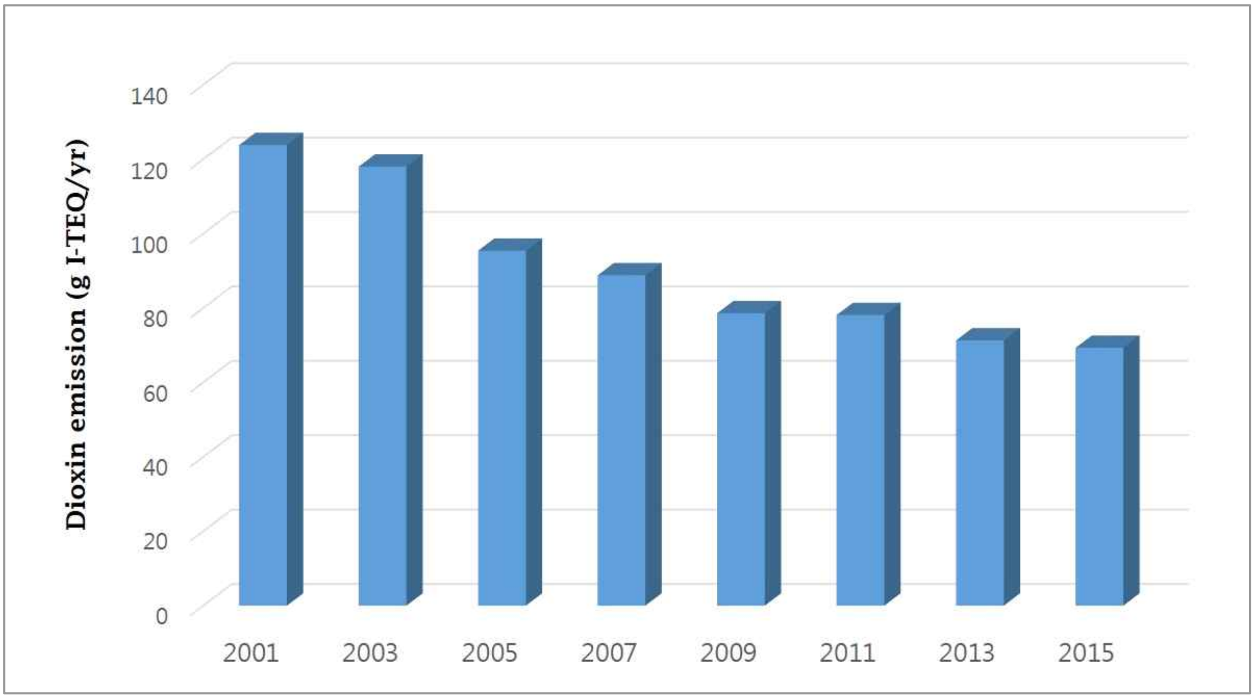

Figure 6. Change of dioxin emissions from industrial sources.

Emission of Unintentional POPs Other Than Dioxin

For unintentional POPs except dioxin, emission of industrial sources are being investigated only. The emission of co-PCB 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. Even though there was a little increase in the energy industry, it represents only 7.5% of the total emission and the total national co-PCBs emission is on the decrease.

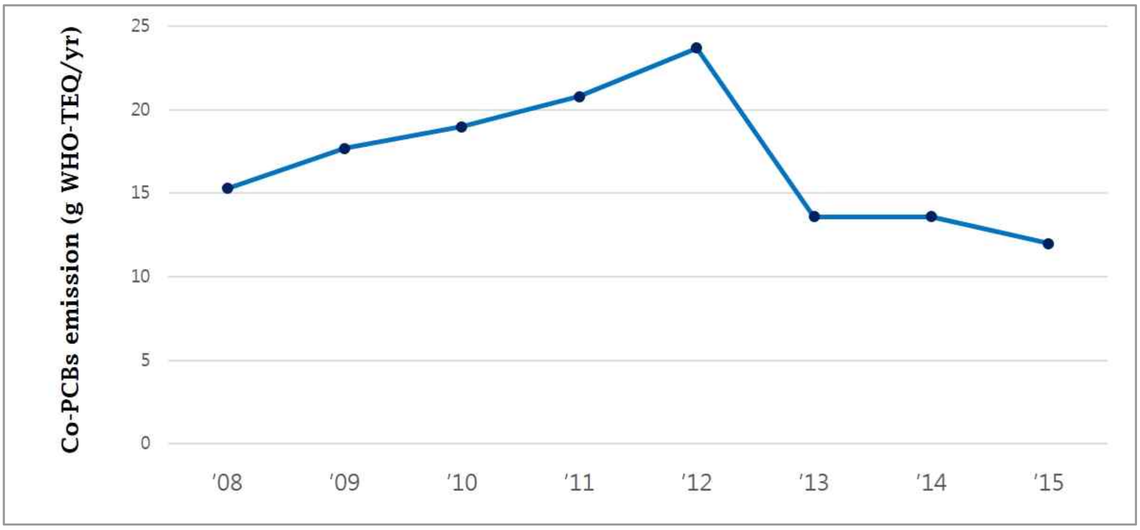

Figure 7. Change of co-PCBs Emissions from Industrial Sources

The emission of HCB increased from 57.8 ㎏/yr in 2001 to 1,120.1 ㎏/yr in 2008. But the HCB emission considerably reduced to 628.7 ㎏/yr in 2009 and it kept decreasing to 55.7 ㎏/yr in 2015. The steel/non-ferrous industry took up 95% of the total HCB emission and all emission sectors show a reduction of emission. 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.

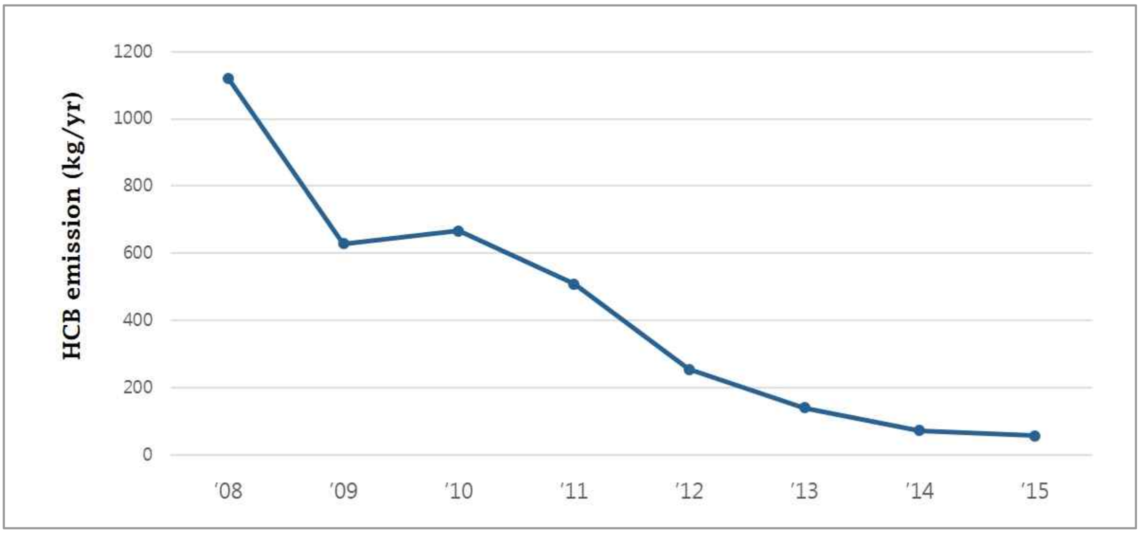

Figure 8. Change of HCB Emissions from Industrial Sources

Concentrations of PCNs by Emission Facility

In 2018, PCNs[21] 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 (NIER, 2018b).

Concentrations of HCBD by Emission Facility

In 2018, HCBD concentrations in emission gas were found in municipal waste incinerator of 13.756 ng/m^3, hazardous waste incinerator of 12.534 ng/m^3, and general industrial waste incinerator of 20.290 ng/m^3 (NIER, 2018b).

2.3.2 Monitoring Status of Dioxin

(1) Dioxin in the Environment

According to the 2014-2016 results of the national POPs monitoring network, the annual average dioxin concentrations in the air were 0.017 ~ 0.025 pg I-TEQ/㎥, considerably low compared to 0.6 pg I-TEQ/㎥ of the Korean environmental standard for the air. The average concentrations were 1.117 ~ 1.307 pg I-TEQ/g for soil, 0.072~0.272 pg I-TEQ/L for water and 0.315 ~ 0.929 pg I-TEQ/g for sediment between 2014 and 2016 (MOE, 2017).

(2) Dioxins in the Marine Environment

The average concentration of dioxin at 50 sites on 36 nationwide coasts (as of 2017) was 0.21 ± 0.35 pg I-TEQ/g dw (N.D ~ 1.60 pg I-TEQ/g dw) and relatively high in the southern coast. In the composition ratio of dioxin, 1,2,3,4,6,7,8-H_7CDD, O_8CDD were dominant congeners. The annual average concentration of dioxin in the marine life was 0.01 ± 0.01 pg I-TEQ/g ww (N.D ~ 0.07 pg I-TEQ/g ww), high

21) Sum of di-CNs ~ octa-CNs (4, 5/7, 6/12, 11/8, 3, 10, 9, 20, 19, 21, 24, 14, 15, 16, 17, 13, 25/26, 22, 23, 18, 42, 33/34/37, 44, 47, 36/45, 28/43, 29, 27/30, 39, 32, 48/35, 38/40, 46, 31, 41, 52/60, 58, 61, 50, 51, 54, 57, 62, 53/55, 59, 49, 56, 66/67, 64/68, 69, 71/72, 63, 35, 70, 73, 74, 75)

at some sites in eastern and southern coasts. In the composition ratio of dioxin in the marine life, 1,2,3,7,8-P_5CDD, 2,3,7,8-TCDF, and 2,3,4,7,8-P_5CDF made up about 50% of the total (MOF, 2018).

(3) Dioxins in Food and Human

The MFDS and the National Institute of Food and Drug Safety Evaluation (NIFDS) have been conducting monitoring and risk assessment on dioxin and PCBs using human samples since 1999. According to the dioxin and PCBs monitoring in breast milk, the residual concentrations were very low (Figure 9). Furthermore, the risk level of breast milk intake for infants (3.77×10^{-5}, WHO 1998-TEF) was much lower than the maximum limit of risk in the background level of EPA (1.0×10^{-3}). In addition, the NIFDS has been carrying out POPs monitoring in breast milk and blood since 2008. The MFDS plans to continue monitoring on the residue level of POPs in food on the Korean market and perform human body monitoring, etc.

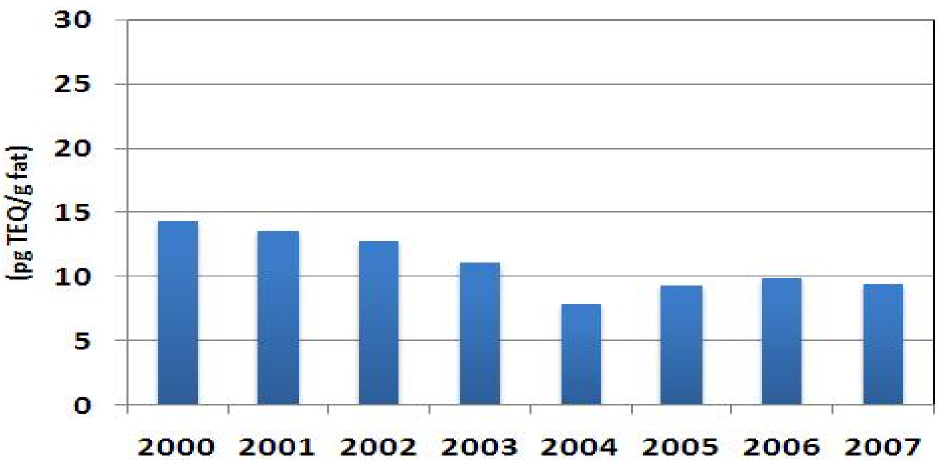

Figure 9. Dioxin Concentrations in Breast Milk (NIFDS, 2008)

2.4 Stockpiles and Wastes Consisting of/Containing/Contaminated with POPs: Management Status

Korea's principle in managing POPs wastes is to minimize the release and the environmental impact from POPs wastes. For PCB-containing wastes, the goal is to control them with environmentally sound waste management before the time stipulated in the Convention. Control policy for other POPs wastes is to manage them in a strict way as equivalent as the management level of hazardous industrial wastes.

Korea has established the limits of POPs wastes for dioxin, PCBs and 15 organochlorine pesticides under the POPs Control Act. There is currently no pesticide POPs stockpiles and wastes in Korea because their production and use were prohibited since the 1970s. Under the POPs Control Act, pesticide POPs-containing waste with more than 0.1 ng/L of the concentration is treated as hazardous industrial waste, and banned from recycling. The wastes contaminated with dioxin (e.g. sludges and dust collected from dioxin emission facilities) is under the control of the Act. The waste with dioxin over 100 pg I-TEQ/L in liquid state or 3 ng I-TEQ/g in solid state shall be appropriately disposed as hazardous industrial waste. More information on PCB-containing waste is described in section 2.2.3.

The limits of other newly listed POPs such as PCP, HCBD, PCN, PFOS, HBCD and PBDE are being developed along with the studies on various disposal technologies for environmentally sound destruction. According to the statistical survey on chemicals, PCP, PCN and HCBD have not been produced or distributed in the country. Therefore, it is regarded that there is less priority for setting the waste limits on them. In addition, the wastes contaminated with PCN or HCBD, which are unintentionally produced from industrial facilities, are controlled as hazardous industrial wastes under the Waste Control Act.

The control methods for PFASs-containing waste are currently under the review by examining various disposal technologies, and the limit will be adopted for stockpiles of PFASs, especially for aqueous fire fighting form which may contain PFOS or PFOA.

Surveys on products in use and wastes revealed that PBDEs and HBCD have been used in various products. Thus, the waste limits for PBDEs and HBCD will be established with a priority waste list to control such wastes in environmentally sound manner. In addition, PBDE and PBB in the electronic products are controlled by setting the content limit of 0.1% by weight in accordance with the Act on Resource Circulation of Electrical and Electronic Equipment and Vehicles.

3. National Implementation Plan

The ROK developed the 1[ST] Master Plan for Persistent Organic Pollutants Control (2012 ~ 2016) in 2011 and the 2[nd] Master Plan (2017 ~ 2020) in 2016 for effective and systematic control of POPs under the Stockholm Convention. The master plan is prepared by relevant ministries every five years in accordance with the POPs Control Act. Korea’s POPs control, including performance of the National implementation plan (NIP), is reflected on the POPs master plan and its implementation of the plan is reviewed annually.

This chapter of the NIP focuses on the substances that require intensive implementation according to the 2[nd] Master Plan. The implementation plans regarding support provisions of the Convention are also presented in this chapter.

3.1 Article 3 : Elimination of Intentional POPs

PFOS and PFAS

The use of PFOS in the ROK rapidly reduced after its listing on the Convention in 2009. The Ministry of Environment developed priliminary drinking water monitoring parameters of PFOS, PFOA and PFHxS, and added them into its monitoring program in 2018. The preliminary limit values for drinking water are 0.48 mg/L for PFHxS, 0.07 mg/L for PFOS and PFOA as a sum. PFAS monitoring has been strengthened in drinking water system, water purification plant, and wastewater treatment plant nationwide. The technology of wastewater treatment is being developed to reduce PFASs input into water system.

Brominated Flame Retardants – PBDE & HBCD

Based on a status survey concerning products and wastes containing 4,5-BDE and 6,7-BDE with specific exemptions of products in use, Korea is to draw up control measures for appropriate disposal. Moreover, with respect to HBCD whose specific exemptions for building insulation will expire on October 27, 2020, Korea tries to actively induce relevant industries to replace HBCD with alternative substances through information-sharing. To that end, the Korean government has been monitoring the distribution status (import, export, use, production and sale) of newly listed and candidate POPs as well as substances with specific exemption through a statistical survey on chemicals every two years in accordance with the “Chemicals Control Act.” To enhance the management of POPs, customs authorization number (HSK code) will be issued to the goods not classified in details and will designate them as goods subject to customs verification.

3.2 Article 5 : Reduction of Unintentional POPs

The emission of dioxin in Korea has continued to decrease from 1,004 g I-TEQ/yr in 2001 to 93.5 g I-TEQ/yr in 2015. In December 2018, Korea significantly strengthened administrative measures on the facilities violating dioxin emission limits. If a facility emits dioxin exceeding the limit, the facility shall stop its operation.

Korea is monitoring the emissions of co-PCBs and HCB in industrial sectors and expands the monitoring for waste incineration sectors. The information on PeCB emission will be publicly available from 2020 after finalizing the emission factors calculated from the 2014 survey. The stack monitoring will be carried out for other unintentional POPs such as PCNs and HCBD to develop emission factors and to estimate the national emission from 2019.

3.3 Article 6 : Management of Stockpiles and Wastes

Korea established the inventory of PCBs-containing wastes and equipments, and will complete treatment and disposal of the equipments containing over 50 mg/L of PCBs by 2028.

Since there is no production of PFOS, PBDE and HBCD in the ROK, stockpiles of these substances will be investigated for manufacturing companies where use them for specific exemption purpose. Import and use of these substances are monitored by the Statistical Survey on Chemicals by the Ministry of Environment every two years.

Korea will adopt the effective and environmentally sound wastes control measures for PFAS, PBDE and HBCD followed by a survey on POPs contents in wastes and priority-setting on wastes for management, as the substances have no concentration limits in wastes as of now.

Besides, Korea is exerting efforts to improve the management of HBCDs-containing wastes to minimize their release into the environment and banned recycling of wastes containing HBCD for the production of buoys since 2017 to prevent the pollution of the marine environment.

3.4 Article 9 : Information Exchange

The Convention requires that Parties facilitate or undertake the exchange of information on POPs control and reductions, and alternatives to POPs. The Korean government hosts the East Asia POPs Information Warehouse to facilitate information exchange among east-asian countries since 2005.

3.5 Article 10 : Public Information, Awareness and Education

The Convention requires that Parties promote and facilitate awareness of their policy and decision makers, provide the public with available information on POPs, and develop and implement educational and public awareness programs on POPs.

The Korean government makes available the information about POPs control policies, POPs monitoring data in the environment and national emission inventory to the public. The PRTR (pollutant release and transfer registers) system has been operated and its data on POPs is available online. The government also supports the private sector forums for information-sharing and academic activities on POPs, and discloses information online for the right to know of the people.

3.6 Article 11 : R&D and Monitoring

The Ministry of Environment operates the national POPs monitoring network according to Article 11 of the POPs Control Act since 2008. The POPs monitoring is carried out for the environmental media such as air, water, soil, and river sediment in order to identify the status of POPs pollution and long range transport. As for now, 22 POPs are currently monitored in the network. Newly listed POPs will be added to the monitoring program after preliminary research on environmental levels.

On the other hand, the Ministry of Oceans and Fisheries (MOF) is in charge of POPs monitoring on the marine ecosystem pursuant to Article 39 of the Marine Environment Management Act. The monitoring sites were selected to evaluate pollution of nationwide coastal areas, and will be expanded to improve accuracy of the evaluation. In addition, the MOF will choose coastal areas in need of detailed investigation through a survey on coastal areas across the country. By doing so, the MOF will understand pollution levels and sources, and take proper actions to protect the marine ecosystem from POPs.

Korea also reinforces food monitoring and human bio-monitoring associated with new and candidate POPs like PFASs and BFRs, especially multimedia monitoring for risk assessment of POPs. Five PFASs (PFOS, PFOA, PFHxS, PFDeA, and PFNA) were added as monitoring chemicals for the Korean National Environmental Health Survey in 2018. In the survey, blood samples of 5,700 persons in different ages for three years will be monitored until 2020. The result will be publicly available by the end of 2021.

3.7 Article 12 : Technical Assistance

Article 12 of the Convention requires Parties shall provide timely and appropriate technical assistance to developing Parties and Parties with economies in transition. Korea operates the POPs analytical training program every year since 2011 to strengthen POPs analysis skills of the East Asian countries.

3.8 Article 13, 14 : Financial Mechanism

The financial mechanism of the Stockholm Convention is based on contributions of the Parties and the GEF (Global Environment Facility). Korea contributes to GEF contributions and will keep its contribution. Furthermore, Korea had been a donor of SAICM Quick Start Program from 2007 to the end of the program funding in 2016.

3.9 Article 15 : Reporting

Korea obtained a signatory status in April 2007 and submitted four National Reports so far. The 1st National Report was submitted in April 2009, the 2nd in December 2011, the 3rd in January 2015 and the 4th in November 2018. Korea will continue to meet the obligations of Party under the Convention by submitting national reports in a timely manner.

3.10 Article 16 : Effectiveness Evaluation

The Conference of Party shall evaluate the effectiveness of the Convention every six years. To facilitate the evaluation, the Global Monitoring Plan (GMP) has been established to obtain comparable monitoring data. The 1st Effectiveness Evaluation was completed at the COP4 in 2009, and the 2nd Evaluation report has been published and adopted at COP7 in 2015. The 3rd Evaluation report need to be prepared by 2020 to be adopted at COP10 in 2021.

The Korean government is contributing its monitoring data and participates in the GMP in the East Asia region for effectiveness evaluation of the Convention. The GMP monitoring has been carried out in Jeju Island, the background site of the ROK. Monthly air samples have been collected and analysed for the organochlorine pesticides since 2009. Newly listed POPs such as PFAS and PBDEs will be added as monitoring substances of the GMP from 2019.

3.11 Article 7 : Update of the NIP

Korea will submit the 3rd revision of the national implementation plan (NIP) to the Secretariat by 2020 including the implementation plans for decabromobiphenyl ether and short-chain chlorinated paraffins that were listed to the Convention at the COP8 in 2017.

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