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Global Trends in Mercury Management

Dae-Seon Kim, Kyunghee Choi

National Institute of Environmental Research, Incheon, Korea

The United Nations Environmental Program Governing Council has regulated mercury as a global pollutant since 2001 and has been preparing the mercury convention, which will have a strongly binding force through Global Mercury Assessment, Global Mercury Partnership Activities, and establishment of the Open-Ended Working Group on Mercury. The European Union maintains an inclusive strategy on risks and contamination of mercury, and has executed the Mercury Export Ban Act since December in 2010. The US Environmental Protection Agency established the Mercury Action Plan (1998) and the Mercury Roadmap (2006) and has proposed systematic mercury management methods to reduce the health risks posed by mercury exposure. Japan, which experienced Minamata disease, aims vigorously at perfection in mercury management in several ways. In Korea, the Ministry of Environment established the Comprehensive Plan and Countermeasures for Mercury Management to prepare for the mercury convention and to reduce risks of mercury to protect public health.

Key words: Mercury, Global trends, Policy, Management, Mercury convention

INTRODUCTION

Mercury discharged into the environment by human activities has extensive influence not only on human beings but also on ecosystems. Biomagnification through the food chain and extinction of species by mercury toxicity are some examples of such influence.

In this regard, the importance of human health and environment protection activities was reaffirmed in the 21st United Nations Environmental Program (UNEP) Intergovernmental Conference, and Decision 21/5 was adopted on February 2001, which agreed to perform a mercury assessment project at the global level due to the ecological destruction and economic importance of mercury discharge. The final report was presented in the 22nd UNEP Intergovernmental Conference in February 2003 [1].

In accordance with this decision, UNEP launched the Global Mercury Assessment (GMA) project in 2001 and held a working group meeting in September 2002, which comprised 66 countries including the US and the European Union (EU) nations, five international organizations such as United Nations Industrial Development Organization (UNIDO), World Health Organization (WHO), and EU, and nine non-governmental organizations such as Green Peace and Basel Action Network. In this meeting, the general status and problems of mercury in each country were introduced and identified in order to prepare potential risks. In addition, scientific presentations were arranged, experiences of capacity building for GMA activities were shared, and the importance of information exchanges on related laws and regulations was emphasized [1].

In the 23rd UNEP Governing Council (GC; Nairobi, February 2005), Resource Mobilizing Partnerships were established to secure financial resources that were to be used to reduce the

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Corresponding author: Dae-Seon Kim, PhD
42 Hwangyeong-ro, Seo-gu, Incheon 404-708, Korea
Tel: +82-32-560-7122, Fax: +82-32-568-2035
E-mail: kimds4@korea.kr

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severe damage caused by mercury and mercury composites and the production of mercury [2]. The UNEP GC has made constant efforts including the establishment of the mercury Open-Ended Working Group on Mercury and is now in the preparation of a legally-binding mercury convention. In this review, the mercury management policies of UNEP and various governments will be summarized.

GLOBAL MERCURY MANAGEMENT

Management of Health Risks Posed by Mercury

The major countries have established daily mercury intake allowances and seafood intake recommendations. According to the Joint FAO/WHO Expert Committee on Food Additives, the recommendations for daily mercury intake are 0.47 μg/kg-BW/d (adults) and 0.23 μg/kg-BW/d (fertile women and children) [3]. The recommendations are assessed according to the amount of seafood intake. In this regard, the EU designated mercury content as 0.5 mg/kg for fish-containing products and 1 mg/kg for predatory fish.

Additionally, the US and the WHO restrict mercury intake by establishing standards for total and methyl mercury concentrations and recommended standards for fish intake (Table 1) [3,4]. In the US, 48 states have established fish consumption advisories, and the US Food and Drug Administration and the Environmental Protection Agency (EPA) recommend not eating more than 340 g of seafood per week and not eating more than 170 g of high mercury-containing species such as tuna [4,5]. Japan has investigated mercury concentrations in various kinds of fish and has restricted the recommended intake numbers and volume of some predacious species by pregnant or fertile women.

The UK Food Standards Agency has proposed that pregnant women, fertile women, and children under 16 years old should avoid eating swordfish, which contains high mercury, and that pregnant and fertile women not have tuna steak more than twice a week [6].

The Canadian government has recommended that ordinary people not have more than 150 g of predacious fish such as tuna, shark, and swordfish, children aged from 5 to 11, more than 125 g, and young children between 1 and 4 years old, more than 75 g per week [7].

Table 1. Comparison of mercury standards for fish in various countries [3,4]

Nation	Standards
International Food Standards (Codex Alimentarius)	Fish: less than 0.5 mg/kg of methyl mercury Carnivorous fish (shark, swordfish, and tuna): less than 1 mg/kg of methyl mercury
US	Fish: less than 1 mg/kg of methyl mercury
EU	Fish: less than 0.5 mg/kg of total mercury Carnivorous fish including shark: less than 1 mg/kg of total mercury
Japan	Seafood (excluding abyssal fish and tuna): less than 0.4 mg/kg of total mercury, less than 0.3 mg/kg of methyl mercury
Australia and New Zealand	Fish: less than 0.5 mg/kg of total mercury Carnivorous fish including shark: less than 1 mg/kg of total mercury
Korea	Seafood (excluding abyssal fish and tuna): less than 0.5 mg/kg of total mercury

Mercury Management by United Nations Environmental Program

In the Global Atmospheric Mercury Assessment Report (2008), UNEP introduced an assessment of emission distribution by region and pollution source based on studies of mercury circulation and movement (Table 2) [8]. In particular, UNEP has pursued various mercury risk reducing countermeasures through the UNEP GC held every two years since 2001, and Table 3 shows the details of such countermeasures [4,9].

According to the necessity of international actions to reduce mercury by accommodating GMA project results (decision

Table 2. United Nations Environment Program's estimate of mercury emission to the air (report of 2008, based on data of 2005) [8]

Rank	Country	Discharge in 2005	Global ratio (%)	Fixed combustion[1]	Industry production	Small-scale gold mining	Other
1	China	825.2	42.85	387.4	243.2	156.0	38.6
2	India	171.9	8.93	139.7	21.6	0.5	10.1
3	US	118.4	6.15	62.8	31.7	0.5	23.4
4	Russia	73.9	3.84	46.0	18.9	3.9	5.1
5	Indonesia	68.0	3.53	3.3	10.2	50.9	3.6
6	South Africa	43.1	2.24	33.4	5.7	2.6	1.4
7	Brazil	34.8	1.81	4.8	11.4	15.8	2.8
8	Australia	33.9	1.76	17.7	15.2	0.4	0.6
9	Korea	32.2	1.67	18.1	12.9	0	1.2
10	Colombia	30.0	1.56	0.8	2.3	26.3	0.6
	Total	1431.4	74.33	714.0	373.1	256.9	87.4

Unit: ton/y.
[1]Fixed combustion: fixed discharging source using fossil fuel such as a coal plant or waste furnace.

Table 3. Major discussions of the UNEP GC [4,9]

UNEP GC	Discussion
21st UNEP GC (2001)	Agreed to perform the Global Mercury Assessment project (decision 21/5)
22nd UNEP GC (2003)	Agreed on the necessity of international actions to reduce mercury by accommodating Global Mercury Assessment project results (decision 22/4V)
23rd UNEP GC (2005)	Agreed to perform the UNEP Global Mercury Partnership project to reduce the hazardousness of mercury, and designated mercury as a global pollutant because its discharge to the environment is hazardous to human beings andoverall ecosystems through the food chain
24th UNEP GC (2007)	Agreed to produce operational guidelines and business scope expansion in line with the agreement on the enforcement of the UNEP Mercury Partnership
25th UNEP GC (2009)	Discussion on mercury legislation Compose INC five times from 2010. Aim to complete by 2013 Parallel performance of voluntary actions such as mercury partnership business (see Table 4) Publish 'Technical Background Report to the Global Atmospheric Mercury Assessment' as a related report Agreed to renew The Global Atmospheric Mercury Assessment: Emission and Transport (UNEP 2008) and propose it to GC 2012

UNEP, United Nations Environmental Program; GC, Governing Council; INC, Intergovernmental Negotiation Council.

Table 5. Configuration of mercury convention (draft) [9,10]

Content	Clause	International trend
Supply	Mercury supply source (e.g., mercury mines)	Developed countries (strong management) vs. China and Algeria (voluntary management)
International trade	Mercury trade with the countries directly involved Mercury trade with the countries not directly involved	Details will be discussed later
Products and processes	Mercury added products Manufacturing process using mercury Exemption for use	Korea's intensive response is needed
Small-scale gold mining	Mercury from small-scale gold mining	Agreement was made
Discharge and leakage	Emission to the air Effluent to water and soil	Korea's intensive response is needed
Storage, waste, and contaminated areas	Storage of mercury Mercury waste Contaminated places	Details of management standards will be discussed later
Financial resources and technology-implementation support	Financial resources and mechanism Technology support Implementation committee	Developed countries (global environmental funding system) vs. developing countries (independent funding system)

Table 4. UNEP mercury partnership fields and host institutions [4,9]

Fields	Hosting Institution	Descriptions
Gold refineries and artisanal gold mines	UNIDO/NRDC	Reduce 50% of mercury use by 2017
Coal combustion	International Energy Agency (IEA CCC)	Construct thermoelectric power plants in Russia and China and prepare mercury discharge reduction guide
Production of chloride-alkali	US EPA	Research for the reduction of mercury use and discharge (reduce it to 250 tons by 2015)
Study on mercury movement	Ministry of Environment in Italy	Published 2008 UNEP Mercury Discharge Report. Perform Mercury Movement Study withparticipating nations
Mercury containing products	US EPA	Set phased reduction goal by material (additional reduction of 25% by 2015)
Mercury waste management	Japanese government	Perform studies on environmentally friendly collection and disposal technology through life cycle management (BAP/BEP guideline development)
Mercury supply and storage	NRDC	Kyrgyzstan mercury mine project, pursue mercury export law in EU and US, perform mercury storage facility construction project in Asia and South America, reduce mercury supply by 50% by 2013

UNEP, United Nations Environmental Program; UNIDO, United Nations Industrial Development Organization; NRDC, Natural Resources Defense Council; IEA CCC, International Energy Agency Clean Coal Centre; EPA, Environmental Protection Agency; BAP/BEP, Biodiversity Action Plan/Best Environmental Practice.

22/4V), the 23rd UNEP GC (2005) agreed to perform the UNEP Global Mercury Partnership project to reduce mercury hazards, and designated mercury as a global pollutant because its discharge to the environment is hazardous to human beings and overall ecosystems through the food chain. UNEP Mercury Partnership fields and host institutions are explained in Table 4 [4,9].

Additionally, since the 1st Intergovernmental Negotiation Council (INC) was held in June 2010 in Stockholm, UNEP has been preparing all the items regarding the Mercury Convention including the overall content and structure (Table 5) [9,10]. Finally, the UNEP GC approved having a legally binding mercury convention by 2013 [9,10].

At the 4th INC meeting held in Punta del Este, Uruguay from June 26 to July 2, 2012 to launch a mercury agreement, allowing temporary storage only for the storage and waste disposal of mercury instead of permanent storage was discussed. Although, according to the Basel Agreement, mercury waste

management and new mercury mine development prohibitions were agreed to, there were some conflicts among nations on some issues. For instance, the EU and African countries proposed prohibiting the use and import/export of major supply sources (e.g., recycling) while the US and Japan wanted to allow for restricted use and export/import [10].

Mercury Management by the European Union

The EU's Mercury Strategy provides comprehensive strategies on mercury risks. As Europe is a major mercury supplier at present and maintains a consistently high demand for mercury, the EU specifies the following goals and actions: 1) stop mercury exports completely by 2011; 2) cooperate globally to regulate mercury transactions, discharge, and mine closure; 3) reduce the demand for mercury containing products; 4) investigate surplus mercury in EU nations and identify a safe storage method; 5) study discharge control to reduce mercury emitted from coal combustion, and review the mercury reduction policy; 6) identify a mercury exposure reduction method by surveying the exposure of fertile women to mercury by food intake, and establish recommendations on mercury intake; and 7) publicize and educate the public about the risks of mercury [11].

Accordingly, the Working Group on Mercury of the EU presented research results on mercury's circulation, risks to humans and the environment, natural and artificial discharge, control technology, and risk assessment in 2001 in the report "Ambient air pollution by mercury" [12].

As a part of the management of mercury-containing products, sales of mercury-containing medical equipment were prohibited as of August 21, 2008, and sales of products containing more than 5 mg of mercury were prohibited.

In most EU nations, regulations against mercury discharge facilities follow Directive 2008/1/EC (revised version of Directive 96/61/EC) called as the Integrated Pollution Prevention and Control (IPPC) Directive. The IPPC sets discharge allowance standards based on best available techniques (BAT) like the maximum available control technology (MACT) of the US, and uses the European Pollutant Emission Register (EPER) in order to monitor the application of BAT and the achievement of discharge allowance standards. The threshold for releases of mercury to the environment by EPER was 10 kg/y to the air, and 1 kg/y to water [13].

The European Economic Community Directive 82/176 sets limits and goals for mercury discharge from the chlor-alkali industry, which is the major user of mercury. The Chlor-alkali Association plans to convert facilities into non-mercury facilities in Europe by 2020 and in India by 2012. The restrictions on mercury discharge from waste incineration plants follow Directive 2000/76/EC. This directive applies to facilities generating an artificial discharge of mercury by setting the discharge standard as 0.05 mg/Sm^3 for new facilities and 0.1 mg/Sm^3 for existing facilities (for designated waste incineration plants approved before December 31, 1996, the limit was set as the mercury composite concentration until January 1, 2007) [4, 12,14].

Mercury Management by the US

In 1998, extensive fish tissue sampling in the New England States showed that they were contaminated by methyl mercury. Afterwards, the US EPA established the Mercury Action Plan (1998) and the Mercury Roadmap (2006) as comprehensive plans and presented a systematic mercury management method. The Mercury Roadmap provided countermeasures in 6 areas: mercury discharge to the environment, management of the use of mercury-containing products and processes, mercury supplies, hazard communication, global mercury pollutant management, and mercury research and monitoring. Additionally, it established a mercury research strategy and a long-term study plan for 2002 to 2010 and performs overall management of mercury movement studies through the STAR Grants Program. Fish consumption advisories are under preparation in 48 states at present [15,16].

The US EPA confirmed the Clean Air Mercury Rule (CAMR) to set a standard method for managing mercury discharged from thermoelectric plants and prepares regulations on the transaction schemes in mercury discharge rights to cost-efficiently reduce mercury discharge from thermoelectric plants. Additionally, it aims to reduce the annual mercury discharge limit to 38 tons (35.4% reduction from the discharge volume in 1999 [48 tons]) and to 15 tons by 2018, which is 70% less than the baseline of 1999 [17].

However, the CAMR became invalid in February 2008 after a court ruling and the EPA is planning to make an appeal, and at the same time, it is preparing new regulations. Accordingly, MACT, which is currently provided in most trade, is planned to be applied to coal thermo-electric plants. Furthermore, the EPA established technology-based standards on specific mercury discharge sources referring to the Clean Air Act and set the regulation that all mercury discharging sources should

Table 6. Mercury discharge source management according to the Clean Air Act by the US EPA [4]

Applied facilities	Related regulations
Cement plants	Final rule to limit emissions of mercury and other toxics from Portland cement plants (August 9, 2010)
Iron and steel foundries	Regulation to control emissions from iron and steel foundries (April 22, 2004)
Steelmaking facilities (electric arc furnace)	EPA issued final National Emission Standards for Hazardous Air Pollutants rule for electric arc furnace steelmaking facilities (December 28, 2007)
Power plants	Development of standards for emissions of mercury from power plants/Clean Air Mercury Rule (vacated February 2008)
Chlor-alkali plants	Reduction of Toxic Air Pollutants from Mercury Cell Chlor-Alkali Plants: final rule (December 19, 2003)
Solid waste combustion facilities	Solid waste combustion rules
Hazardous waste combustion facilities	Reduction of toxic air emissions from combustion sources that burn hazardous waste
Industrial combustion for energy	Reduction of toxic air emissions from industrial, commercial, and institutional boilers and process heaters

EPA, Environmental Protection Agency.

maintain the discharge standards in order to obtain an operational permit or license. The regulations on mercury discharge of such facilities are shown in Table 6 [4].

Mercury, which is already being produced and stored in the US, came to be under full-scale management with the passing of the Mercury Export Ban Act in 2008. Mercury reserves retained by the Department of Energy and the Department of Defense are 145 tons and 4435 tons respectively. The EPA designates and manages 5 surplus mercury storage facilities [4,18].

Additionally, the EPA enforces restrictions on mercury-containing products by executing mercury content survey research. For this, it prohibits sales of mercury-containing clinical thermometers and blood pressure gauges and the use of mercury oxide cells and requires that mercury containing products such as batteries be labeled as such.

In August 2006, the EPA announced the National Vehicle Mercury Switch Recovery Program to collect mercury brake sensors and mercury switches in vehicles. It aims to collect 80% to 90% of the mercury switches by 2017. Related to the final waste management of mercury-containing products, the EPA requires mercury abstraction for products containing more than 260 ppm of mercury and mercury stabilization/solidification for products containing less than 260 ppm of mercury, instead of abstraction [4].

It is estimated that 5% to 36% of mercury in air originates from discharge in Asia, and it was reported that 31% of incidents of high Hg^0 in the air in the US were caused by long distance travel from East Asia including China [16]. Studies to identify the relationship between mercury in the air and methyl mercury in fish were conducted through the Mercury Experiment to Assess Atmospheric Loading in Canada and the United States (2007). Additionally, for the systematic management of mercury-contaminated areas, the Mercury Map was created and utilized. The Mercury Deposition Network (1995) monitors mercury concentration and accumulation in rainfall, and compiles a nationwide database [19].

The US is also working on various mercury management guidelines for the water system and establishes a comprehensive mercury management plan and water quality management standards for the five largest lakes in the US through the Water Quality Guidance for the Great Lake Systems (1995). It prepares test procedure guidelines for analyzing mercury in water through Method 1631 and utilizes it for water quality monitoring. There are water quality criteria for managing methyl mercury in seafood, and restrictions and guidelines using the concept of the Total Maximum Daily Load [4,20].

Mercury Management in Japan

Just as in Korea, the US and the EU nations, the major mercury discharging sources in Japan are industrial waste incineration facilities, steel manufacturing facilities, non-metal manufacturing facilities, and cement plasticity facilities. The mercury discharge coefficient of cement plasticity facilities, the biggest mercury discharging source, is 0.16 g-Hg/Mg-clinker. For waste incineration facilities (hospital waste), it was 0.13 to 0.16 g-Hg/Mg-waste.

The management of mercury in Japan can be classified into three activities as follows: 1) conversion to non-mercury-using facilities and manufacturers' contribution such as discontinuing mercury battery production; 2) establishment of a collection system for mercury-containing waste; and 3) setting waste discharging allowance guidelines for air, water, and waste for mercury sources.

The national use of mercury included in alkali button batteries, silver oxide batteries, and zinc-air batteries in Japan was reported to be 0.19, 1.05, and 0.57 tons, respectively, in 2003. The amount of mercury included in the backlight of liquid crystal display (LCD) screens is reported to be 2.4 mg/unit on average. As LCD screens are being more widely used, national

use of mercury is increasing. Mercury abstracted from batteries and fluorescent lights is condensed and purified and then reused in fluorescent light manufacturing, universities, and laboratories in the form of elemental mercury or mercury compounds. On 2006, it was reported that 346 kg of mercury was recycled and reused. However, there are cases in which approximately 15 tons of mercury was collected per year from batteries, fluorescent lights, measuring equipment, medical devices, reagents, construction equipment, and absorbers.

Mercury discharge in Japan decreased from 34.6 ton/y in 1990 to 26.5 ton/y in 1998 thanks to robust measures such as the introduction of non-mercury battery manufacturing processes and advanced air pollution prevention facilities to satisfy dioxin allowance standards. However, with the increase of waste use in coal combustion facilities, sewage sludge incineration facilities, and cement plasticity facilities, the discharge in 2006 increased a little to 29.4 ton/y. According to the statistics reported in 2009, mercury discharge from artificial mercury discharge sources in Japan was estimated to be 21 to 28 ton/y [21-24]. Table 7 shows the amount of mercury exported and imported through mercury-containing products in Japan [24].

MERCURY MANAGEMENT IN KOREA

Health Risk Management of Mercury

The Study on the Exposure to and Health Effects of Mercury (2005-2008) conducted by the National Institute of Environmental Research (NIER), Korea addressed biological mercury exposure. It reported that the exposure through environmental media was 0.108 μg/d and the intake through food was 18.71 μg/d, which shows that most of the exposure occurs through food intake. Additionally, the exposure per vaccination was approximately 0.00 to 0.42 μg, which makes the total lifelong accumulation 22.24 μg, assuming that the average lifespan is 70 years [25].

In a survey conducted in 2009 on residents in the Gyeongbuk areas who were highly exposed to mercury, it was found that the main cause of the high exposure might be traditional shark intake in those areas [26]. In 2010, there was a follow-up study, which was the biggest in Korea, to investigate mercury exposure of about 5000 residents in the Gyeongnam and the Gyeongbuk areas. It was found that people who live in coastal areas or islands are more likely tobe exposed to mercury [27]. In 2011, however, the blood mercury concentration was successfully reduced through risk communication with residents in the areas with the highest mercury concentration in Korea [28].

According to the results of The Korea National Survey for Blood Heavy Metal Concentration (Ministry of Environment, 2005) and The Korea National Survey for Environmental Pollutants in the Human Body (NIER, 2007-2009), the blood mercury concentration was 4.34 ppb in 2005, while it was 3.0 ppb in 2008 [29,30]. The figures are still high compared to those in developed countries. Thus, countermeasures are needed to reduce human mercury exposure to prevent health damage by mercury.

Table 7. Amount of mercury exported/imported through mercury-containing products in Japan [24]

Classification		2001	2002	2003	2004	2005	Average over 5 y
Battery (silver oxide cells)	Export	707	478	420	500	539	529
	Import	-	-	-	-	-	-
Fluorescent and HID Lamp	Export	491	396	344	467	492	438
	Iimport	268	291	297	338	380	332
Thermometer	Export	85	82	151	67	43	85
	Import	58	57	50	75	40	58
Blood pressure gauge	Export	1489	1374	1520	1182	859	1285
	Import	505	524	498	610	473	522
Total	Export	2772	2330	2435	2215	1932	2337
	Import	831	872	844	1022	894	900

Unit: kg/y.
HID, High intensity discharge.

Mercury-containing Products

Manufacturing and import of mercury batteries is prohibited in Korea. Additionally, the content of mercury in alkali-manganese batteries is restricted to under 1 ppm per unit weight. Although there are no restrictions on mercury content in fluorescent lights in Korea, it is set to less than 5 mg (after 2010) for lamps labeled with the Environmental Mark. There is no legal restriction or prohibition on mercury in amalgam for dental treatments. However, mercury is prohibited from being used in agricultural chemicals and cosmetics, and the mercury allowance for paints is set to 60 ppm per unit weight [31].

When it comes to vaccines, the Korea Food and Drug Ad-

Table 8. The amount of mercury exported/imported in Korea [35]

Article		2005	2006	2007	2008	2009	2010	2011
Mercury (kg)	Export	258	112	4	30	7	397	3347
	Import	15 716	7888	13 738	12 789	13 113	6605	11 168

ministration recommended in 2006 that less than 10 μg/mL of thimerosal or none at all should be included. For finished products such as writing materials, the mercury allowance is set as 60 mg/kg according to the Quality Management and Product Safety Management Act [4].

Mercury in Raw Materials

In Korea, mercury is designated as a toxic material in the Toxic Chemicals Control Act. Mercury and its discharge and distribution are controlled through the Chemicals Discharge Survey System. In the survey on the distribution amount of chemical materials in 2006, the total mercury distribution in Korea was identified to be 18.3 tons [32].

According to the Pollutant Release and Transfer Registers system in 2008 (http://ncis.nier.go.kr), it was found that seven companies discharged mercury and its compounds in Korea. It was also found that the transfer to waste was greater than the transfer to nature [33].

It was noted that there was no surplus mercury storage and management law in Korea. In the report of The Basic Study on Domestic Mercury Distribution and Discharge Status in 2009, a total of 265.8 tons of mercury flowed in Korea, of which 9.1 tons came from domestic production and 256.7 tons from imports [34]. Table 8 shows the amount of mercury exported and imported in Korea, as reported by the Korea International Trade Association [35].

Mercury-containing Product Disposal

In Korea, as the collection rate of disposed mercury-containing products is low, there is the possibility of mercury contamination in waste incineration and landfill facilities. In the domestic producer responsibility scheme, there are distribution and recycling status survey materials on fluorescent lights and batteries among other mercury-containing products. For fluorescent lights and batteries, compulsory recycling rates were set. They were 20.7% in 2006 and 24% in 2009 for fluorescent lights, and 29.3% in 2006 and 49% in 2008 for mercury batteries [4,34].

Mercury Discharge Source Management

Related to the calculation of domestic mercury discharge, UNEP estimated domestic mercury discharge in 2005 to be 32.2 ton/y through the Technical Background Report to the Global Atmospheric Mercury Assessment, 2008. However, under the construction of inventory and under the calculation of the discharge coefficient and discharge amount, which were based on the actual measurement of domestic artificial mercury sources, the mercury discharge was calculated to be 6.5 to 20.2 ton/y in the Mercury Discharge Survey on Atmospheric Emission Facilities [36]. However, according to the report of the Basic Study on Domestic Mercury Distribution and Discharge Status in 2009, the amount of mercury released to the air was 14.4 ton in 2006 [34].

Although the air discharge allowance standards for incineration facilities and thermoelectric plants were reduced from 5 mg/Sm^3 to less than 0.1 mg/Sm^3 in 2005, this is still too generous compared to the EU (0.05 mg/Sm^3) and the US (0.01 mg/Sm^3). In the Survey on Mercury Discharge from Thermoelectric Plants, the discharge was measured at 0.08 to 26.3 μg/Sm^3, which may be caused by the use of low grade fuels in the plants [37]. Table 9 explains domestic law, regulations and standards related to mercury [4,38].

The mercury discharge allowance in the water system is 0.001 mg/L for clean areas and 0.005 mg/L for other areas. When it comes to wastes, they are regulated if effluent has contained more than 0.005 mg/L of mercury in the effluent test by a waste process test method on the designated waste. However, the mercury discharge from wastewater discharge facilities and mercury-containing wastes has not been calculated [38].

Table 9. Domestic laws and regulations and standards related to mercury [4,38]

Content	Standards	Regulating laws
Atmospheric emission facility	Less than 0.1 mg/Sm^3	Clean Air Conservation Act
Area A (schools and historical places)	Less than 4 mg/kg	Soil Environment Conservation Act
Area B (factories and roads)	Less than 16 mg/kg	
Drinking water	Less than 0.001 mg/L	Drinking Water Regulations (Water Quality Standards)
Streams/lakes	Below DL	
Seashores	Less than 0.0005 mg/L	
Clean zones	Less than 0.001 mg/L	Water Quality Conservation Act (Effluent Quality Standard)
Area A and B and other special areas	Less than 0.005 mg/L	
Abyssal fish, seafood excluding tuna and sword fish	Less than 0.5 mg/kg of total mercury	Food Sanitation Act
Abyssal fish, tuna and sword fish	Less than 1.0 mg/kg of methyl mercury	
Mollusks and shellfish	Less than 0.5 mg/kg of total mercury	

DL, detection limit.

Enforcement of Environmental Monitoring

Whereas mercury exposure occurs through multiple pathways, mercury concentration in a single medium only is measured in Korea. Since mercury assessment in integrated media in the environment has not been achieved, scientific grounds for the evaluation of the local contamination level and trends are insufficient. The allowance is set to 0.001 mg/L for water quality and to 4 to 60 mg/kg for soil, and a measurement network is under operation. However, data on the water system are still insufficient [38].

Policies on Mercury in Korea

With the recognition of the risks of mercury, the Ministry of Environment of Korea prepared the first step of the Comprehensive Plan and Countermeasures for Mercury Management in 2006. Aims were set up for mercury management in several areas from mercury-containing products to discharge management, pollution survey, and monitoring [29].

Through this policy, management of mercury and mercury-related activities was established and implemented, and problems in Korea were identified. In order to address these problems, the second Comprehensive Plan and Countermeasures for Mercury Management was set up in 2010, aiming for the establishment of a foundation for unified mercury management and the preparation of countermeasures for the Mercury Convention. This policy includes the comprehensive management of mercury across the life span through the cycle of production, consumption, and waste, strengthening mercury management in discharge facilities, environmental monitoring, and precautions regarding the health effects of mercury on vulnerable populations (Figure 1) [29].

NIER has been designated to host the 12th International Conference on Mercury as A Global Pollutant in 2015. This will be an important opportunity not only to protect the health of the public from mercury but also to respond to international trends regarding mercury.

CONCLUSION

The UNEP GC regulates mercury as a global contaminant because discharge of mercury to the environment poses threats to humans and the ecosystem as a whole. Since 2001, it has also executed the Global Mercury Assessment, reinforced mercury partnerships, implemented mercury special task forces, and prepared a legally-binding mercury agreement.

In 2008, UNEP identified the emissions contribution of each region and each contaminant, evaluated their environmental influences through the Atmospheric Emission Report, and requested the list of mercury sources and annual discharge in various countries around the world as a basis for entering into the international Mercury Convention while providing an overall report of mercury discharge by nation and a toolkit to cal-

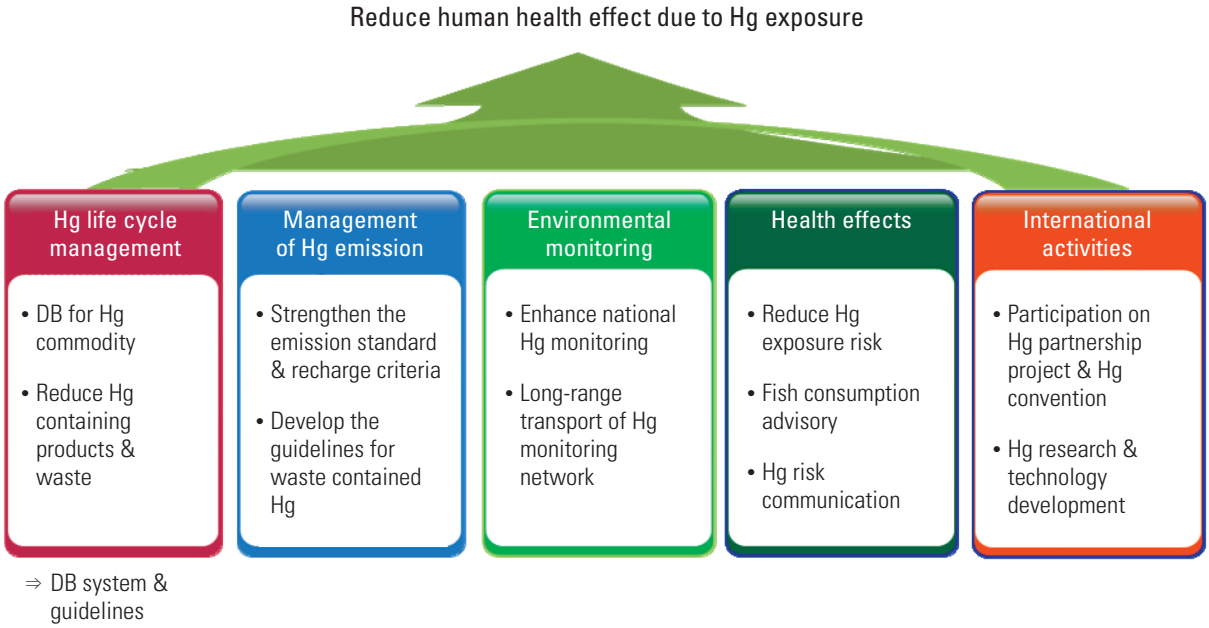

Figure 1. Mercury action plan from the 2nd comprehensive plan for mercury management (2011-2015) [29]. Hg, mercury; DB, database.

culate the mercury discharge amount.

Additionally, the EU proposed an inclusive strategy to manage the risk of mercury, executed the Mercury Export Ban Act in December 2010, and pursued regulation of the international movement of mercury by expanding the construction of mercury storage facilities for complete disposal. The US EPA proposed a systematic management method by establishing the Mercury Action Plan (1998) and the Mercury Roadmap (2006) to reduce the risks to human health caused by mercury exposure. Japan, which had experienced Minamata disease, put an emphasis on the management of mercury through reducing mercury use, collecting mercury-containing waste, and establishing guidelines for mercury discharge.

Korea has been irregularly participating in the efforts to reduce mercury discharge from thermoelectric plants among UNEP partnership projects. It is necessary for Korea to find ways to join other partnership programs, prepare for mercury conventions, and play a leading role in international efforts.

CONFLICT OF INTEREST

The authors have no conflicts of interest with the material presented in this paper.

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