IISD International Institute for Sustainable Development

BRIEFING NOTE

# Canada Advancing Global Efforts on Mercury Management

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April 2017

## 1.0 Context

Today, Canada ratified the Minamata Convention on Mercury (United Nations Environment Programme [UNEP], 2013). There are now 41 countries that have ratified the convention, including Canada, and 128 that have signed it since it was completed.

Through this ratification, the Canadian federal government has formally met various requirements stipulated within the convention to track and reduce transboundary mercury pollution. Like other UN legal agreements—including the United Nations Framework Convention on Climate Change and Montreal Protocol—the requirements under the convention comprise domestic strategies to manage mercury emissions, point source release, exposure, remediation of contaminated sites and other matters.

This brief summarizes the state of knowledge on mercury management in Canada based on recent reports, as well as decades of research at the IISD-Experimental Lake Area (IISD-ELA).

Based on requirements under international agreements including the Minamata Convention and the Basel Convention, as well as principles provided by international groups such as the International Council on Mining and Metals (ICMM), we summarize required areas of effort on mercury management for Canada, with an illustrative emphasis in Ontario.

## 2.0 Canadian Mercury Science Assessment

Environment and Climate Change Canada (ECCC) recently released summary (ECCC, 2016a) and full assessment reports (ECCC, 2016b) providing a comprehensive, peer-reviewed state of scientific knowledge on mercury in Canada. This assessment built on other studies including the Canadian Arctic Northern Contaminants Program, as well as regional environmental assessments of the Great Lakes basin and northeastern North America. In addition to summarizing current scientific knowledge, the summary of key results provides science-based recommendations for several policy-related questions and recommendations for mercury research and management in Canada.

This assessment (ECCC, 2016a) emphasizes that mercury (Hg) is emitted into the atmosphere from both natural and anthropogenic sources, and can be re-emitted from previously deposited mercury. While natural sources include weathering of the Earth's surfaces, forest fires, aquatic emissions, etc., human sources include the burning of coal, logging, mining, and mercury from incinerators and other industrial processes emitted into the air and released into water systems. Mercury is a neurotoxin that magnifies biologically in organisms.

The two main processes responsible for biogeochemical transformations of mercury include oxidation/reduction processes that convert Hg0 ⇔ $Hg^{2}$+ and methylation/demethylation that convert Hg2+ ⇔ MeHg (methylmercury). Methylation is the transformation of elemental mercury to the more toxic methylmercury under anaerobic conditions in sediments and water, while demethylation is the degradation of methylmercury into inorganic mercury driven by photochemical or microbial processes.

## 2.1 Why is Mercury a Concern in Canada?

While different forms of mercury occur naturally in the environment, human activities have exacerbated the emission (air) and release (land and water) of large quantities of mercury into the environment. Human actions (such as mining, coal combustion and reservoir impoundment) have affected processes such as methylation, making mercury management a priority. While Canadian emissions of atmospheric mercury have significantly reduced in the last decade, Canada is susceptible to long-range transport and deposition from places such as Asia. Currently, anthropogenic emissions contribute to about 40 per cent of total mercury deposition in Canada, and over 95 per cent of this 40 per cent is from outside Canada's borders. In addition, current mercury emissions in Canada come from electric power plants, waste incinerators and other sources, and must continue to be addressed to minimize mercury-related risks.

Due to mercury's ability to bioaccumulate within animals and plants and biomagnify as it travels through prey to higher predators, methylmercury remains a public health issue, particularly for populations who work closely with mercury-based products or rely heavily on the consumption of large predatory fish and traditional wild food sources. Vulnerable parts of the population, such as infants and young children, are particularly susceptible to the toxic impacts of mercury poisoning.

**"Predatory fish and wildlife may have mercury levels in their tissue 1,000,000 times greater than the levels in the freshwater where they live" (ECCC, 2016a).**

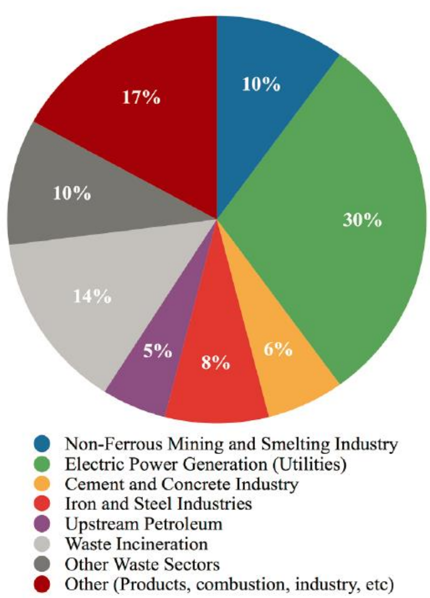


Figure 1. Major sector contributions of mercury emissions to air in Canada in 2010 (ECCC, 2016b)

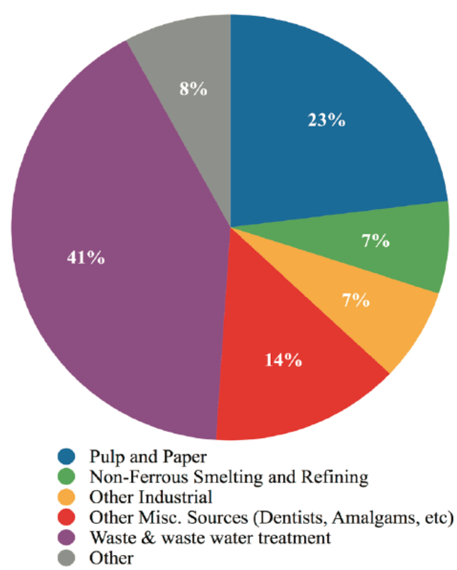


Figure 2. Sector contributions of mercury releases to water in Canada in 2010 (ECCC, 2016b)

## 2.2 Science Gaps

A number of key gaps in knowledge have been acknowledged in the Canadian Mercury Science Assessment (ECCC, 2016a). These include: the need for a more comprehensive understanding of mercury emissions, including from specific point sources; responses to regulatory approaches; a detailed inventory of mercury-containing products still in use in Canada; better understanding and characterization of mercury emissions from forest fires, agricultural burning and waste burning; an improved understanding of Canadian legacy emissions; and an understanding of methylation processes, including the impacts of climate change on mercury mobilization and impacts on aquatic systems and humans.

**Table 1.** Total mercury emissions from provinces and territories

| Province | 1990 | | 2000 | | 2010 | |
|---|---|---|---|---|---|---|
| | kg | % | kg | % | kg | % |
| Alberta | 1 184 | 3 | 1062 | 16 | 1 175 | 22 |
| British Columbia | 3 668 | 10 | 1 139 | 6 | 549 | 10 |
| Manitoba | 20 169 | 57 | 1 231 | 13 | 366 | 7 |
| New Brunswick | 729 | 2 | 436 | 5 | 158 | 3 |
| Newfoundland | 253 | 1 | 184 | 2 | 122 | 2 |
| Nova Scotia | 384 | 1 | 261 | 5 | 139 | 3 |
| Northwest Territories | 79 | 0 | 4 | 0 | 13 | 0 |
| Nunavut | 2 | 0 | 2 | 0 | 2 | 0 |
| Ontario | 4 426 | 13 | 2 675 | 31 | 1 191 | 22 |
| Prince Edward Island | 35 | 0 | 27 | 0 | 16 | 0 |
| Quebec | 3 667 | 10 | 1296 | 15 | 730 | 14 |
| Saskatchewan | 662 | 2 | 575 | 7 | 855 | 16 |
| Yukon | 4 | 0 | 2 | 0 | 1 | 0 |

*Source: ECCC (2016a)*

## 3.0 Mercury Research at IISD-ELA

IISD-ELA has been involved in mercury-related research for a number of decades. Many ELA scientists were previously involved in research on mercury at other locations than ELA. For example, the creation of new reservoirs often results in elevated concentrations of mercury in fish. One of the earliest demonstrations of this phenomenon was by researchers working in reservoirs created by the Churchill River Diversion in 1974–98 (Bodaly et. al., 1984). During the late 1970s and early 1980s, future ELA researchers also explored possible remediation strategies for the English–Wabigoon system, which was contaminated with mercury from the Dryden pulp and paper mill (e.g., Rudd et. al., 1980; Turner & Rudd, 1983).

At ELA itself, there were several additions during the 1980s of radioisotopic metal tracers including $^{203}Hg$ to whole lakes (e.g., Hesslein, Broecker, & Schindler, 1980; Klaverkamp, Hodgins, & Lutz, 1983; Bird et al., 1998) and enclosures at ELA ( e.g., Jackson et al., 1980; Schindler et al., 1980; Santschi et al. 1986). These studies investigated the effects of acidification and eutrophication on mercury cycling and transfer to fish and other biota (see also Kidd et al., 1999).

Starting in 1991, the ELA Reservoir Project (**ELARP**) took advantage of newly developed methods for measuring methylmercury in water and sediments to further understand the effects of reservoir construction on mercury cycling and bioaccumulation by fish. Using a whole-lake flooding manipulation, the ELARP project established the time course of changes in mercury cycling following initial impoundment and demonstrated the importance of the food web for transfer of methylmercury to fish (e.g., Paterson et al., 1998, Gerrard & St. Louis, 2001). Results from the ELARP study and from northern Manitoba (Johnston et al. 1991) suggested that the extent of mercury methylation and contamination of new reservoirs may be related to the amount of organic carbon in flooded soils and vegetation. This led to a second whole-ecosystem experiment, called **FLUDEX**, where three small reservoirs were created that flooded experimental catchments containing different amounts of organic matter (Bodaly et al., 2004). This experiment showed that the magnitude of the initial increase of mercury methylation did not vary with flooded carbon, but that the duration of the period of greater methylation increased in reservoirs with more carbon (Bodaly et al., 2004; Hall et al., 2009). Several associated projects directly tested possible remediation methods such as burning of vegetation prior to flooding (Mailman & Bodaly, 2006) and selenium additions to decrease mercury uptake by fish (Mailman et al., 2013).

In 1999, researchers at ELA began a large collaborative whole-ecosystem manipulation called **METAALICUS** (Harris et al., 2007) to determine whether proposed restrictions on mercury emissions to the atmosphere from coal-fired power plants would lead to decreased methylmercury accumulation by fish in remote lakes. This research showed a clear relationship between changes in direct mercury deposition to the study lake and methylmercury accumulation by fish and other biota, supporting proposed legislation (for e.g., Paterson et al., 2006).

In addition to the studies described above, the IISD-ELA has amassed an extensive database on mercury in different lakes and long-term changes in mercury deposition that has contributed to better understanding of mercury dynamics.

## 4.0 International Agenda


### 4.1 Minamata Convention

The Minamata Convention on Mercury calls for reductions of emissions from products, processes and industries using, emitting or releasing mercury. In 2005, the UNEP established the Global Mercury Partnership to track sources and pathways of mercury emissions. Several countries are responsible under the global partnership for different sources and pathways. These comprise:

- **Mercury Emissions from Coal** – International Energy Agency Clean Coal Center (CCC)
- **Mercury Air Transport and Fate Research** – Consiglio Nazionale delle Ricerche (CNR) Institute for Atmospheric Pollution, Italy
- **Mercury Waste Management** – Government of Japan
- **Mercury Cell Chlor Alkali Production** – Government of the United States (Environmental Protection Agency), United Nations Industrial Development Organization (UNIDO)
- **Artisanal and Small-Scale Gold Mining** – Natural Resources Defense Council (NRDC), United Nations Industrial Development Organization (UNIDO)
- **Mercury Supply and Storage** – Government of Spain, Government of Uruguay
- **Mercury in Products** – Government of the United States (Environmental Protection Agency)

The convention requires signatories to comply with requirements including the banning of primary mercury mining, reductions in mercury emissions (into air), release (into land and water), exposure through products and consumptions, remediation of contaminated regions, monitoring, outreach and other means. By ratifying the convention, Canada is declaring itself in compliance with requirements, including implementing controls on mercury exports. The convention requirements (based on a checklist provided by National Resources Defense Council,], n.d.) most relevant to Ontario include:

**Supply and trade.** Restrict import/export and use of mercury from decommissioning chlor-alkali plants; require environmentally sound disposal; require information on stocks or compounds of mercury exceeding 50 metric tonnes (MT) and mercury supply generating stocks exceeding 10 MT/year.

**Mercury-added products.** Restrict the manufacture, import and export of products containing mercury (listed); phase out the use of dental amalgam through two or more measures listed; take measures to prevent the incorporation of products listed (i.e., switches and relays, batteries) into larger, assembled products; discourage the manufacture and distribution of new mercury product types.

**Manufacturing processes.** Disallow and/or restrict the use of mercury or mercury compounds in manufacturing processes; do not allow new facilities to use mercury; for facilities, identify and obtain information on mercury or mercury compound use; control mercury emissions (air) and release (land and water); and discourage new uses of mercury in industrial processes.

**Air emissions.** Require best available techniques/best environmental practices (BAT/BEP) or associated emission limit values for new sources listed (coal-fired power plants, coal-fired industrial boilers, non-ferrous metal smelting and roasting processes, waste incineration, cement production). As well, require one or more measures identified to control/reduce mercury emissions from existing sources listed, which shall be operational at the source within 10 years. Finally, require monitoring/reporting and otherwise establish a mercury emissions inventory for sources listed.

**Releases to land and water.** Require reporting or otherwise obtain information as needed to identify significant sources of mercury/mercury compound releases to land or water, and to maintain an inventory of releases from the sources identified; take measures specified to control/reduce mercury and mercury compound releases to land and water from significant sources it identifies.

**Interim mercury storage.** Take measures to ensure interim mercury storage is conducted in an environmentally sound manner, taking into account guidelines to be developed by the Conference of the Parties (COP).

**Mercury waste management.** Use a definition of mercury waste consistent with that provided by Minamata; take measures to manage mercury waste in an environmentally sound manner taking into account guidelines developed under the Basel Convention and in accordance with requirements (to be developed); take measures to restrict mercury derived from the treatment or reuse of mercury waste to allowed uses under the convention or environmentally sound disposal; and require transport across international boundaries in accordance with the Basel Convention, consistent with international rules, standards and guidelines.

**Contaminated sites.** Develop strategies for identifying and assessing mercury/mercury compound contaminated sites. If risk reduction activities are undertaken at contaminated sites, they are undertaken in an environmentally sound manner, incorporating risk assessment where appropriate.

**Public health.** Promote the development and implementation of strategies to identify and protect populations at risk, such as developing fish consumption guidelines; promote occupational exposure educational and prevention programs; promote prevention, treatment and care services for affected populations.

**Financial resources.** Access domestic resources as needed to implement convention obligations.

**Monitoring, research and outreach.** Collect and disseminate information on annual quantities of mercury and mercury compounds emitted, released or disposed, and other information as specified; share information on the health and safety of humans and the environment as non-confidential; report to the COP on progress in implementing convention obligations.

### 4.2 Basel Convention

Canada ratified the Basel Convention in 1992, under which elemental mercury and mercury-containing or contaminated wastes are categorized as hazardous wastes. Improper handling, collection, transportation or disposal of mercury wastes as well as some disposal technologies can lead to emissions or releases of mercury (UNEP, 2011). As a signatory under both international conventions, while trading with any non-signatories, Canada must develop bilateral agreements to conform with requirements for trade under the Basel Convention.

Under the Basel Convention, elemental mercury and mercury-containing or contaminated wastes are categorized as hazardous wastes. Improper handling, collection, transportation or disposal of mercury wastes, as well as some disposal technologies, can lead to emissions or releases of mercury. Technical guidelines have been developed under the Basel Convention for the environmentally sound management of the wastes falling under its scope. Technical guidelines provide the foundation upon which countries can operate at a standard that is not less environmentally sound than that required by the Basel Convention. The growing global trend towards phasing out mercury-added products and processes using mercury will result in the generation of an excess of mercury if mercury supplies remain at the current level. Therefore, ensuring environmentally sound management of mercury wastes will be a critical issue for most countries.

The ICMM, a global, industry-led initiative, provides the following commitments for member companies:

1. Do not open any mines designed to produce mercury as the primary product.
2. Apply materials stewardship to promote the responsible management of mercury produced from ICMM members' operations, including that which naturally occurs in our products.
3. Identify and quantify point source mercury air emissions from our operations and minimize them through the application of cost-effective best-available technology, using a risk-based approach.
4. Report significant point source mercury air emissions from our operations consistent with our commitment to report in accordance with the Global Reporting Initiative framework.
5. Participate in government-led partnerships to transfer low- to no-mercury technologies into the artisanal and small-scale mining sector in locations where ICMM member companies have operations in close proximity to artisanal and small-scale mining activity, such that livelihoods are enhanced through increased productivity and reduced impacts to human health.
6. Through ICMM, encourage the development of sound science on the fate and transport of mercury as well as natural sources of mercury in the environment.
7. Work on an integrated multistakeholder strategy through ICMM to reduce and eventually cease supplying mercury into the global market once policy and economically viable long-term technological solutions for the retirement of mercury are developed. (ICCM, 2009)

These government and industry commitments are rapidly moving governments and industry, including in the mining, energy, waste management and health sectors, to manage mercury in Canada.

## 5.0 Mercury Management: Past and Present

In the United States, Mercury is managed primarily through the Clean Air Act, which regulates hazardous air pollutants through a series of regulations and standards applicable to industries including iron and steel foundries, and chlor-alkali plants. The Clean Water Act also establishes acceptable levels for the release of pollutants (including mercury) in water. The Food and Drug Administration has set an acceptable level of mercury in fish, shellfish and crustaceans of 1 ppm methylmercury in an edible portion (U.S. EPA, 2017). Finally, the U.S. Environmental Protection Agency (EPA) Emergency Planning and Community Right-to-Know Act helps increase public access to information on chemicals at individual facilities, and releases into the environment (U.S. EPA, 2017).

Environment Canada and Health Canada developed a Risk Management Strategy for Mercury (Environment Canada, 2010) that included specific risks to Canadians, key sources of mercury in Canada, and responses from government and industry on emissions reductions, phasing out mercury-containing products, monitoring, research and the Accelerated Reduction/Elimination of Toxics program.

Apart from being a signatory on the Minamata and Basel conventions, Canada is also part of the Arctic Contaminants Action Plan (ACAP) and the Arctic Monitoring and Assessment Program (AMAP) as members of the Arctic Council. Ontario is a participant of the Canada–U.S. Strategy for the Virtual Elimination of Persistent Toxic Substances in the Great Lakes Basin. Known as the Great Lakes Binational Toxics Strategy, a framework for addressing mercury pollution in the basin was developed by establishing a goal of "virtual elimination" of anthropogenic mercury inputs to the Great Lakes, as well as establishing goals for reducing U.S. mercury emissions and use by 50 per cent and reducing Canadian mercury releases by 90 per cent. This group has achieved its targets and has ceased activities.

More broadly than Ontario, under the North American Commission for Environmental Cooperation, Canada, the United States and Mexico developed a North American Regional Action Plan (NARAP) on Mercury, which was finalized in 2000. The goal of this 10-year plan was to reduce anthropogenic mercury releases within North America through tri-national and national initiatives in the three countries. NARAP contained provisions on risk management approaches to address mercury in air emissions, industrial processes and operations, products and waste. It also describes activities related to research, monitoring, modelling, inventories and communication.

### 5.1 Summary of Mercury Management in Ontario

The following section highlights specific points of mercury management required based on current knowledge of the mercury cycle. The section also provides a summary of the Ontario programs and regulations that address some of these identified needs. A framework linking points of mercury management with points in the mercury cycle are depicted in Figure 3 below. This framework is used to highlight mercury management regulations and programs in Ontario:

**A. Emissions control.** Mercury is listed under Schedule 1: List of Toxic Substances, under the Canadian Environmental Protection Act, 1999 (CEPA, 1999); Canada-wide standards for Mercury Emissions were developed by the Canadian Council of Ministers of the Environment in 2000; Ontario has a Toxics Reduction Act and environmental assessment processes that limit mercury emissions from regional processes such as the development of mines.

**B. Methylation control.** The Canadian Fisheries Act provides for specific controls for deleterious substances that "would degrade or alter or form part of a process of degradation… so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man of fish that frequent that water."

**C. Guidelines and standards for environmental safety and human exposure.** Management instruments include Canadian water quality guidelines, Canada-wide standards for mercury emissions, Ontario drinking water quality objectives and the Occupational Health and Safety Act limiting exposure to mercury.

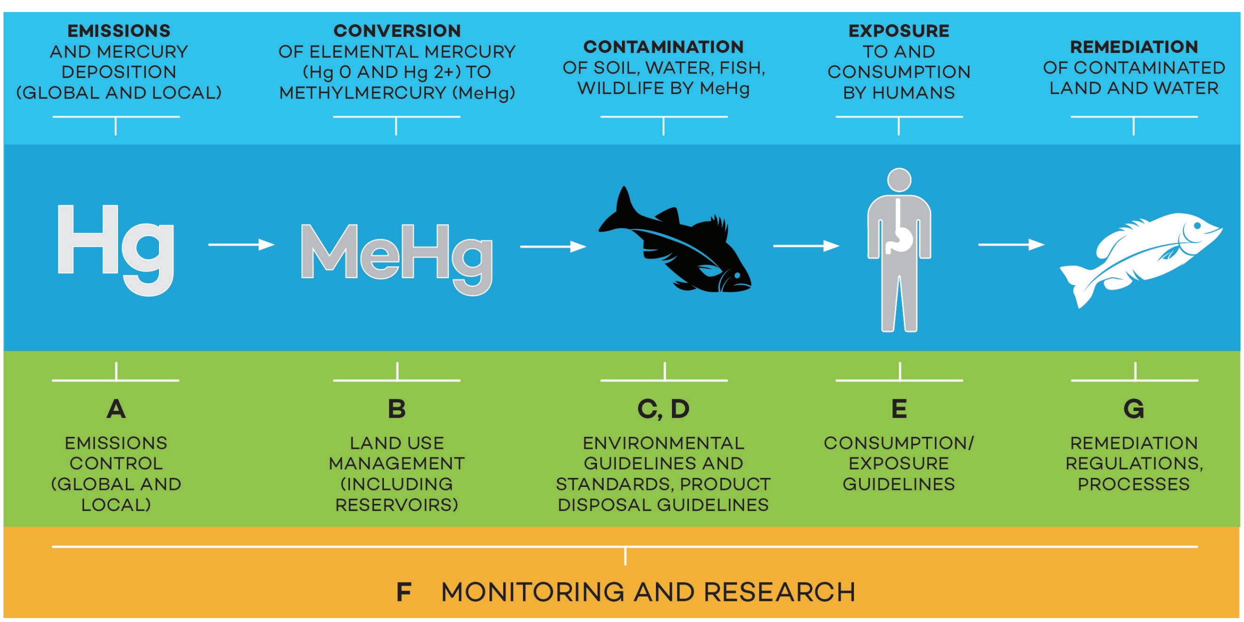


**Figure 3.** Mercury cycle and relevant points of management intervention

**D. Mercury-containing product management.** Management efforts include Bill 238 for developing a strategy for the safe disposal of mercury-containing lamps, the Canadian Environmental Protection Act, Ontario Dental Amalgam Waste Disposal Regulation and Ontario forest management practices.

**E. Consumption/exposure management.** This area of management includes Health Canada guidelines for mercury exposure as well as Ontario's fish consumption guidelines.

**F. Management targeted research.** This includes the Canadian Mercury Science Program, the Canadian Atmospheric Mercury Measurement Network, Canadian Air and Precipitation Monitoring Network, and Ontario Ministry of Natural Resources and Forestry.

**G. Remediation. Based** on commitments made in environmental impact assessments of industrial and other development. In Ontario, the provincial government has recently committed to remediate all industrial mercury contamination that continues to poison people at Grassy Narrows and Wabaseemong First Nations.

## 6.0 Managing Mercury: A Path Forward

Based on a review of the current state of knowledge on mercury and its management, as well as requirements under international conventions and commitments, Canada and Ontario are well placed to fulfill global and regional requirements on mercury management. Based on a comprehensive approach to mercury risk management, some priorities for future efforts, investment and direction on mercury management in Canada and in Ontario are provided below.

**Need for safe disposal of mercury waste from smelters:** Mercury emissions from smelters remain a risk, and there is a need to develop a means for safe disposal of mercury. Smelters process feedstocks that contain traces of mercury and may be used in the future to capture mercury to reduce further emissions. More stringent regulations, such as mercury transport under the Minamata and a shrinking market around mercury capture and disposal, necessitate long-term solutions for processes that mobilize naturally occurring mercury.

**Management of mercury from non-point sources:** A gap that is not covered under Minmata, Basel or other commitments is in the management of non-point sources of mercury such as from reservoirs and other flooded areas that release mercury as methylmercury into aquatic systems. As this toxic form is the one most prevalent in fish and bioaccumulates in human populations that are dependent on contaminated fish for their food, this source must be understood and addressed through land-use management.

**Remediation of contaminated sites:** Under the requirements of the Minamata convention, plans must be put in place for the remediation of contaminated sites. Implementation of these plans and effective monitoring of efforts to ensure that their remediation efforts are effective are clearly a priority moving forward to protect aquatic and human health in Canada.

**Research on mercury:** Based on science gaps identified in the recent Canadian assessment, ongoing research efforts need to focus on understanding mercury emissions, understanding impacts of climate change, and better understanding and characterization of mercury emissions and releases from natural and human processes such as forest fires, agricultural burning, waste burning, reservoir development etc., to create more effective management systems.

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