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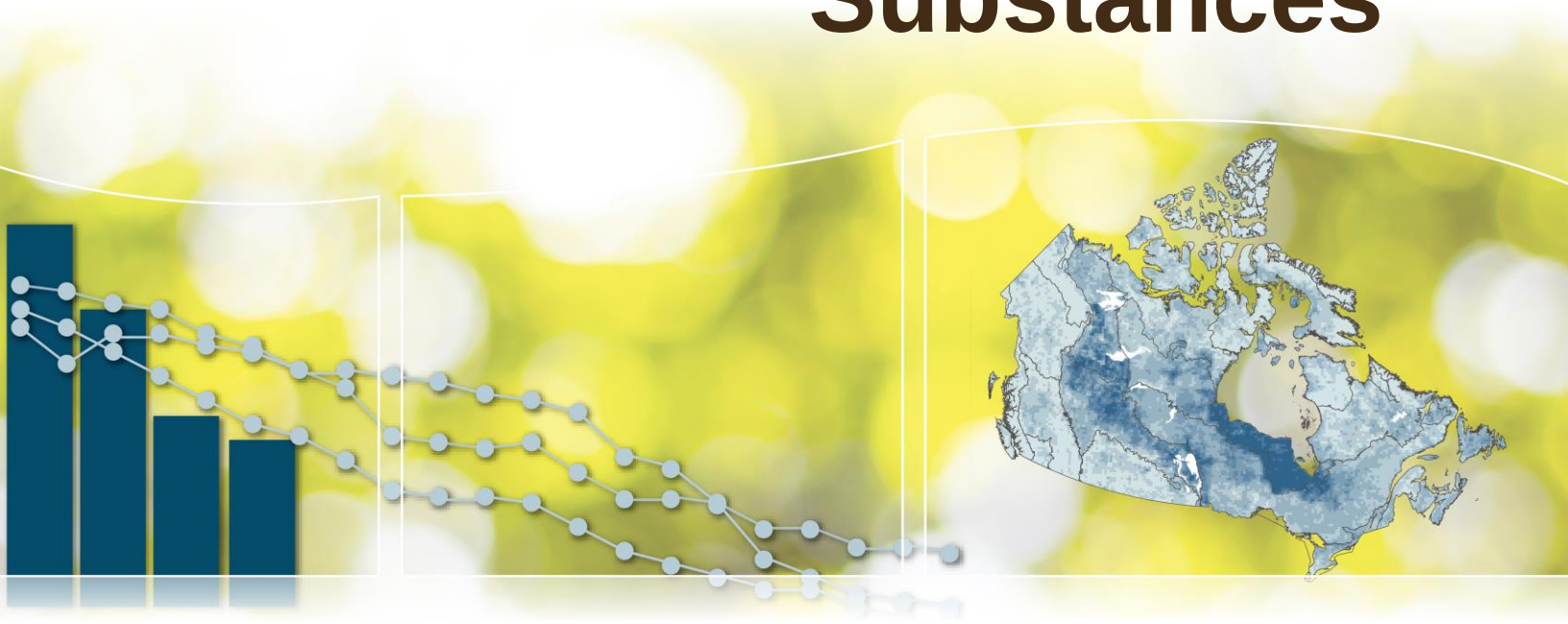
Canadian Environmental Sustainability Indicators

Levels of Human Exposure to Harmful Substances



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Canadian Environmental Sustainability Indicators

Levels of Human Exposure to Harmful Substances

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Part 1. Levels of Human Exposure to Harmful Substances Indicator

The Levels of Human Exposure to Harmful Substances indicator presents the concentrations of select environmental chemicals in the Canadian population from Cycle 1 (2007–2009), Cycle 2 (2009–2011) and Cycle 3 (2012–2013) of the Canadian Health Measures Survey (CHMS). The indicator includes cadmium, lead and mercury in blood and bisphenol A (BPA) in urine for participants aged 6 to 79 years, as well as the concentration of 2,2',4,4'-tetrabromodiphenyl ether (PBDE-47) and perfluorooctane sulfonate (PFOS) in blood plasma for participants aged 20 to 79 years. These results are important to monitoring chemical exposure and to track trends in Canadians over time.

The CHMS is a cross-sectional survey started in 2007 to address important data gaps and limitations in existing health information in Canada. Its principal objective is to collect national-level data on important indicators of Canadians' health status, including those pertaining to exposures to environmental chemicals. The CHMS examined 48 environmental chemicals in Cycle 3. The biomonitoring data aids the government in assessing human exposure to environmental chemicals and in developing policies to reduce exposure to toxic chemicals.

Some chemicals may be present and detectable in a person without causing an adverse health effect. Detection of a chemical indicates that an exposure has occurred. However, biomonitoring alone cannot predict the health effects, if any, that may result from exposures. Factors such as age, health status, the dose, the duration, frequency and timing of exposures, along with the toxicity of the chemical must be considered to predict whether adverse health effects may occur.

Table 1. Geometric mean concentrations of selected substances in blood, blood plasma or urine, Canada, 2007 to 2013

Survey years	Cadmium Blood (µg/L)	Lead Blood (µg/L)	Mercury Blood (µg/L)	BPA Urine (µg/L)	PBDE-47 Blood plasma (µg/L)	PFOS Blood plasma (µg/L)
2007–2009	0.34	13	0.69	1.2	0.06	8.9
2009–2011	0.31	12	0.71	1.2	n/a	6.9
2012–2013	0.34	11	0.81	1.1	n/a	n/a

Note: Mercury is shown as total mercury (organic and inorganic). Concentrations of total blood mercury differs between cycles in part due to changes in the limit of detection (LOD) from 0.1 µg/L in Cycle 1 and 2 to 0.4 µg/L in Cycle 3. The concentrations of cadmium, lead and mercury in blood and bisphenol A (BPA) are from participants aged 6 to 79 years, while the concentrations of 2,2',4,4'-tetrabromodiphenyl ether (PBDE-47) and perfluorooctane sulfonate (PFOS) in blood plasma are from participants aged 20 to 79 years. The selection of environmental chemicals varies between cycles. n/a means that the data is not currently available for those survey years and µg/L means microgram per litre. For more information, refer to the Data Sources and Methods section.
Source: For cadmium, lead, mercury and BPA: Health Canada (2015) Third Report on Human Biomonitoring of Environmental Chemicals in Canada: Results of the Canadian Health Measures Survey Cycle 3 (2012–2013). For PFOS: Health Canada (2013) Second Report on Human Biomonitoring of Environmental Chemicals: Results of the Canadian Health Measures Survey Cycle 2 (2009–2011). For PBDE-47: Health Canada (2010) Report on

Human Biomonitoring of Environmental Chemicals in Canada: Results of the Canadian Health Measures Survey Cycle 1 (2007–2009).

Biomonitoring cannot tell us the source, or route, of exposure. The amount of chemical measured in a person's blood, urine or blood plasma is representative of the total amount that is present in the body at a given time, from all sources (air, water, soil, food, and consumer products) and all routes of exposure (ingestion, inhalation, skin contact).

Cadmium: Cadmium is a naturally occurring metal used in batteries and in electroplating to protect other metals from corrosion. It may be emitted directly to air from human activities such as non-ferrous smelting and refining, and fuel consumption for electricity generation or heating. Inhalation of cigarette smoke is the major source of cadmium exposure in smokers. Non-smokers are primarily exposed to cadmium through food, although occupational exposure can also be a source. Other minor sources of exposure include drinking water, soil or dust, while other minor exposure pathways may include inhalation and releases from consumer products. Cadmium and its compounds have been classified as probably carcinogenic to humans by inhalation by Environment and Climate Change Canada and Health Canada. Inorganic cadmium compounds are listed on Schedule 1, List of Toxic Substances, under the *Canadian Environmental Protection Act, 1999* (CEPA 1999).

Lead: Lead is a naturally occurring element found in rock and soil. It is currently used in the refining and manufacturing of products such as lead acid car batteries, lead shot and fishing weights, sheet lead, solder, some brass and bronze products, pipes, paints (other than paints for use by children) and some ceramic glazes. Exposure to trace amounts of lead occurs through soil, household dust, food, drinking water, and air, due to lead's natural abundance in the environment and its widespread use for much of the twentieth century. Lead exposure in Canada has decreased substantially since the early 1970s, mainly because leaded gasoline was phased out; the use of lead in consumer paints and other coatings on children's products have been restricted by regulations; and the use of lead solder in food cans was eliminated. Current potential sources of lead exposure may include ingestion of chips from lead-based paints on interior and exterior surfaces of older buildings; ingestion of lead-contaminated household dust; ingestion of water from drinking water distribution systems containing lead pipes, lead plumbing fittings, or lead-based solder; ingestion of food grown in areas with high levels of lead in air, water or soil (e.g., near base metal smelters, combustion sources or roads, or in cities); use of ceramic or glass foodware with lead-containing glazes; and mouthing of consumer products containing lead. Housing renovations and hobbies, including stained-glass making, can also increase exposure to lead. Lead is considered a cumulative general poison. Very high exposure may result in vomiting, diarrhea, convulsions, coma and death. Chronic exposure to relatively low levels may affect the central and peripheral nervous systems, blood pressure, renal functioning and result in reproductive problems and developmental neurotoxicity. Lead is listed on Schedule 1, List of Toxic Substances, under CEPA 1999.

Mercury: Mercury is a naturally occurring metal but is widespread in the environment due to many industrial processes (e.g., chemical manufacturing operations and coal combustion). The general population is exposed to primarily methylmercury through consuming contaminated fish and seafood. To a much lesser extent, the general population is also exposed to inorganic mercury from sources such as dental amalgams and broken mercury-containing lamps. Mercury is toxic to humans. The human health effects depend on different factors, such as the form of mercury encountered, the amount, length of exposure and the age of the person. For example, oral exposure to organic mercury compounds can cause neurological effects and developmental neurotoxicity. The exposure of a fetus or young child to organic mercury can affect the development of the nervous system, including fine-motor function, attention, verbal learning and memory. Mercury is listed on Schedule 1, List of Toxic Substances, under CEPA 1999.

BPA: BPA is a synthetic chemical used in plastics, epoxy resins and thermal paper. The main route of exposure to BPA for the general public is through dietary intake through various sources, including food packaging and repeat-use plastic containers. Exposure can also occur from ambient and indoor air, drinking water, soil, and dust, and from the use of consumer products. BPA is toxic to human health and is listed on Schedule 1, List of Toxic Substances, under CEPA 1999.

PBDEs: PBDEs are a synthetic chemical used to produce fire retardants. The public may be exposed to PBDEs in food (mostly fish, dairy products and meat), drinking water, soil and air. Food represents the principal source of exposure to PBDEs for the majority of age groups. Health Canada concluded that exposure to PBDEs used in consumer products, via inhalation, dermal contact with dust, or oral contact with household products treated with flame retardants is negligible in comparison with intake from food. PBDEs have a harmful effect on the environment and polybrominated biphenyls are classified as a possible human carcinogen by the International Agency for Research on Cancer. PBDE-47 is listed on Schedule 1, List of Toxic Substances, under CEPA 1999.

PFOS: Perfluorinated compounds are produced for industrial and commercial uses, such as stain/water/oil-repellent fabric protectors, in water/oil-repellent paper coatings, wiper blades, bike chain lubricant, wire and cable insulation, pharmaceutical packaging, food packaging, engine oil additives, nail polish, hair-curling and straightening products, metal plating and cleaning, fire retardant foams, inks and varnishes. For the general public, exposure is widespread through food, drinking water, consumer products, dust, soil and air. Generally, ingestion of food, drinking water and house dust are expected to be the main routes of exposure for adults in the general population whereas oral hand-to-mouth contact with consumer products, such as carpets, clothing and upholstery, is a significant contributor for infants, toddlers and children. No definitive links between exposure to these substances and human health effects have been established; however, adverse effects have been observed in animals, including developmental toxicity and carcinogenicity. PFOS is listed on Schedule 1, List of Toxic Substances, under CEPA 1999.

This indicator is used to measure progress towards Target 4.8: Chemical Management – Reduce risks to Canadians and impacts on the environment and human health posed by releases of harmful substances of the Federal Sustainable Development Strategy 2013–2016.

Part 2. Data Sources and Methods for the Levels of Human Exposure to Harmful Substances Indicator

Introduction

The Levels of Human Exposure to Harmful Substances indicator is part of the Canadian Environmental Sustainability Indicators (CESI) program, which provides data and information to track Canada's performance on key environmental sustainability issues. This indicator is also used to measure progress towards the goals and targets of the Federal Sustainable Development Strategy.

Description and rationale of the Levels of Human Exposure to Harmful Substances indicator

Description

The Levels of Human Exposure to Harmful Substances indicator presents the concentrations of select environmental chemicals in the Canadian population from Cycle 1 (2007–2009), Cycle 2 (2009–2011), and Cycle 3 (2012–2013) of the Canadian Health Measures Survey (CHMS). The indicator includes cadmium, lead and mercury in blood and bisphenol A (BPA) in urine for participants aged 6 to 79 years, as well as the concentration of 2,2',4,4'-tetrabromodiphenyl ether (PBDE-47) and perfluorooctane sulfonate (PFOS) in blood plasma for participants aged 20 to 79 years. These results are important to monitoring chemical exposure and to track trends in Canadians over time.

Rationale

Chemical substances are everywhere – in air, soil, water, products and food – and can enter the body through ingestion, inhalation, and skin contact. The Government of Canada uses a variety of methods, tools and models to assess human exposure to environmental chemicals and the potential effects this exposure may have on health. Human exposure to chemicals can be estimated indirectly by measuring chemicals in the environment, food or products, or directly using biomonitoring.

Biomonitoring is the measurement of a chemical; the products it makes after it has broken down; or the products that might result from interactions in the body. These measurements are usually taken in blood, blood plasma and urine, and sometimes in other tissues and fluids such as hair, fingernails, toenails and breast milk. The measurements show how much of a chemical or its elements are present in that person at a given time.

The Levels of Human Exposure to Harmful Substances indicator uses human biomonitoring data on environmental chemicals collected in the biomonitoring component of the CHMS. The biomonitoring component, developed by Health Canada, assesses the exposure to environmental chemicals and helps to develop and assess the effectiveness of policies to reduce exposure to chemicals for the protection of the health of Canadians.

Recent changes to the indicator

Bisphenol A (BPA) was added to the indicator because data was available from all three cycles of the CHMS.

Data

Data source

The data used to establish the Levels of Human Exposure to Harmful Substances indicator are from Health Canada's Report on Human Biomonitoring of Environmental Chemicals in Canada: Results of the Canadian Health Measures Survey Cycle 1 (2007–2009), the Second Report on Human Biomonitoring of Environmental Chemicals in Canada: Results of the Canadian Health Measures Survey Cycle 2 (2009–2011) and the Third Report on Human Biomonitoring of Environmental Chemicals in Canada: Results of the Canadian Health Measures Survey Cycle 3 (2012–2013). These reports present nationally representative data on concentrations of environmental chemicals in Canadians. The data were collected as part of Cycles 1, 2 and 3 of the Canadian Health Measures Survey (CHMS). Statistics Canada, in partnership with Health Canada and the Public Health Agency of Canada, launched the CHMS to collect health and wellness data as well as biological specimens, from a nationally representative sample of Canadians. In Cycle 1, data were collected between March 2007 and February 2009 from approximately 5600 Canadians aged 6 to 79 years. For Cycle 2, data were collected between August 2009 and November 2011 from approximately 6400 Canadians aged 3 to 79 years. Data for Cycle 3 were collected between January 2012 and December 2013 from approximately 5800 Canadians aged 3 to 79 years. Although data were collected on children as young as three years of age in Cycle 2 and Cycle 3 of the survey, the indicator only includes data from people aged six and older.

Spatial coverage

The indicator includes nationally representative data collected in Cycle 1, 2 and 3 of the CHMS. In Cycle 1, data were collected at 15 sites across Canada (Moncton, Québec, Montréal, Montérégie, South Mauricie, Clarington, North York, Don Valley, St. Catherines-Niagara, Kitchener-Waterloo, Northumberland County, Edmonton, Red Deer, Vancouver and William Lakes & Quesnel). In Cycle 2, data were collected at 18 sites across Canada (St. John's, Colchester and Pictou Counties, Laval, South Montérégie, Gaspésie, North Shore Montréal, Central and East Ottawa, South of Brantford, Southwest Toronto, East Toronto, Kingston, Oakville, Edmonton, Winnipeg, Calgary, Richmond, Central and East Kootenay, Coquitlam). In Cycle 3, data were collected at 16 sites across Canada (Kent County, Halifax, South-central Laurentians, Southwest Montérégie, East Montréal, West Montréal, Brampton, Brantford-Brant County, Orillia, Oshawa-Whitby, North Toronto, Windsor, Southwest Calgary, Lethbridge, Victoria-Saanich and Vancouver).

Temporal coverage

The indicator includes data collected in Cycle 1, 2 and 3 of the CHMS. In Cycle 1, data were collected between March 2007 and February 2009. In Cycle 2, data were collected between August 2009 and November 2011. In Cycle 3, data were collected between January 2012 and December 2013.

Data completeness

The data collected by the CHMS is representative of approximately 96% of the Canadian population aged 6 to 79 years (Cycle 1) and 3 to 79 years (Cycle 2 and Cycle 3). The CHMS design does not target specific exposure scenarios, meaning that participants are not selected or excluded on the basis of their potential for low or high exposures to environmental chemicals.

Data timeliness

Data for the CHMS are collected over a two year period and analysts require approximately an additional 18 months for data interpretation, quality control, and verification.

Methods

The biomonitoring data were collected as part of Cycle 1, 2 and 3 of the Canadian Health Measures Survey (CHMS), measuring select environmental chemicals in blood, blood plasma and urine of survey participants. For each substance, the geometric mean was used because it is less influenced by extreme values and provides a better estimate of central tendency. This type of mean is commonly used with biomonitoring data.

The following tables provide a summary of data characteristics for selected chemicals by survey cycle.

Table 2. Concentrations of selected substances in blood, urine or plasma from the Canadian Health Measures Survey Cycle 1 (2007–2009)

Chemicals	Sample size	Percentage of results that fall below the limit of detection	Geometric mean (µg/L)	95% confidence interval (µg/L)
Cadmium	5319	2.91	0.34	0.31–0.37
Lead	5319	0.02	13	12–14
Mercury	5319	11.64	0.69	0.55–0.86
Bisphenol A	5476	9.26	1.2	1.1–1.3
2,2',4,4'-tetrabromodiphenyl ether	1668	25.24	0.06	0.05–0.07
Perfluorooctane sulfonate	2880	0.14	8.9	8.0–9.8

Note: The concentrations of cadmium, lead and mercury in blood and bisphenol A (BPA) in urine were from participants in the Canadian Health Measures Survey (CHMS) aged 6 to 79 years, while the concentrations of 2,2',4,4'-tetrabromodiphenyl ether (PBDE-47) and perfluorooctane sulfonate (PFOS) in blood plasma were from participants aged 20 to 79 years. Mercury is shown as total mercury (organic and inorganic). Geometric mean calculated at the 95% confidence interval (CI). µg/L means microgram per litre. There may be variations between cycles in reporting limits and analytical methods, which may impact data comparisons.
Source: For cadmium, lead, mercury and BPA: Health Canada (2015) Third Report on Human Biomonitoring of Environmental Chemicals in Canada: Results of the Canadian Health Measures Survey Cycle 3 (2012–2013). For PFOS: Health Canada (2013) Second Report on Human Biomonitoring of Environmental Chemicals: Results of the Canadian Health Measures Survey Cycle 2 (2009–2011). For PBDE-47: Health Canada (2010) Report on Human Biomonitoring of Environmental Chemicals in Canada: Results of the Canadian Health Measures Survey Cycle 1 (2007–2009).

Table 3. Concentrations of selected substances in blood, urine or plasma from the Canadian Health Measures Survey Cycle 2 (2009–2011)

Chemicals	Sample size	Percentage of results that fall below the limit of detection	Geometric mean (µg/L)	95% confidence interval (µg/L)
Cadmium	5575	4.27	0.30	0.27–0.33
Lead	5575	0	12	11–13
Mercury	5575	14.28	0.71	0.57–0.89
Bisphenol A	2036	5.26	1.2	1.0–1.2
2,2',4,4'-tetrabromodiphenyl ether	n/a	n/a	n/a	n/a
Perfluorooctane sulfonate	1017	0.39	6.9	6.2–7.6

Note: The concentrations of cadmium, lead and mercury in blood and bisphenol A (BPA) in urine were from participants in the Canadian Health Measures Survey (CHMS) aged 6 to 79 years, while the concentration of perfluorooctane sulfonate (PFOS) in blood plasma was from participants aged 20 to 79 years. Mercury is shown as total mercury (organic and inorganic). Geometric mean calculated at the 95% confidence interval (CI). n/a means that the number is not currently available from the survey. The environmental chemicals vary between surveys but may reappear in future cycles. µg/L means microgram per litre. There may be variations between cycles in reporting limits and analytical methods, which may impact data comparisons.
Source: For cadmium, lead, mercury and BPA: Health Canada (2015) Third Report on Human Biomonitoring of Environmental Chemicals in Canada: Results of the Canadian Health Measures Survey Cycle 3 (2012–2013).
For PFOS: Health Canada (2013) Second Report on Human Biomonitoring of Environmental Chemicals: Results of the Canadian Health Measures Survey Cycle 2 (2009–2011).

Table 4. Concentrations of selected substances in blood or urine from the Canadian Health Measures Survey Cycle 3 (2012–2013)

Chemicals	Sample size	Percentage of results that fall below the limit of detection	Geometric mean (µg/L)	95% confidence interval (µg/L)
Cadmium	5067	8.51	0.34	0.31–0.37
Lead	5067	0.10	11	10–12
Mercury	5067	34.93	0.81	0.65–1.0
Bisphenol A	5149	8.0	1.1	1.0–1.2
2,2',4,4'-tetrabromodiphenyl ether	n/a	n/a	n/a	n/a
Perfluorooctane sulfonate	n/a	n/a	n/a	n/a

Note: The concentrations of cadmium, lead and mercury in blood and bisphenol A (BPA) in urine were from participants in the Canadian Health Measures Survey (CHMS) aged 6 to 79 years. Mercury is shown as total

mercury (organic and inorganic). Geometric mean calculated at the 95% confidence interval (CI). n/a means that the number is not currently available from the survey. The environmental chemicals vary between surveys but may reappear in future cycles. µg/L means microgram per litre. There may be variations between cycles in reporting limits and analytical methods, which may impact data comparisons.
Source: Health Canada (2015) Third Report on Human Biomonitoring of Environmental Chemicals in Canada: Results of the Canadian Health Measures Survey Cycle 3 (2012–2013).

Further information on survey methodology can be obtained by consulting Health Canada's Report on Human Biomonitoring of Environmental Chemicals in Canada: Results of the Canadian Health Measures Survey Cycle 1 (2007–2009), the Second Report on Human Biomonitoring of Environmental Chemicals in Canada: Results of the Canadian Health Measures Survey Cycle 2 (2009–2011), and the Third Report on Human Biomonitoring of Environmental Chemicals in Canada: Results of the Canadian Health Measures Survey Cycle 3 (2012–2013), which detail survey design, fieldwork, laboratory analysis and statistical data analysis.

Caveats and limitations

The Canadian Health Measures Survey (CHMS) was designed to provide national level estimates and does not permit further breakdown of data by collection site. In addition, the CHMS design did not target specific exposure scenarios, and consequently did not select or exclude participants on the basis of their potential for low or high exposures to environmental chemicals.

People living on reserves or in other Aboriginal settlements in the provinces, residents of institutions, full-time members of the Canadian Forces, people living in certain remote areas, and people living in areas with a low population density were excluded.

While not every province and territory in Canada had a collection site, the CHMS sites were chosen to represent the Canadian population, east to west, including larger and smaller population densities. Regardless, the CHMS is representative of approximately 96% of the Canadian population aged 6 to 79 years (Cycle 1) and 3 to 79 years (Cycle 2 and Cycle 3) for certain substances. The results highlighted by the Levels of Human Exposure to Harmful Substances indicator for cadmium, lead, mercury and bisphenol A (BPA) are for those aged 6 to 79 years, though participants in Cycles 2 and 3 were as young as three years of age for those substances.

Annex A. References and additional information

References and further reading

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Related information

Air Pollutant Emissions

Canadian Health Measures Survey

Perfluorooctane Sulfonate (PFOS) in Fish and Water

Polybrominated Diphenyl Ethers (PBDEs) in Fish and Sediment

Releases of Harmful Substances to the Environment

www.ec.gc.ca

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