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Data Sources and Methods for the Polybrominated Diphenyl Ethers (PBDEs) in Fish and Sediment indicators

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1 Introduction

The Polybrominated Diphenyl Ethers (PBDEs) in Fish and Sediment indicators (www.ec.gc.ca/indicateurs-indicators/default.asp?lang=en&n=0970C75C-1) are part of the Canadian Environmental Sustainability Indicators (CESI) program (www.ec.gc.ca/indicateurs-indicators/default.asp?lang=En&n=47F48106-1), which provides data and information to track Canada's performance on key environmental sustainability issues. These indicators are also used to measure progress towards the goals and targets of the Federal Sustainable Development Strategy (www.ec.gc.ca/dd-sd/default.asp?lang=En&n=CD30F295-1).

2 Description and rationale of the Polybrominated Diphenyl Ethers (PBDEs) in Fish and Sediment indicators

2.1 Description

The PBDEs in Fish and Sediment indicators identify the drainage regions where concentrations are within or have exceeded the Federal Environmental Quality Guidelines (FEQGs) (www.ec.gc.ca/ese-ees/default.asp?lang=En&n=05DF7A37-1) for PBDEs in fish and sediment. The FEQGs were developed under the Chemicals Management Plan (CMP) (www.chemicalsubstanceschimiques.gc.ca/plan/index-eng.php) and are used in various ways. In this report they are used to evaluate the significance of monitoring data.

PBDEs are a group of chemicals containing 209 compounds. They are classified into 10 subgroups known as homologues, based on the number of bromine atoms they contain. Four of the 10 subgroups are considered for the indicators of PBDEs in fish, and six in sediment.

Table 1: Polybrominated diphenyl ether (PBDE) subgroups

Subgroup	Chemical group name	Fish	Sediment
triBDE	tribromodiphenyl ether	X	X
tetraBDE	tetrabromodiphenyl ether	X	X
pentaBDE	pentabromodiphenyl ether	X	X
hexaBDE	hexabromodiphenyl ether	X	X
octaBDE	octabromodiphenyl ether		X
decaBDE	decabromodiphenyl ether		X

2.2 Rationale

These and other indicators in the CESI program (www.ec.gc.ca/indicateurs-indicators/default.asp?lang=En&n=47F48106-1) track environmental levels of toxic substances released by human activity. These indicators provide information on the presence in the environment of key pollutants that have been listed as toxic, and on the progress of strategies and policies to reduce or control their occurrence in the environment.

PBDEs are commonly used as additive flame retardants, in that they are physically combined with the materials being treated for flame resistance. Since PBDEs are not chemically linked in the products for which they are used, they are slowly and consistently released throughout the production, use and disposal stages of the products.

Due to the bioaccumulative characteristics of the tetraBDE, pentaBDE and hexaBDE homologues, and because PBDEs generally end up in soil and sediment, they can bioaccumulate over time in certain organisms such as soil microbes and invertebrates. In addition, tetraBDE, pentaBDE and hexaBDE have a propensity to biomagnify through food webs. As a result, certain PBDEs can attain high concentrations in and cause harm to animals at the top of food webs, such as predatory fish, birds and mammals.

The PBDEs that were assessed have been declared by the Government of Canada to be "toxic," as defined under the *Canadian Environmental Protection Act, 1999* (CEPA 1999). As a result, the

Government has developed a Risk Management Strategy for PBDEs (www.ec.gc.ca/toxiques-toxics/Default.asp?lang=En&n=98E80CC6-1&xml=5046470B-2D3C-48B4-9E46-735B7820A444), with the objective of minimizing their release into the Canadian environment. Among the PBDE subgroups that were assessed, tetraBDE, pentaBDE and hexaBDE were found to meet the criteria for virtual elimination (www.ec.gc.ca/toxiques-toxics/default.asp?lang=En&n=2A3F2768-1) under CEPA 1999.

PBDEs found in the Canadian environment are not only from domestic sources but also from foreign sources. This is due to PBDEs being suspended in air and transported over long distances. As such, Canada is engaged in two international agreements that restrict and ultimately target the elimination of the production, use, trade, release and storage of PBDEs; the Stockholm Convention on Persistent Organic Pollutants (chm.pops.int/default.aspx) and the Protocol on Persistent Organic Pollutants of the United Nations Convention on Long-range Transboundary Air Pollution (www.unece.org/env/lrtap/pops_h1.html). Canada is also a party to the Rotterdam Convention, an international agreement that obligates parties to apply the prior informed consent procedure for international trade of certain PBDEs. The objective of these international agreements is to protect human health and the environment.

2.3 Recent changes to the indicator

No methodological change has been made to the indicator since its inception in 2012.

3 Data

3.1 Data source

The PBDEs environmental concentration data were obtained from Environment Canada's CMP Monitoring and Surveillance program.

The FEQGs were developed under the CMP, and were used to evaluate the significance of monitoring data. Measured concentrations exceeding the guideline levels indicate the potential for aquatic organisms to be affected by PBDEs in those locations.

Table 2: Federal Environmental Quality Guidelines (FEQGs) for polybrominated diphenyl ethers (PBDEs)

PBDE subgroups ^[A]	FEQG for fish tissues (nanograms per gram wet weight)	FEQG for sediment ^[B] (nanograms per gram dry weight)
triBDE	120	44
tetraBDE	88	39
pentaBDE	1	0.4
hexaBDE	420	440
octaBDE	-	5700 ^[C]
decaBDE	-	19 ^{[C],[D]}

Note: Not all of the FEQGs are shown in this table; only the ones required for the indicators are shown.

^A FEQGs for triBDE, tetraBDE, hexaBDE and decaBDE are based on data for BDE-28, BDE-47, BDE-153 and BDE-209, respectively, unless otherwise noted. Congener-specific FEQGs exist for BDE-99 and BDE-100.

^B Values normalized to 1% organic carbon.

^C Values adopted from the Ecological Screening Assessment Report (SAR) (www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=EE479482-1&wsdoc=09F567A7-B1EE-1FEE-73DB-8AE6C1EB7658). Sediment guidelines for octa- and deca-BDE were adapted from the SAR by being corrected for the sediment organic carbon in the actual tests, and then normalized to 1% organic carbon instead of the 4% in the SAR.

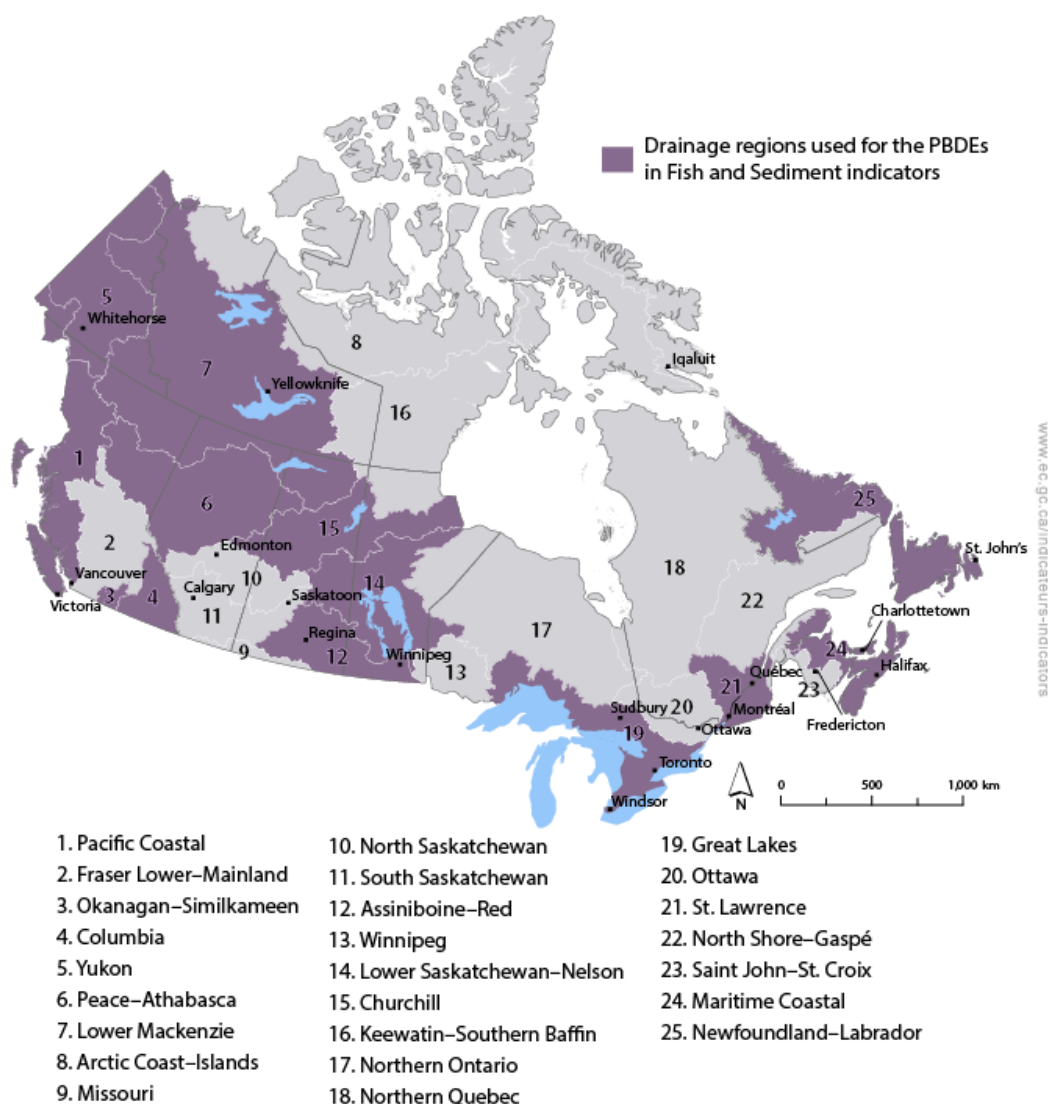
^D Based on a mixture of decaBDE with some nonaBDE.

Source: Environment Canada (2012) Polybrominated Diphenyl Ethers in the Canadian Environment. Available from: publications.gc.ca/site/eng/407109/publication.html.

3.2 Spatial coverage

The PBDEs in Fish and Sediment indicators use water drainage regions as a geographical unit for the calculation of the national indicators. These drainage regions correspond to those defined in Statistics Canada's Standard Drainage Area Classification (www.statcan.gc.ca/subjects-sujets/standard-norme/sdac-ctad/sdacinfo2-ctadinfo2-eng.htm). The drainage regions in Figure 1 outline the regions where sampling for PBDEs was conducted.

Figure 1: Geographic extent of the drainage regions used for the PBDEs in Fish and Sediment indicators



3.3 Temporal coverage

The latest two years of data, 2011 and 2012, were available for the PBDEs in fish indicator. For the PBDEs in sediment indicator, five years of data were available, 2009–2010 to 2013–2014. Data from the latest five years were used for the sediment indicators to get acceptable drainage region coverage. For the pentaBDE trends analysis in fish in Lake Ontario, data for the years 1997 to 2012 were used.

3.4 Data completeness

The sampling locations for fish and sediment varied throughout the reporting years. Data for fish and sediments were gathered in as many drainage regions as permitted by program capacity in any year. To provide a better representation of each drainage region, all the samples for all the recent available years, 2011–2012 for fish and 2009–2010 to 2013–2014 for sediment, were used to calculate the indicators.

3.5 Data timeliness

There is a time lag of one to two years between the sampling date and publication of the indicators. This time lag is due to the time required to perform the monitoring, compile the data, and validate (i.e., perform quality assurance and control), analyze, review and report on the indicators.

4 Methods

4.1 Indicators calculation

The PBDEs in Fish and Sediment indicators are presented by drainage regions showing whether or not FEQGs (www.ec.gc.ca/indicateurs-indicators/default.asp?lang=En&n=816059AD-1&offset=3&toc=show#table2) have been exceeded for PBDEs in fish and sediment.

Monitoring for PBDEs in fish was conducted in 10 drainage regions between 2011 and 2012, and in nine drainage regions for sediments between 2009 and 2014. Samples with PBDE concentrations above the guidelines are defined as an exceedance. Because PBDE guidelines are set by subgroup (PBDE homologue), the exceedances are presented by subgroup. For PBDEs in fish, sample measurements were conducted in representative predatory fish (Lake Trout, Walleye, Cutthroat Trout, Rainbow Trout or Brook Trout). For PBDEs in sediment samples consist of surface sediment. To summarize the PBDEs in Fish and Sediment indicators, drainage regions with at least one exceedance are categorized as a "drainage region with at least one sample above the guideline."

4.2 PBDE trends in fish from Lake Ontario

A retrospective analysis of PBDE concentrations in Lake Trout from Lake Ontario was completed using samples preserved in the National Aquatic Biological Specimen Bank (www.ec.gc.ca/inre-nwri/default.asp?lang=En&n=D488F7DE-1), in order to extend the monitoring timeline back to 1997. Annual average concentrations of PBDE homologues were determined in whole Lake Trout samples. Only the pentaBDE levels exceeded the FEQGs.

The annual geometric average for pentaBDE concentrations in Lake Trout from Lake Ontario (www.ec.gc.ca/indicateurs-indicators/default.asp?lang=en&n=0970C75C-1) is shown with a 95% confidence level. A statistically significant trend line is reported at the 95% confidence level. The trend curve line is $Y = 2.68209 \cdot 10^{40} \cdot e^{(-0.0448X)}$ and the correlation coefficient is $R^2 = 0.618$. This line shows a 4.5% annual decreasing trend for the concentration of pentaBDE in fish tissues for the period 1997–2012.

5 Caveats and limitations

Monitoring and surveillance of polybrominated diphenyl ethers (PBDEs) in lakes and rivers under the CMP (www.chemicalsubstanceschimiques.gc.ca/plan/index-eng.php) began in 2007 (except for Lake Ontario, which was initiated in the 1990s [retrospective study 1997–2012]). As monitoring is not necessarily performed at the same location each year, because of challenges in obtaining fish or sediment samples due to remoteness, staffing issues, shipping logistics and resource constraints, a comparison from one year to the next at the national level is not yet possible. To address this limitation, the PBDEs in Fish and Sediment indicators are estimated by

grouping the samples for all recent available years by drainage area (2011–2012 for PBDEs in fish and 2009–2014 in sediment).

6 References and further reading

6.1 References

Environment Canada (2010) Risk Management Strategy for Polybrominated Diphenyl Ethers (PBDEs). Retrieved in June 2014. Available from: www.ec.gc.ca/toxiques-toxics/Default.asp?lang=En&n=5046470B-1.

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Environment Canada (2012) Polybrominated Diphenyl Ethers in the Canadian Environment. Retrieved in June 2014. Available from: publications.gc.ca/site/eng/407109/publication.html.

6.2 Further reading

Environment Canada (2013) Polybrominated diphenyl ethers in the suspended matter and sediments of the St. Lawrence River. (PDF; 2.94 MB) Retrieved on 25 November, 2014. Available from: planstlaurent.qc.ca/fileadmin/site_documents/documents/SESL/PBDE_e.pdf.

McGoldrick DJ *et al.* (2010) Canada's national aquatic biological specimen bank and database. *Journal of Great Lakes Research* 36(2):393-398. Available from: www.sciencedirect.com/science/article/pii/S0380133010000407.

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