Monitoring the State of the
ST. LAWRENCE RIVER

Water quality in the Richelieu and Yamaska rivers

Contamination by toxic substances
Status: Poor for 2014-2019
Trend: Unchanged since 2001-2003

Highlights

Status: Over the 2014-2019 span of time, the general quality of the waters of the Richelieu River measured at the city of Sorel-Tracy, and the Yamaska River measured at the city of Saint-Hyacinthe, was poor. Median concentrations of PCBs and, in particular, the very high levels of PCDD/Fs in toxic equivalent, exceeded established criteria for the protection of fish-eating terrestrial wildlife.

Evolution: Concentrations of penta-BDE in the Richelieu for 2014-2019 dropped significantly, while in the Yamaska, concentrations of PCBs and penta-BDE were lower than in the preceding period. No significant changes were observed for the other indicators.

Problem

The Richelieu and Yamaska river basins are characterized by the presence of a number of active agro-food, chemical, metal transformation and plastics plants. Past or current industrial activity at these plants is likely to have discharged or currently discharge toxic substances into the environment, such as polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), polychlorinated dioxins and furans (PCDD/F) and polybrominated diphenyl ethers (PBDEs), including penta-BDEs.

PCBs are industrial chemicals that were used in the past to manufacture electrical products, heat exchangers and hydraulics systems and had a variety of other specialized applications until the late 1970s, when they were banned. Importing, manufacturing and selling PCBs (for re-use) were made illegal in Canada in 1977, while their discharge into the environment became illegal in 1985 (Government of Canada, 2017).

PBDEs are industrial chemicals that are added to a variety of plastic dies, synthetic resin

and textile fibres to reduce the flammability of a wide range of consumer products that include furniture stuffing, television and computer cases and auto parts. PBDEs were progressively banned between 2004 and 2013 (EC, 2013).

Environmental PAH comes from both natural and anthropic sources. In Canada, forest fires are the greatest natural source of PAH. By contrast, anthropic sources are many, and include aluminum refineries, home wood-burning for heating, petroleum product spills, metallurgical plants, coking plants, transportation, residual materials incineration, etc. (Environment Canada and Health Canada, 1994).

PCDD/Fs are subsidiary products from the combustion of various types of matter and the manufacture of chemical composites. Forest fires, wood incineration and combustion and the utilization of fossil fuels are all sources of dioxin and furan. In Canada, the largest source is the incineration of municipal and medical waste (Health Canada, 2004).

Study area

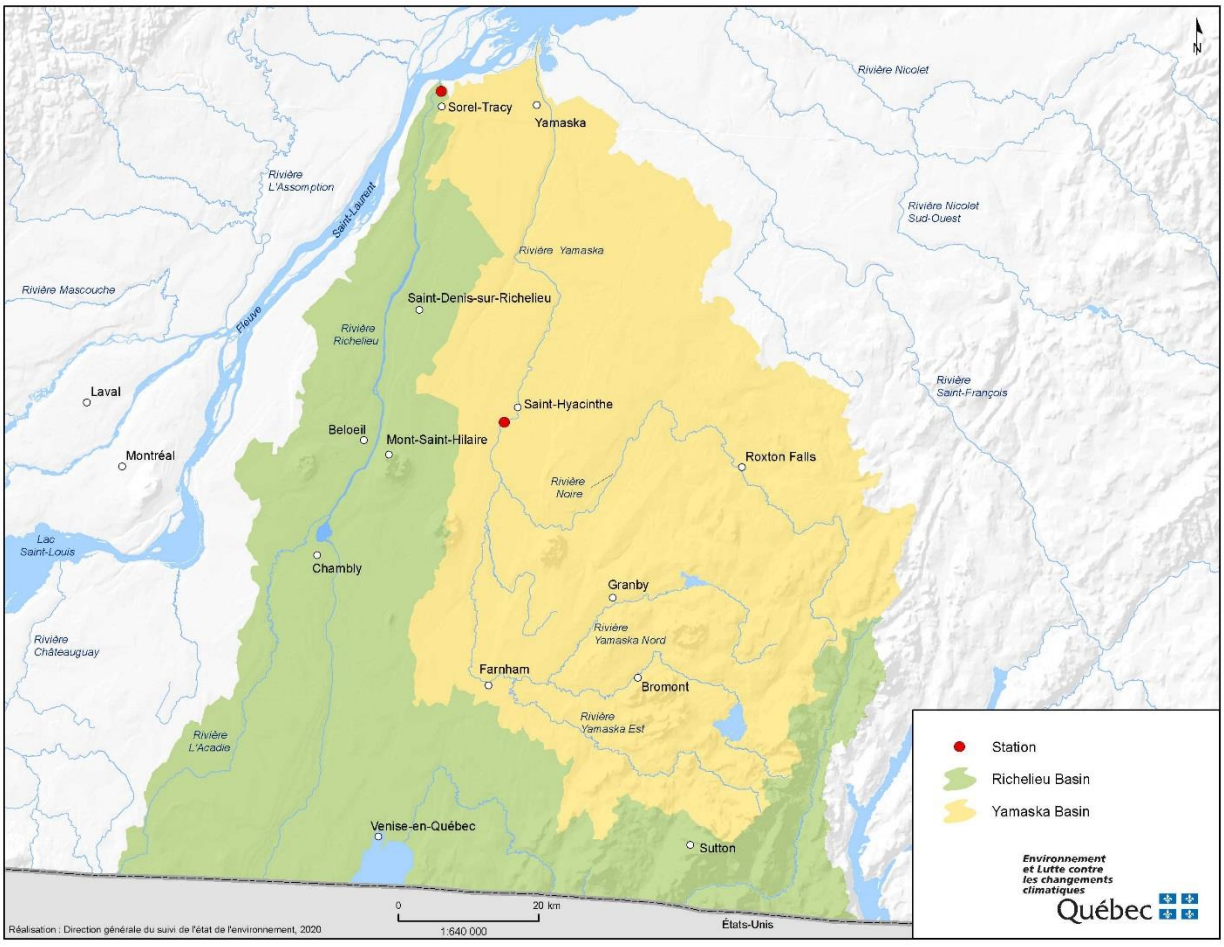

Figure 1 Richelieu and Yamaska river basins

The contiguous Richelieu and Yamaska river basins are located in the Centre-du-Québec administrative region, which has a high level of socioeconomic activity (Figure 1). With its 23,720 km^2 basin, the Richelieu is the largest tributary on the south shore of the St. Lawrence River. Rising in Lake Champlain (U.S.A.), the river flows northward and empties into the St. Lawrence at Sorel-Tracy. The main tributaries of the Richelieu in Québec are the Sud, Hurons, Lacolle and Acadie rivers. The Canadian part of the basin measures 3,855 km^2, which is about 16% of its total area.

The rivière Yamaska rises in lac Brome and empties into the St. Lawrence in lac Saint-Pierre. The total area of its basin is 4,784 km^2, with three main tributaries: the Noire, Yamaska Nord and Yamaska Sud-Est rivers.

Key measures

Monitoring results were compared to MELCC 2019 and EC 2013 surface water quality criteria using values established for the protection of the most vulnerable aquatic and terrestrial organisms. The PCB and PCDD/F values were established for protecting fish-eating land wildlife (CFTP) and, for penta-BDE, for protecting aquatic life (CVAC). As for PAH, the criterion for the prevention of water and aquatic organism contamination (CPCEO) was selected[1] for assessing the potential risk to terrestrial wildlife when no CFTP is present. All of the quality criteria were established on the basis of highly safe scenarios of risk-free levels for the most exposed and sensitive organisms (MELCC, 2019). Levels that are over and above these values do not necessarily imply that these organisms will be impacted, but rather that the water quality is not ideal and that the danger from fish contamination for fish-eating wildlife or indeed, for the fish, increases with the magnitude of the overage.

Quality indices for each substance are calculated by dividing the median measured concentration by its quality criterion. An index of greater than 1 indicates that the concentration exceeds the quality criterion and that the risk of environmental contamination from PCBs, PCDD/Fs and PAHs and/or the danger of penta-PBDEs affecting organisms rises as the index increases. Inversely, a value of less than 1 is an indication that the water quality is deemed good.

The overall state of the environment can be evaluated from the indicator, which is based on the sum of the quality indices for each group of substances, with indices < 1 considered to have a value of 0. The sum of the indices defines an overall water quality state of between good and poor.

[1]The list of 7 target PAH substances suspected of being carcinogenic to humans appears in MELCC, 2019. The criteria were established on the basis of 70-year exposure, and the approach is highly accurate when used for fish-eating terrestrial wildlife.

Status and trends

Table 1 Median, maximum and average concentrations of substances analyzed in the waters of the Richelieu River at Tracy, and the Yamaska River at Saint-Hyacinthe (2001-2019)

Period	Turbidity		Total PCB Quality criterion 120 pg/l (CFTP)				PAH with carcinogenic potential [3] Quality criterion 3.8 ng/l (CPCEO)			
	Median (UTN)	Maximum (UTN)	Median (pg/l)	Maximum (pg/l)	Average [1] (pg/l)	Index [2]	Median (ng/l)	Maximum (ng/l)	Average [1] (ng/l)	Index [2]
Richelieu										
2001-2003	13	61	354	1330	377 [a]	**3.0**	3.2	32	4.8	0.8
2004-2013	22	126	318	1095	348 [a]	**2.7**	6.0	21	5.7	**1.6**
2014-2019	19	89	271	634	295 [a]	**2.3**	6.4	15.6	6.3	**1.7**
Yamaska										
2001-2003	16	121	489	1714	456 [a]	**4.1**	5.7	57	5.7	**1.5**
2004-2013	15	162	431	2026	412 [a]	**3.6**	4.2	84	4.4	**1.1**
2014-2019	8	74	267	1050	293 [b]	**2.2**	3.2	19,4	5 [ab]	0.8
			Dioxins and furans in toxic equivalent (TEQ) [4] Quality criterion .003 pg/l (CFTP)				penta-BDE Quality criterion 200 pg/l (CVAC)			
			Median (pg/l)	Maximum (pg/l)	Average [1] (pg/l)	Index [2]	Median (pg/l)	Maximum (pg/l)	Average [1] (pg/l)	Index [2]
Richelieu										
2001-2003	13	61	0.059	0.619	0.066 [a]	**19.7**				
2004-2013	22	126	0.081	0.232	0.058 [a]	**27.0**	50	236	56 [a]	0.25
2014-2019	19	89	0.074	0.273	0.068 [a]	**24.7**	30	98	23 [b]	0.15
Yamaska										
2001-2003	16	121	0.085	0.639	0.097 [a]	**28.3**				
2004-2013	15	162	0.104	0.825	0.107 [a]	**34.7**	64	349	66 [a]	0.32
2014-2019	8	74	0.078	1.22	0.073 [a]	**26.0**	21	98	24 [b]	0.11

[1] Average concentration ajusted to 15 units of Nephelometric Turbidity (NTU). Same letter averages have no significant differences at the 0.05 threshold

[2] Index = median/quality criterion

[3] Benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, dibenzo(a,h) anthracene, indeno(1,2,3-cd)pyrene

[4] Dioxins et furans in toxic equivalents for 2,3,7,8-TCDD using WHO 2005 equivalence factors

Water contaminant trends

Between 2001 and 2019, the Ministère de l'Environnement et de la Lutte contre les Changements climatiques took 65 samples from the Richelieu at Sorel-Tracy, and 67 samples from the Yamaska at Saint-Hyacinthe using the ECSOTE automatic sampler described in Laliberté & Mercier, 2006. The samples were taken at 90-minute intervals, usually over two weeks, three times a year in spring, summer and autumn. In this study, the concentrations of the four groups of substances examined were correlated with water turbidity to take this latter factor into account. The turbidity value is a good indicator of suspended particulate matter in the water and correlates with the concentrations of the substances. Inasmuch as the substances that were studied are mostly adsorbed on the particulate, their concentrations vary as a function of the hydrological conditions and are in general, higher when flow increases due to rain or snowmelt. The value of 15 units of nephelometric turbidity (NTU) is close to the median of all measured turbidity values. It was used to compare the average concentrations of the substances, based on a covariance analysis using the turbidity as a covariate. The maximum values for turbidity in the Richelieu for 2001-2003, 2004-2013 and 2014-2019 were measured in March-April 2002 (61 NTU), 2005 (126 NTU) and 2017 (89 NTU), while for the Yamaska, they were measured in March-April 2001 (121 NTU), 2005 (162 NTU) and 2017 (74 NTU).

Polychlorinated biphenyl (PCB)

The median concentrations of PCBs in the Richelieu and Yamaska rivers for 2014-2019 exceeded the 120 pg/l criterion that was established for the protection of fish-eating terrestrial wildlife (CFTP), by an amplitude factor of 2.2. Almost all values for both rivers exceeded the CFTP quality criterion, meaning that wildlife whose principal source of food is fish could become exposed to non-negligible quantities of PCBs, given the bioaccumulation of these substances in the food chain. PCB concentrations for 2014-2019 decreased significantly with respect to earlier periods only in the case of the Yamaska (Table 1).

Results clearly showed that for the Richelieu, the concentrations of PCBs varied between 89 and 1330 pg/l for 2001-2003; 114 and 1095 pg/l for 2004-2013; and 130 and 634 pg/l for 2014-2019. With respect to the Yamaska, results showed that the concentrations of PCBs varied between 237 and 1714 pg/l for 2001-2003; 140 and 2026 pg/l for 2004-2013; and 180 and 1050 pg/l for 2014-2019 (Figure 2).

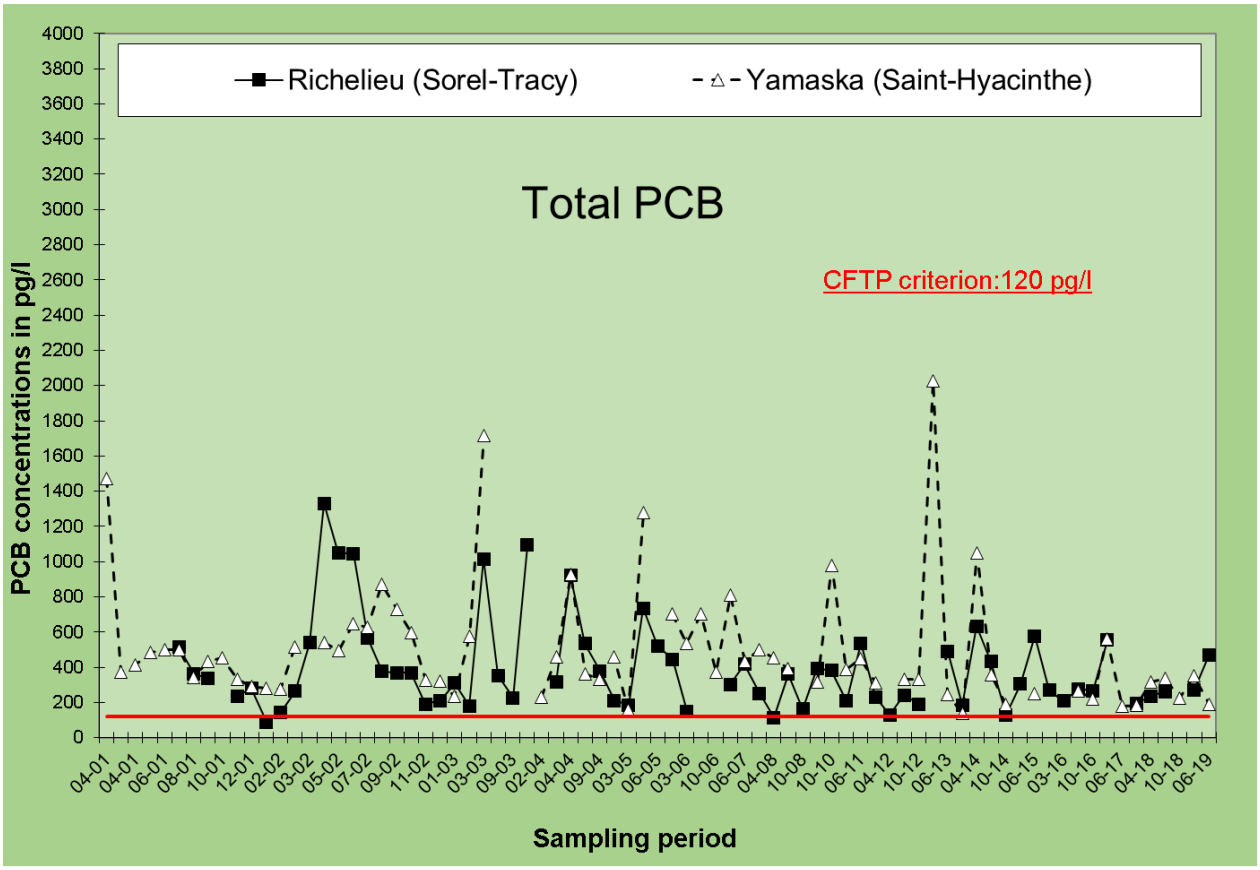

Figure 2 PCB concentrations in the waters of the Richelieu and Yamaska rivers (2001-2019)

Polycyclic aromatic hydrocarbons (PAHs)

For 2014-2019, the median concentrations of PAHs with carcinogenic potential in the Richelieu and Yamaska rivers reached respectively 1.7 and 0.8 times the value of the 3.8 ng/l criterion that was established for the prevention of the contamination of the water and its aquatic organisms (CPCEO) (Table 1). As such, when we consider all of the concentrations that were measured for 2014-2019 in the Richelieu, 62% exceeded the quality criterion, while for the Yamaska, this figure was 47%. PAH concentrations measured for 2014-2019 showed no significant reduction with respect to the earlier periods.

For the Richelieu, PAH concentrations varied between 1 and 32 ng/l for 2001-2003, 1.5 and 21 ng/l for 2004-2013 and 1.1 to 15.6 ng/l for 2014-2019. For the Yamaska, PAH concentrations varied between 3 and 57 ng/l for 2001-2003, 1 and 84 ng/l for 2004-2013, and 1 and 19.4 ng/l for 2014-2019 (Figure 3).

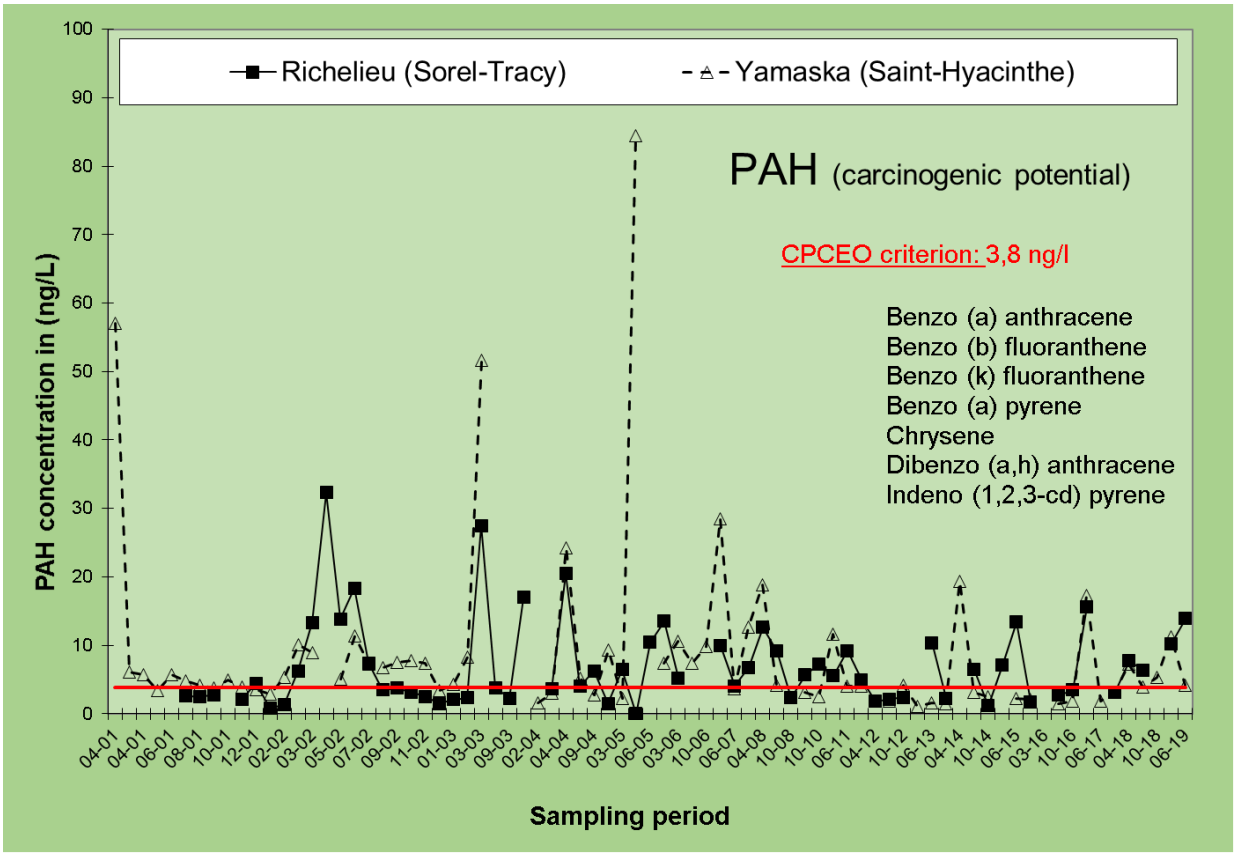

Figure 3 Concentrations of PAH deemed to have carcinogenic potential in the waters of the Richelieu and Yamaska rivers (2001-2019)

Polychlorinated dioxins and furans (PCDD/F)

For 2014-2019, median concentrations of 2,3,7,8-tetrachlorodibenzodioxin (2,3,7,8-TCDD) in toxic equivalent (TEQ) for both rivers exceeded the 0.003 pg/l criterion for the protection of fish-eating wildlife (CFTP) by a factor of 25 to 26 (Table 1). Such major levels of quality criterion overage for this group of substances deserve special attention since they cause the quality of water in both rivers to be deemed poor. Wildlife that mainly feeds on fish may as such become exposed to high quantities of dioxins and furans, given their bioaccumulation in the food chain. In both rivers, almost all concentration measured in toxic equivalent exceeded the CFTP toxic criterion. In comparison with 2001-2003, the data shows no water quality improvement for dioxins and furans in toxic equivalent.

For the Richelieu, 2,3,7,8-TCDD concentrations in toxic equivalent varied between 0.003 and 0.619 pg/l during the first period, 0.007 and 0.232 pg/l during the second and 0.010 and 0,273 pg/l during the third (Figure 4). For the Yamaska, 2,3,7,8-TCDD concentrations in toxic equivalent varied between 0.029 and 0.639 pg/l during the first period, 0.011 and 0.825 pg/l during the second and 0.009 and 1.22 pg/l during the third (Figure 4).

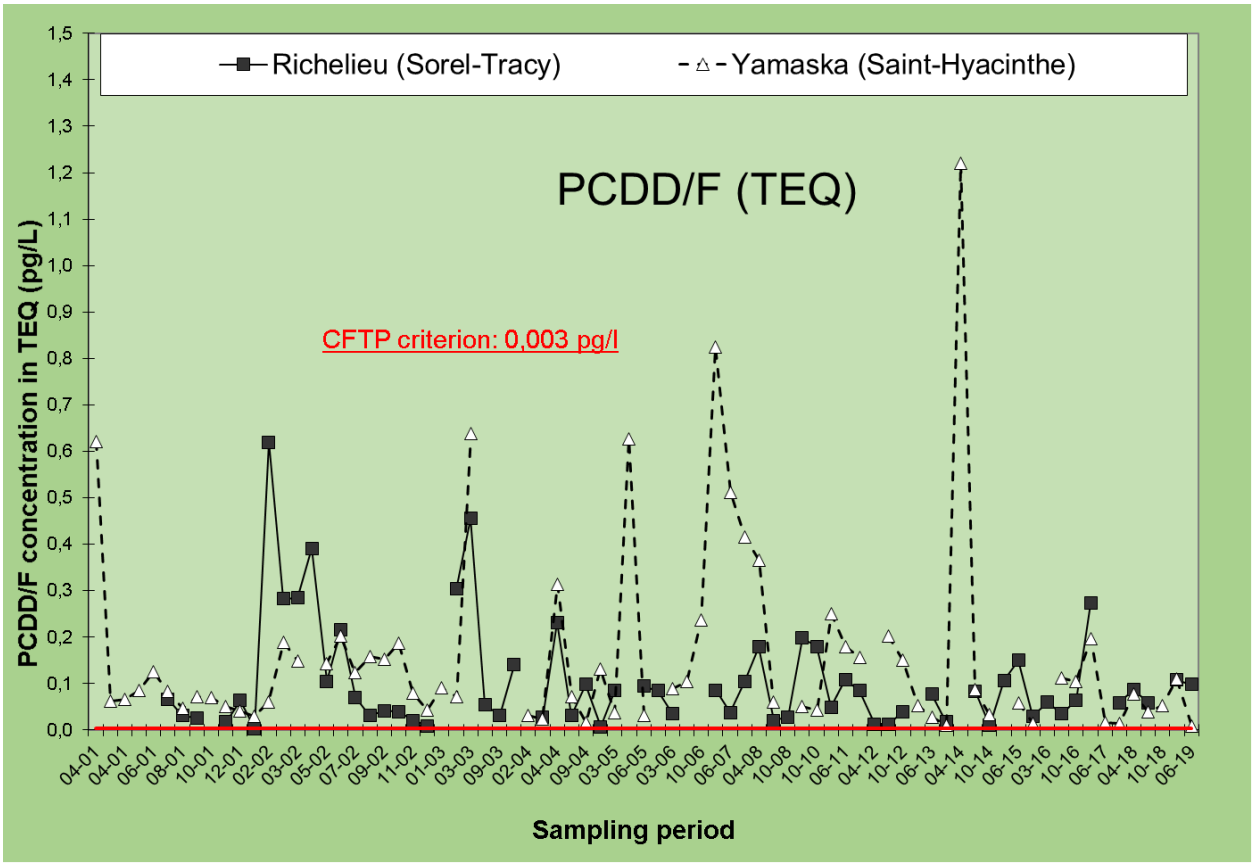

Figure 4 Concentrations of PCDD/F in toxic equivalent (TEQ) in the waters of the Richelieu and Yamaska rivers (2001-2019)

Polybrominated diphenyl ethers (PBDEs)

PBDE concentrations in the Richelieu and Yamaska were only examined for 2004-2013 and 2014-2019. The median concentrations of penta-BDE in both rivers for 2014-2019 were inferior to the penta-BDE criterion of 200 pg/l that was established for the protection of aquatic organisms (CVAC). Penta-BDE concentrations in both rivers significantly dropped between the two periods of time under study, confirming the efficiency of regulations that came into force in Canada as of June 2008 prohibiting the utilization, sale and import of commercial mixes containing congeners of tetra-BDE, penta-BDE and hexa-BDE (Environment Canada, 2013) (Table 1).

For the Richelieu, penta-BDE concentrations varied from 0 to 236 pg/l during the first period and 5 to 98 pg/l for the second. For the Yamaska, penta-BDE concentrations varied between 0 and 349 pg/l during the first period and 12 and 98 pg/l during the second (Figure 5).

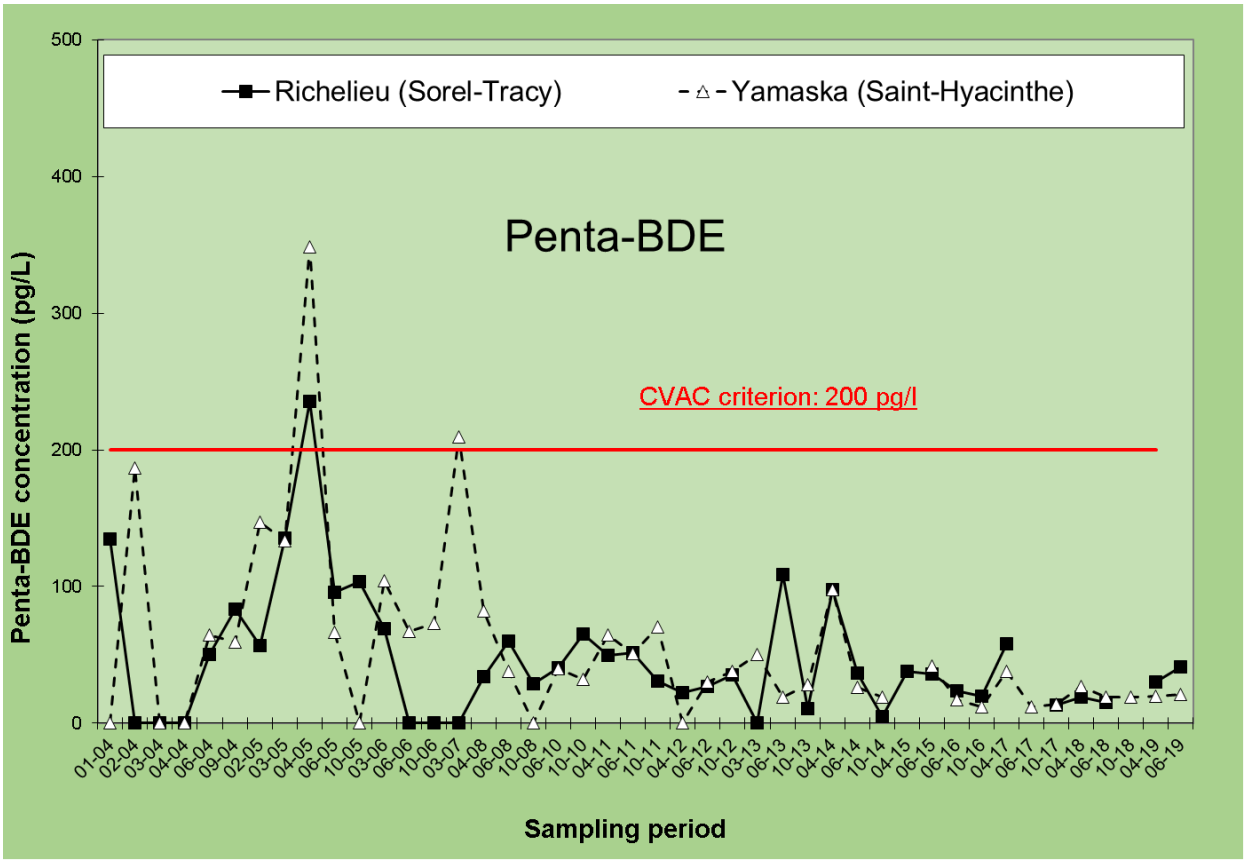

Figure 5 Penta-BDE concentrations in the waters of the Richelieu and Yamaska rivers (2004-2019)

Outlook

Future studies will examine these contaminants in the Richelieu and Yamaska rivers, thereby ensuring long-term contamination monitoring of the aquatic environment.

For more information

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State of the St. Lawrence Monitoring Program

Five government partners—Environment and Climate Change Canada; Fisheries and Oceans Canada; Parks Canada; the Ministère de l'Environnement et de la Lutte contre les changements climatiques du Québec; and the Ministère des Forêts, de la Faune et des Parcs du Québec—and Stratégies Saint-Laurent, a non-governmental organization that works actively with riverside communities, are pooling their expertise and efforts to provide Canadians with information on the state of the St. Lawrence and the long-term trends affecting it.

For more information about the State of the St. Lawrence Monitoring Program, please visit our website: http://planstlaurent.qc.ca/en/state_monitoring.html.

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