Monitoring the State of the ST.LAURENCE RIVER

WATER | SEDIMENTS | SHORELINES | BIOLOGICAL RESOURCES | USES

Water quality in the fluvial section

Contamination by Toxic Substances

Current status: Intermediate-good

According to recent analytical results on the water quality of the St. Lawrence River, concentrations of polybrominated diphenyl ethers (PBDE) are decreasing whereas pharmaceutical products and flame retardants such as Estradiol and polybrominated diphenyl ethers (PBDE) are detected at levels of concern.

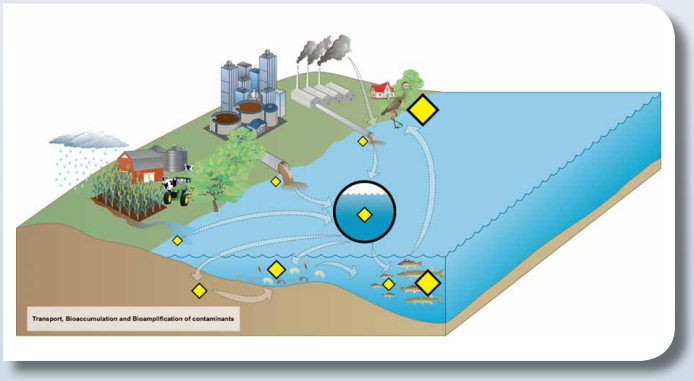

Figure 1: Conceptual diagram of transport, bioaccumulation and bioamplification of toxic contaminants in freshwaters

Urban development, industrial activities and farming have released a number of toxic substances into our watercourses over the last century. These inputs have contributed to degrading the water quality of the immense Great Lakes – St. Lawrence River Basin and have harmed some of the species it supports. Periodically, metals, nutrients, pesticides and emerging contaminants such as pharmaceuticals have been detected in the water at concentration levels that are cause for concern.

Four monitoring stations are used to assess the water quality status of the St. Lawrence River in terms of toxic substances by recording seasonal and interannual fluctuations and long-term concentration trends of several contaminants (Figure 2).

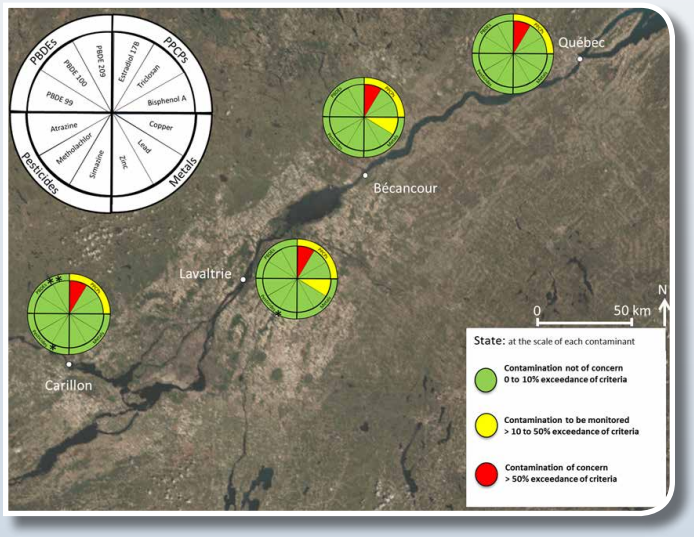

Figure 2: State of the contamination at the four principal sites: Carillon, Lavaltrie, Bécancour and Québec

The pie charts represent each contaminant assessed, and the four quadrants represent the contaminant groups.

* Pesticides have been measured at the Carillon station between 1995 and 1997 and at the Lavaltrie station between 2004 and 2006.

** PBDEs have been measured at Carillon between 2004 and 2006.

The station in the Quebec City region has been used as a reference station since 1995 because the tide brings the different upstream water masses together in the river here, thus combining sources of contamination. Since 2004, measurements have also been taken at Carillon, near the mouth of the Ottawa River. The Ottawa is the largest tributary of the St. Lawrence and its so-called "brown waters" flow along the St. Lawrence's north shore. These highly coloured waters are easily identified as far downstream as Trois-Rivières. Two additional stations were added in 2006 to cover other major water masses in the St. Lawrence: Lavaltrie, which is located in the brown-water mass along the north shore of the St. Lawrence, downstream of the municipal wastewater discharges from the Montreal urban area; and Bécancour which covers the water masses affected by the agricultural tributaries on the south shore of Lake Saint-Pierre.

DID YOU KNOW?

The source and quantity of a contaminant released in an ecosystem has a direct effect on its concentration in the aquatic environment. Hydrological phenomena like dilution, sedimentation and groundwater flow, which fluctuate with periods of high or low water, also influence variations in concentrations. Variations in the chemical composition of the river water near Quebec City therefore largely result from seasonal fluctuations in the waters entering from the Great Lakes and the tributaries of the St. Lawrence.

Status of water quality between 2006 and 2011

This fact sheet presents the results of analyses of metals; pesticides; pharmaceuticals and personal care products (PPCPs); and polybrominated diphenyl ethers (PBDEs) in samples taken at the four stations between 2006 and 2011. Given the high affinity of contaminants for suspended particulate matter and the differences in their behaviour in the dissolved and particulate phases, the two phases were analyzed separately in some cases. The use of the latest sampling and analysis techniques ensures the precision of the results for substances present at trace and ultra trace levels.

Table 1: Median concentrations of toxic contaminants at the four main fluvial stations and frequency of exceedance (%) of the criteria for the protection of aquatic life

Parameters	Median concentrations				Quality criteria (ng/L)
	Carillon	Lavaltrie	Bécancour	Quebec	
Metals					
Arsenic	420	455	780	660	5000
Cadmium	10	19	14	12	90
Copper	1210 (3%)	1930 (49%)	1810 (40%)	1400 (17%)	2000
Iron	58550	59500	28550	27600	300000
Nickel	770	1450	1765	1120	65000
Lead	190	475 (3%)	415 (3%)	281	2000
Zinc	1880 (3%)	5660	3250	2450	30000
Mercury	1.75	2.79	2.11	1.67	26
Pesticides					
Atrazine	ND	ND	28	32	1800
Metolachlor	ND	ND	9	6	7800
Simazine	ND	ND	4	4	10000
PBDE					
Tribromodiphenyl ethers (IUPAC #28)	ND	0.034	0.044	0.014	46
Tetrabromodiphenyl ethers (IUPAC #47)	ND	0.14	0.14	0.051	24
Pentabromodiphenyl ethers (IUPAC #99)	ND	0.081	0.025	0.02	4
Pentabromodiphenyl ethers (IUPAC #100)	ND	0.017	0.0069	0.0047	0.2
Hexabromodiphenyl ethers (IUPAC #153)	ND	0.012	0.01	0.0032	120
Decabromodiphenyl ethers (IUPAC #209)	ND	0.64	0.79	0.39	
PPCP and others					
Acetaminophen	ND	190	ND	87	
Ibuprofen	<6	50	14	14	
Estradiol- 17B	<1	<1 - 11	<1 - 1.3	<1 - 3	<1
Caffeine	27	495	115	130	
Triclosan (disinfectant)	<6	16	6	10	115
Bisphenol A (plastifier)	3	7.1	3.7	5.4	175

See the legend of the figure 2 for the meaning of the codes of color

Metals

In general, the measured metal concentrations lower than recognized water quality guidelines for the protection of aquatic life (Table 1). Observed exceedances were generally associated with high levels of suspended matter such as those during the spring freshet. For example, exceedances for copper were observed mainly in spring.

The sources of metals can be difficult to determine since these compounds are naturally present in all bodies of water. Only when metal concentrations exceed a certain level can we conclude that anthropogenic inputs are involved. Metal concentrations in the St. Lawrence are slightly higher at the Lavaltrie and Bécancour stations (Table 1). Increased metal concentrations in the brown waters between the Carillon and Lavaltrie stations could be associated with anthropogenic inputs from the Montreal and Laval urban area.

Water sampled at the Bécancour station is affected by metal inputs that probably originate from the tributaries on the south shore of Lake Saint-Pierre. These tributaries have high levels of suspended matter, with which metals are associated. The concentrations of metals adsorbed on suspended particles in the river are very close to the levels measured in the Earth's crust; consequently, the tributaries and particles from the eroding banks and bed of the river are thought to be the major sources of metal inputs to the St. Lawrence River (Rondeau et al., 2005).

Pesticides

The pesticides analyzed in the monitoring program were chosen based on their intensity of use in the St. Lawrence Lowlands. Widely applied herbicides such as atrazine and metolachlor, used especially on corn and soybean crops, were the pesticides most commonly detected in the St. Lawrence.

Pesticides are not monitored regularly in the brown waters of the Saint-Maurice and Ottawa rivers (Carillon and Lavaltrie stations). A previous study (Cossa et al., 1998) found a near-absence of these contaminants at the mouth of the Ottawa River which can be readily explained by lower agricultural land use in the major watersheds on the north shore of the St. Lawrence.

Pesticide concentrations measured in the other St. Lawrence water masses are very similar. Little variation was found in median concentrations from station to station and values did not exceed water quality guidelines for the protection of aquatic life (Table 1). However, strong seasonal variations were observed in the levels of these contaminants. At the Quebec City station (Figure 3), higher values were observed in summer (up to 100 ng/L), likely owing to the application of pesticides on crops in the St. Lawrence Lowlands. Mass balance calculations from sampling completed in 1995 and 1996 demonstrated the importance of Lake Ontario as a source of these herbicides (Pham et al., 2000). However, locally, Lake Saint-Pierre is vulnerable to pesticide contamination since major tributaries affected by intense farming activity empty into this riverine lake (Trudeau et al., 2010; Giroux et al., 2016).

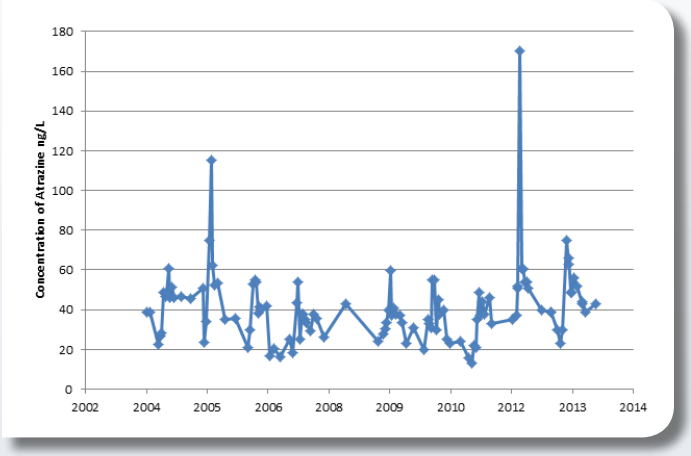

Figure 3: Variation of atrazine concentration at the Quebec station

Polybrominated diphenyl ethers (PBDEs)

These products are used as flame retardants in familiar items such as carpets, fabrics, computers and paint. PBDEs in these products can be emitted during manufacturing or use and after disposal, and then find their way into the environment through effluents or atmospheric deposition. Manufacturing, importation, usage and sale of commercial products pentaBDE and octaBDE have been banned in Canada since 2008.

Monitoring for the presence of PBDEs was carried out in the suspended particles of the St. Lawrence River at the Carillon, Lavaltrie, Bécancour and Quebec stations between 2006 and 2011 (Table 1). Median concentrations of six PBDE congeners detected in suspended matter in the St. Lawrence at a frequency greater than 50% are shown in Table 1. At each station, the median concentration of congener 209 was higher than the total concentrations of all other detected congeners combined. However, pentabromodiphenyl ethers (congeners 99 and 100), also commonly detected in the St. Lawrence, are recognized to be more toxic than congener 209. The highest concentrations of PBDEs are measured at the Lavaltrie station which appears to confirm the urban region of Montreal as a notable source. Nonetheless, the quality criteria have not been exceeded at this station. In addition, concentrations at this location have clearly decreased between 2007 and 2016 (Figure 4) which reflects the impact of regulation on these products.

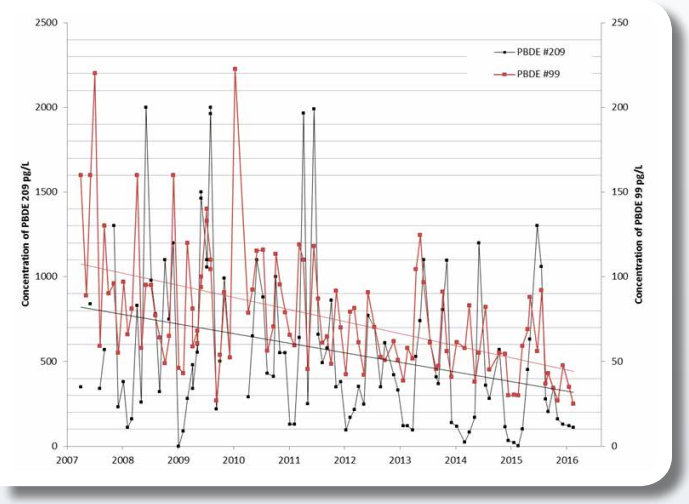

Figure 4: Trends in PBDE 209 and PBDE 99 concentrations at Lavaltrie between 2007 and 2016

Pharmaceuticals and personal care products (PPCPs)

Significant fractions of commonly used pharmaceuticals and personal care products (PPCPs) such as skin moisturizer, shampoo and toothpaste are transferred into the water when we take a shower or perform other personal hygiene activities. Other products, such as oral medications, are partially eliminated in human excreta and also end up in domestic wastewater. The industries producing these substances and the inappropriate disposal of unused products (e.g., medications flushed down the toilet) are also sources of PPCPs in municipal and industrial wastewater.

Municipal wastewater treatment facilities partially eliminate PPCPs from wastewater, but the degree of elimination depends on the substance and type of treatment. Consequently, fractions of these substances are found in the final effluent from treatment plants which discharge into receiving watercourses such as the St. Lawrence River. The highest concentrations were measured near the large urban centres in the Montreal region (Lavaltrie-station) and the Quebec City region (Quebec City station) (Table 1). Concentrations in the St. Lawrence are of the same order of magnitude as in other major rivers in the world (Berrymann et al., 2014). Few quality guidelines have been established for these substances (Table 1). However, detection of estrogen in the St. Lawrence River is of concern. Because the quality criterion for this product is lower than our analytical detection limit, it is not actually possible to make a statement on the risk to the aquatic life caused by this product. In addition, there is little information on the effects of combined products and degradation products which can be just as toxic as the parent products.

Outlook

Recent technological advances now make it possible to detect new and emerging substances of concern and monitoring and surveillance programs have been implemented to understand their chemical behaviour and fate in the aquatic environment. A number of these substances (surfactants, steroids, medications, hormones, etc.) are associated with endocrine system disruption in aquatic organisms. Information on the occurrence and sources of these compounds will contribute to improving water quality monitoring in the St. Lawrence. In addition, the flow of the St. Lawrence is an important factor affecting contaminant transport. Changes in the river's flow regime resulting from climate change or the control of water levels on the Great Lakes will have repercussions that must be documented.

Key variables

Water quality criteria

Water quality criteria are used as reference levels for assessing the health of aquatic ecosystems. They are values associated with a safe threshold by which a water use is protected from all possible deleterious effects. Among these criteria, the protection of aquatic life from chronic effects is defined as the highest concentration of a substance at which aquatic organisms (and their progeny) will suffer no harmful effects when exposed to it daily throughout their lifetimes. Any concentration in the environment that exceeds this criterion on a continuous basis is likely to have an undesirable effect. The frequency of exceedance of these criteria is used to establish findings at the following scales: contaminant, contaminant group, station and river as a whole (Figure 5).

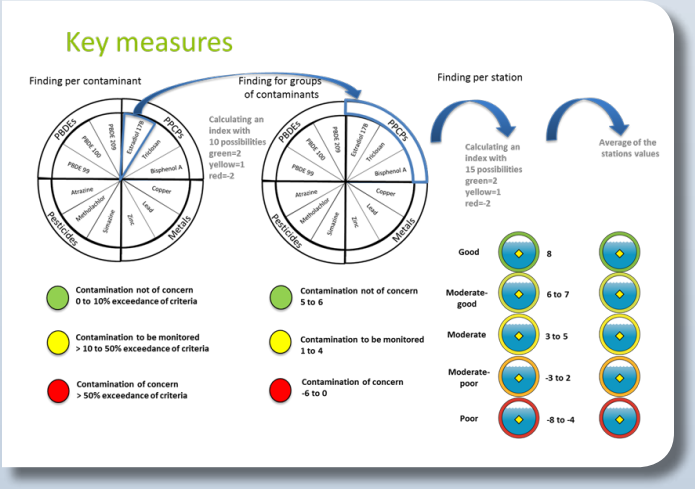

Figure 5: Key variables

Bibliography

BERRYMAN, D. M. RONDEAU, V. TRUDEAU. 2014. Concentrations de médicaments, d'hormones et de quelques autres contaminants d'intérêt émergeant dans le Saint-Laurent et dans trois de ses tributaires. Environnement Canada et Ministère du Développement durable, de l'Environnement et de la lutte contre les changements climatiques, Québec, 14 pages.

COSSA, D., T.-T. PHAM, B. RONDEAU, S. PROULX, C. SURETTE et B. QUÉMERAIS. 1998. Bilan massique des contaminants chimiques dans le fleuve Saint-Laurent. Environnement Canada – Région du Québec, Conservation de l'environnement, Centre Saint-Laurent. Rapport scientifique et technique ST-163, 258 pages.

GIROUX, I., S. HÉBERT, D. BERRYMAN. 2016. Qualité de l'eau du Saint-Laurent de 2000 à 2014 : paramètres classiques, pesticides et contaminants émergents. Le naturaliste Canadien. Vol. 140, no 2: 26-34

PHAM T.T., B. RONDEAU, H. SABIK, S. PROULX, D. COSSA. 2000. Lake Ontario: the predominant source of triazine herbicides in the St. Lawrence River. Can J Fish Aquat Sci 57(S1): 78-85

RONDEAU B, D. COSSA, P. GAGNON, T.T. PHAM, C. SURETTE. 2005. Hydrological and biogeochemical dynamics of the minor and trace elements in the St. Lawrence River. Appl Geochem 20: 1391–1408

TRUDEAU, V., M. RONDEAU et A. SIMARD. 2010. Pesticides aux embouchures de tributaires du lac Saint-Pierre (2003-2008). Montréal, Environnement Canada, Direction des sciences et de la technologie de l'eau, Section Monitoring et surveillance de la qualité de l'eau au Québec, 81 pages.

State of the St. Lawrence Monitoring Program

Five government partners—Environment and Climate Change Canada, Fisheries and Oceans Canada, Parks Canada, Quebec's Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques and the Ministère des Forêts, de la Faune et des Parcs—in collaboration with 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 its long-term changes.

To this end, environmental indicators have been developed on the basis of data collected as part of each organization's ongoing environmental monitoring activities over the years. These activities cover the main components of the environment, namely water, sediments, biological resources, uses and shorelines.

For more information on the State of the St. Lawrence Monitoring Program, please visit our website at www.planstlaurent.qc.ca/en.

Prepared by: Myriam Rondeau
Fresh Water Quality Monitoring and Surveillance
Water Quality Monitoring and Surveillance
Water Science and Technology
Science and Technology Branch
Environment and Climate Change Canada

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