Water Quality in the Fluvial Section

Contamination by Toxic Substances


Photo: Environment Canada

Background

Urban development, industrial activities and farming have unleashed a massive load of toxic substances into our watercourses over the last century. These toxic inputs have contributed to degrading the water quality in the immense Great Lakes–St. Lawrence Basin, thus placing this unique ecosystem at risk.

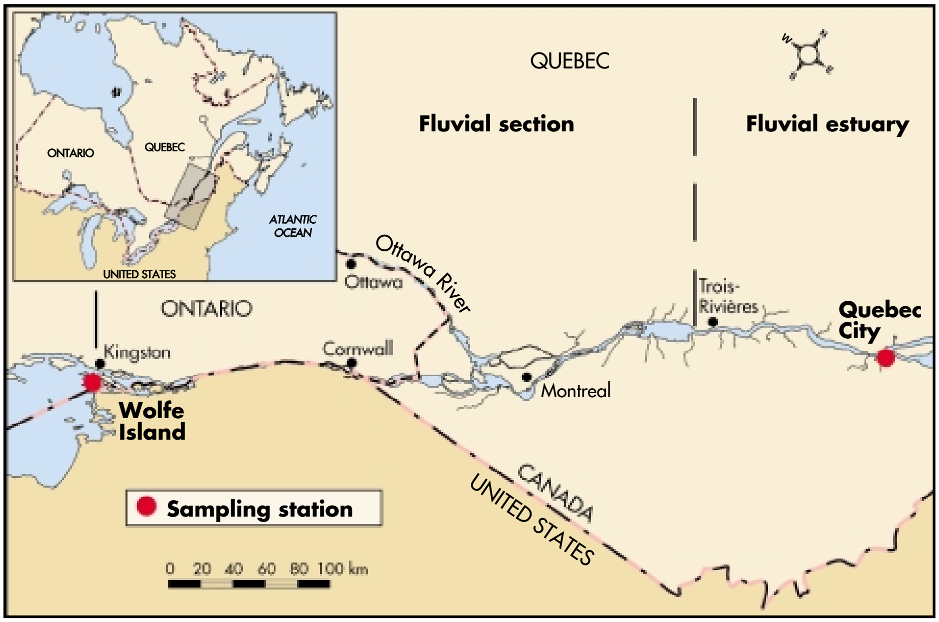
Since 1995, seasonal and interannual fluctuations and long-term trends in contaminant concentrations have been tracked at a reference station in the St. Lawrence River, to evaluate its state of contamination. The Quebec City region (Figure 1) was selected as the site for this station because the tide brings the different water masses in the river together here, thus combining the sources of contamination coming from upstream.

From this vantage point, scientists track the trends in 86 different contaminants. The analytical results are grouped into four classes (metals, polychlorinated biphenyls, polycyclic aromatic hydrocarbons and pesticides), as shown in Table 1.


Photo: Françoise Lapointe, Environment Canada

These contaminants were chosen for analysis based on the Priority Substances lists of Environment Canada, the United States Environmental Protection Agency and the International Joint Commission. The dissolved and particulate phases are analysed separately, due to the great affinity of most contaminants for suspended matter and their distinctive behaviour in the dissolved and particulate phases when transported in the aquatic environment. The use of the latest sampling and analysis techniques ensures the precision of the results for substances present at trace and ultratrace levels. The sampling

Figure 1. Water quality monitoring stations for toxic substances



conducted in the area of Wolfe Island, at the outlet of Lake Ontario (Figure 1), serves to assess the quality of the water coming into the St. Lawrence River from the Great Lakes, the river's main source.

Overview of the Situation

Just as the quantity of a given contaminant released to an ecosystem has a direct effect on its concentration in the aquatic environment, so too does its source have an influence on how concentrations will vary in the environment. These variations are amplified or attenuated by hydrological phenomena like dilution, sedimentation and groundwater flow, which fluctuate with periods of high or low water. Variations in the chemical composition of the river water near Quebec City, therefore, are largely the result of seasonal fluctuations in the proportion of water entering from the Great Lakes and from the tributary rivers of the St. Lawrence.

Metals

Metal sources are sometimes difficult to determine, metals being naturally present in all bodies of water. It is only when the metal concentrations exceed a certain level that we can conclude that human activities are making a significant contribution. No exceedances were found when comparing observed concentrations of dissolved metals against the quality criteria (Table 1). Further, the concentrations of metals associated with suspended particles in the river are close to the levels measured in the Earth's crust.

The tributaries draining the north shore of the St. Lawrence exhibit higher natural metal concentrations than the rivers draining the Great Lakes basin. In contrast, the waters from the Great Lakes are richer in major ions than the water that drains the north shore. The observed variations in metal concentrations near Quebec City are primarily the result of proportional changes in the mixing waters of the Great Lakes and the St. Lawrence tributaries. The tributaries and the eroding banks and bed of the river are estimated to be the largest sources of metal inputs to the St. Lawrence. Only the concentrations of lead, zinc and mercury in suspended particles are indicative of anthropogenic inputs when compared with levels in the Earth's crust.

Some metals exhibit a slight decreasing trend since 1995, whereas others display slight increasing trends (Table 1). This phenomenon is easily explained by the proportion of Great Lakes water in the St. Lawrence, which has declined somewhat over the past few years in favour of water from the river's tributaries. Mercury levels, however, have grown markedly (Figure 2), due not simply to hydrological factors but rather to an increase in human sources that have not yet been identified. These sources could very well be located outside the St. Lawrence basin, as mercury is highly volatile and can be carried over long distances in the atmosphere.

Polycyclic aromatic hydrocarbons (PAHs)

Concentrations of dissolved PAHs show high seasonal variations (Figure 2), being maximal in winter and minimal in summer. Unlike metals, these variations are not connected to the water cycle; the high concentration of PAHs in winter probably testifies to the increase in the combustion of wood and other fossil fuels. Indeed, the highest PAH concentration measured since 1995 (Figure 2) corresponds to the period following the 1998 ice storm.

Table 1. Concentrations and temporal trends in toxic substances in the St. Lawrence River near Wolfe Island and Quebec City

Parameters	Number of samples drawn near Quebec City	Average concentrations near Wolfe Island (ng/L) 1996*	Average concentrations near Quebec City (ng/L) 1995–2002	Quality criteria (ng/L)**	Temporal trends near Quebec City (estimated % of annual changes)	
					Dissolved	Particulates
METALS						
Aluminum	185	46 000	18 000	100 000	↑ 10	↓ 2
Arsenic	185	567	600	5 000	↑ 4	—
Cadmium	185	< 100	13	800	—	↓ 8
Copper	185	1 032	950	2 000	↑ 3	↓ 2
Iron	185	58	50	300 000	↑ 15	↓ 3
Mercury	256	—	0.7	100	↑ 11	↑ 12
Nickel	185	750	630	65 000	↓ 4	↓ 2
Lead	65	< 200	< 5	2 000	—	↓ 2
Zinc	185	890	750	30 000	↑ 17	↓ 3
PESTICIDES						
Atrazine	122	53	48	1 800	—	—
Metolachlor	94	18	21	7 800	—	—
Simazine	94	—	8	10 000	—	—
PAHs						
Anthracene	73	< 0.18	< 0.07	12	—	—
Benzo (a) anthracene	73	< 0.25	0.4	18	—	—
Benzo (a) pyrene	73	0.2	0.5	15	—	—
Fluoranthene	73	0.4	2.3	40	—	↑ 9
Fluorene	73	0.2	1.6	3 000	↑ 5	—
Phenanthrene	73	0.8	7.5	400	—	↑ 10
Pyrene	73	< 0.3	1.8	25	↓ 4	↓ 6
PCBs						
Total PCBs	17	—	0.4	—	—	—

Photo: The Biosphere

* Data from Environment Canada, Ontario Region. Note that work is currently underway to verify the comparability of the analytic methods employed by the Quebec and Ontario regions.

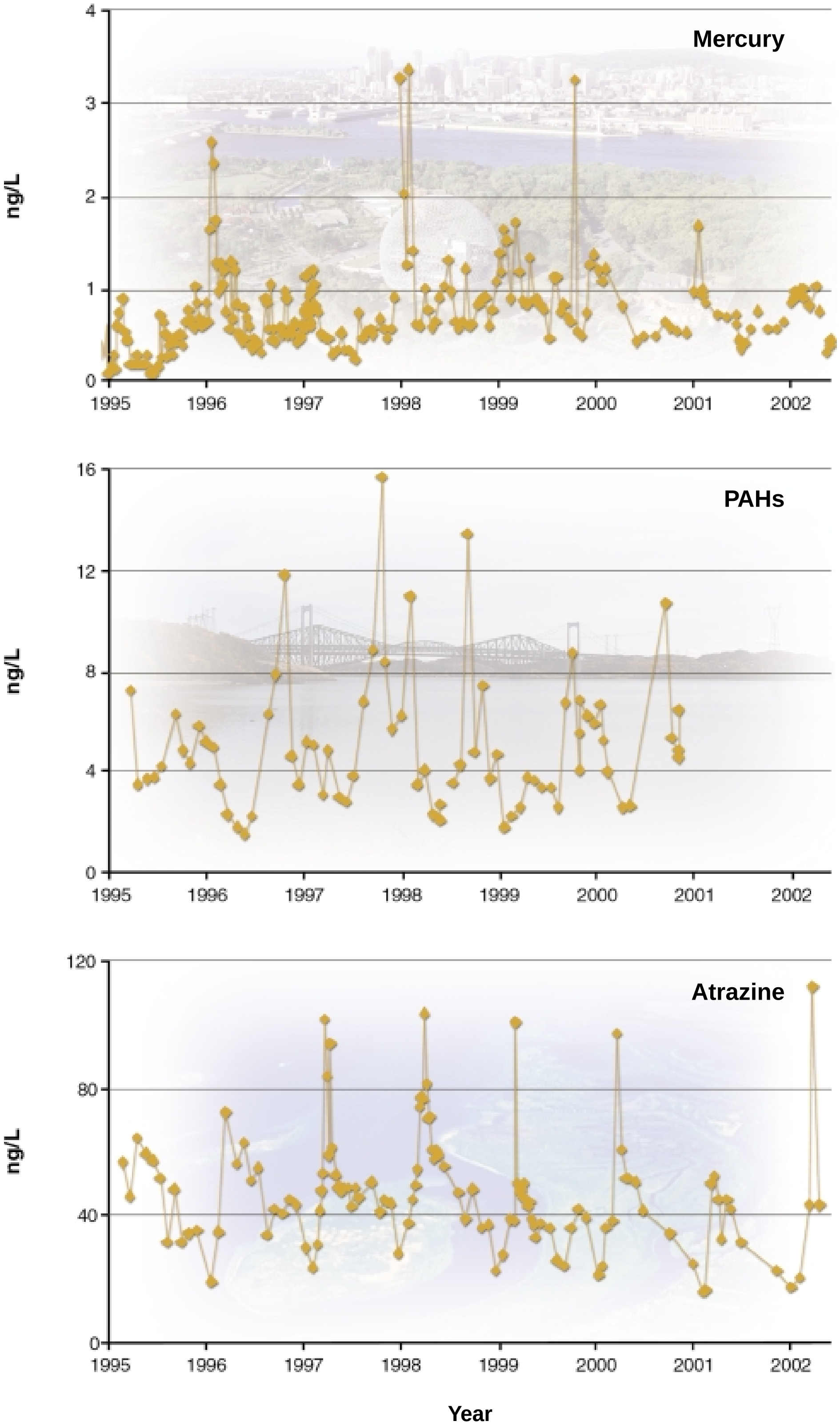
** Protection of aquatic life (chronic toxicity).

Levels were compared against the quality criteria and not a single exceedance was found (Table 1). Current PAH concentrations are comparable to levels measured in the river in 1990; on the other hand, PAH levels at the outlet of Lake Ontario have fallen since 1990. Temporal trends calculated since 1995 show a slight increase in PAHs in suspended particles, while levels in the dissolved phase are unchanged.

Pesticides

The Great Lakes basin is by far the largest source of the three pesticides detected in the St. Lawrence River, namely, atrazine, simazine, and metolachlor. Generally speaking, the concentrations measured in the river are of the same order of magnitude as those measured at Wolfe Island, at the outlet of Lake Ontario (Table 1). However, at the Quebec City station, higher levels are observed in summer (Figure 2), seemingly

Figure 2. Seasonal variations in concentrations of mercury, PAHs and atrazine in water in the Quebec City region from 1995 to 2002



due to the application of pesticides on farmlands located in the St. Lawrence Lowlands. The lower levels measured in spring probably result from dilution due to snowmelt. While the concentrations of pesticides fluctuate greatly on a seasonal basis, no upward or downward trend has been observed since 1995. At the Wolfe Island station, however, the concentrations of atrazine have grown since 1990.

Polychlorinated biphenyls (PCBs)

Measured PCB concentrations at the Quebec City station are five to ten times lower than the levels in Lake Ontario in the 1980s, reflecting how the situation has probably improved. It is difficult to compare concentrations in the Quebec City region with those of other bodies of water due to the lack of data on PCBs in water, a situation that results from the complexity of analysing PCBs at ultratrace levels in water. What data are available relate mainly to PCB levels in sediments in lakes and rivers. In general, though, PCB levels in the river are comparable to levels in the North Sea and 10 to 100 times lower than the concentrations observed in some European rivers like the Seine and the Rhone.

Outlook

Although the St. Lawrence shows clear signs of contamination by toxic substances, the levels compare favourably with other bodies of water. Metal concentrations measured in the area of Quebec City are of the same order of magnitude as those detected in environments deemed relatively uncontaminated. For the metals considered here, levels are 10 to 100 times lower than in large European rivers like the Rhine and the Seine. Furthermore, metal concentrations in suspended particles are of the same order of magnitude as the levels in the Earth's crust. When we compare PCB concentrations measured near Quebec City with those of other watercourses in the world, the St. Lawrence ranks among the least contaminated rivers. By contrast, its concentrations of PAHs and pesticides place the St. Lawrence midway between water bodies deemed to be contaminated and relatively "pristine" areas.

The information presented in this fact sheet is limited to conventional contaminants. Little data exist on other toxic substances in the aquatic environment. However, technological advances are now making it possible to analyse less conventional contaminants. Several of these substances (surfactants, steroids, medications, hormones, etc.) are associated with endocrine system disruption in aquatic organisms. Research is currently underway to assess the levels of these contaminants in the river. The results will contribute to improving water quality monitoring in the St. Lawrence.

Photo: Luc Thibault

KEY VARIABLES

Water quality criteria

Thresholds or recommendations are used to evaluate whether or not the different water uses are being compromised by the presence of a substance. Water quality criteria are not standards and they carry no legal weight. Rather, these values are integrated into management procedures, where they serve as a reference level for assessing the health of aquatic ecosystems. Quality criteria are values associated with a safe threshold by which a water use is protected from all possible deleterious effects: toxicity, organoleptic properties or aesthetic degradation.

The criterion for chronic toxicity in aquatic life used herein is the highest concentration of a substance at which aquatic organisms (and their progeny) will suffer no harmful effect 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.

Considerations about ecosystem health, the cumulative effects of several different substances for both aquatic life and human health, and the presence of a specific use, may necessitate additional requirements.

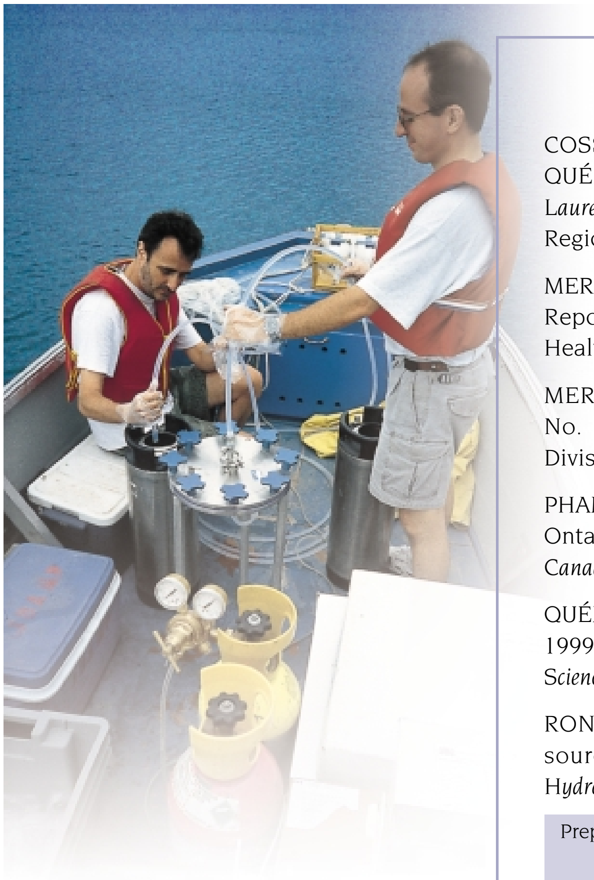


Photo: Christiane Hudon, St. Lawrence Centre

To Know More

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State of the St. Lawrence Monitoring Program

Four government partners — Environment Canada, the ministère de l'Environnement du Québec, the Société de la faune et des parcs du Québec, and Fisheries and Oceans Canada — are pooling their expertise and efforts to provide Canadians with information on the state of the St. Lawrence and long-term trends affecting it. To this end, environmental indicators have been developed on the basis of data collected as part of each organization's ongoing environmental monitoring activities. These activities cover the main components of the environment, namely water (quality and quantity), sediments, biological resources (species diversity and condition), uses and, eventually, shorelines.

For additional copies or the complete collection of fact sheets, contact the St. Lawrence Vision 2000 Coordination Office:

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The fact sheets and additional information about the program are also available on the Web site: **www.slv2000.qc.ca** .

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