2nd edition

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.

Reference stations have been set up in the fluvial section of the St. Lawrence River to assess the quality of the water by tracking seasonal and interannual fluctuations and long-term trends in contaminant concentrations. The Quebec City region (Figure 1) was selected for a reference station in 1995 because the tide brings the different water masses in the river together here, thus combining sources of contamination. Since 2003, measurements have also been taken at Wolfe Island, at the mouth of Lake Ontario (Figure 1), to assess the quality of the water entering the river from the Great Lakes, which is characterized by its clarity and high mineral content. A new station was added to the network in 2004 at Carillon, Quebec, close to the mouth of the Ottawa River. The Ottawa is the largest tributary of the St. Lawrence and its so-called “brown waters” cover a large portion of the St. Lawrence north shore and are easily identified as far downstream as Trois-Rivières.

Photo: Françoise Lapointe, Environment Canada

These contaminants were chosen for analysis based on the Priority Substances lists of Environment Canada, the United States Environmental

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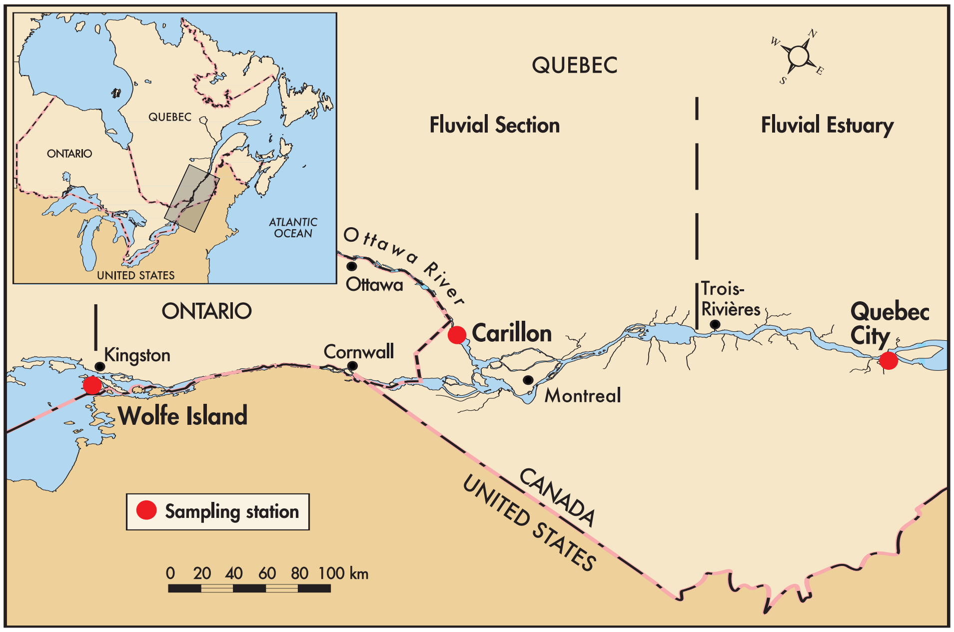
Figure 1. Water quality monitoring stations for toxic substances



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 phase and the particulate phase 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 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 largely result from seasonal fluctuations in the waters entering from the Great Lakes and 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 natural concentrations of some metals were higher in the tributaries draining the north shore of the St. Lawrence than in the rivers draining the Great Lakes Basin. By 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, however, do not appear to be located in the Lake Ontario watershed because concentrations there are so much lower (Figure 2), but they could very well be found outside the St. Lawrence

Table 1. Concentrations and temporal trends in toxic substances in the water at the Carillon, Wolfe Island and Quebec City stations

Parameters	Average concentrations (ng/L)			Quality criteria (ng/L)*	Temporal trends at Quebec City (1995-2002) (estimated % of changes)	
	Carillon 2004	Wolfe Island 2003-2004	Quebec City 2003-2004		Dissolved	Particulate
METALS						
Aluminum	33 000	13 000	19 000	100 000	↑ 10	↓ 2
Arsenic	340	780	590	5 000	↑ 4	NT
Cadmium	11	13	17	800	NT	↓ 8
Copper	960	800	1 000	2 000	↑ 3	↓ 2
Iron	185	58	50	300 000	↑ 15	↓ 3
Lead	36	16	25	2 000	NT	↓ 2
Mercury	1.2	0.3	0.9	100	↑ 11	↑ 12
Nickel	660	1 200	1 100	65 000	↓ 4	↓ 2
Zinc	817	440	700	30 000	↑ 17	↓ 3
PESTICIDES						
Atrazine	—	53	41	1 800	NT	NT
Metolachlor	—	18	13	7 800	NT	NT
Simazine	—	NT	9	10 000	NT	NT
PAHs						
Anthracene	0.09	0.02	0.15	12	NT	NT
Benzo[a] anthracene	< 0.03	< 0.03	0.06	18	NT	NT
Benzo[a] pyrene	0.04	< 0.01	0.09	15	NT	NT
Fluoranthene	1	0.36	0.8	40	NT	↑ 9
Fluorene	0.3	0.34	0.9	3 000	↑ 5	NT
Phenanthrene	1.8	0.85	2	400	NT	↑ 10
Pyrene	1.4	0.25	0.8	25	↓ 4	↓ 6

*For the protection of aquatic life from chronic toxicity.
NT: No trend noted.

watershed, as mercury is highly volatile and can be carried over long distances in the atmosphere.

Polycyclic aromatic hydrocarbons (PAHs)

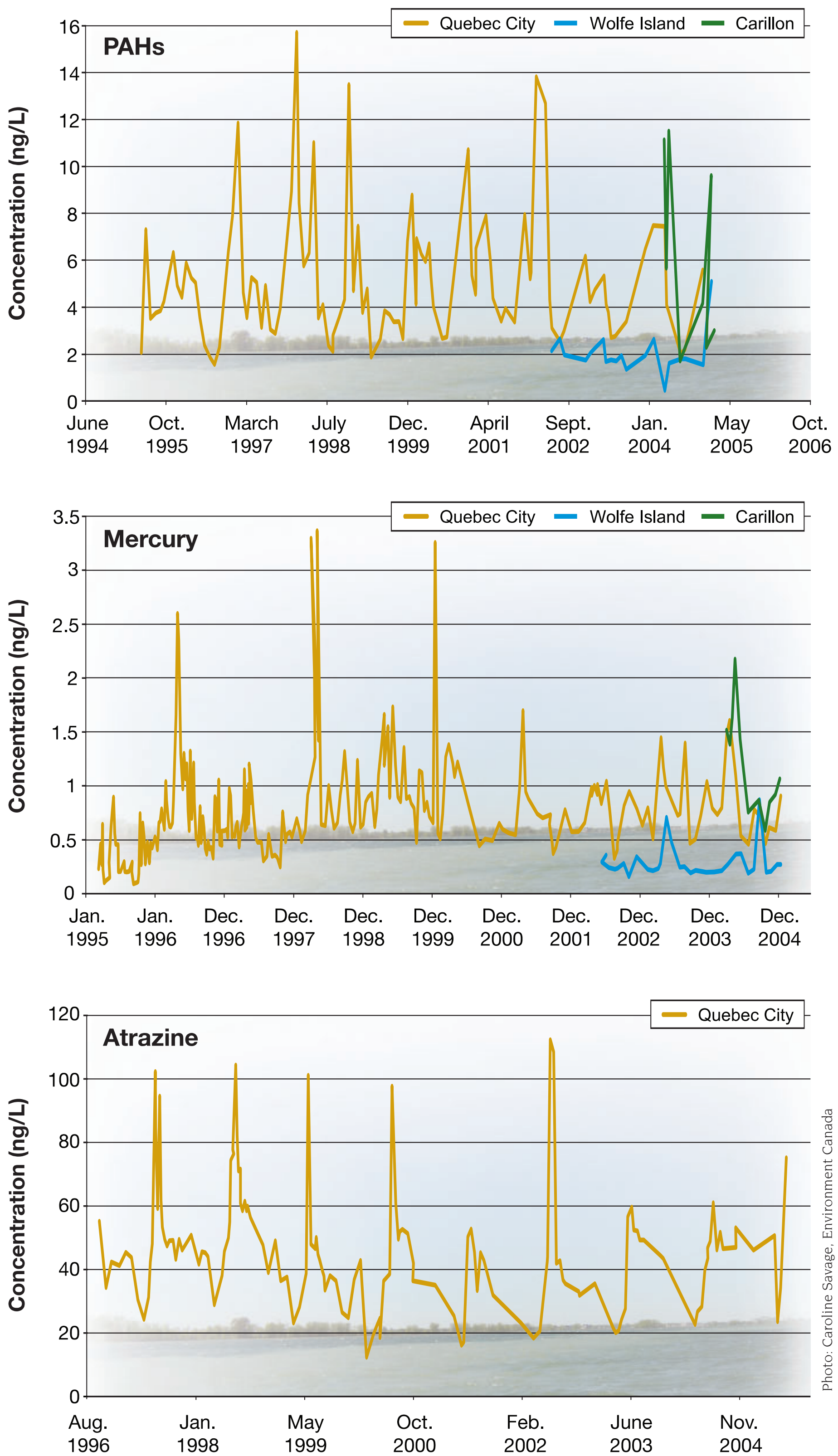
Concentrations of dissolved PAHs show high seasonal variations in both the St. Lawrence and the Ottawa River (Figure 2), being maximal in winter and minimal in summer. Unlike metals, these variations are not connected to the water cycle; the high concentration of PAHs in winter probably testifies to the increased 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. Levels don't fluctuate quite so dramatically at the Wolfe Island station, probably due to the long residence time of water in Lake Ontario.

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 only 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 mouth of Lake Ontario (Table 1). However, at the Quebec City station, higher levels are observed in summer (Figure 2), seemingly 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, concentrations of atrazine have grown since 1990. There is no regular monitoring of pesticides in the Ottawa River. An earlier study by Cossa et al. (1998) found the near-absence of any such contaminants due to the marginal nature of farming activity in the basin.

Figure 2. Seasonal variations in concentrations of mercury, PAHs and atrazine in water in the Quebec City region from 1995 to 2004



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. By contrast, its concentrations of PAHs and pesticides place the St. Lawrence midway between water bodies deemed to be contaminated and relatively "pristine" ones. Our knowledge of the toxic contamination of the water in a larger system — that of the Great Lakes–St. Lawrence — was recently overviewed (Rondeau and Klawunn 2005).

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 polybrominated diphenyl ethers (PBDEs) 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 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.

Among these criteria, that to protect aquatic life from chronic effects 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.

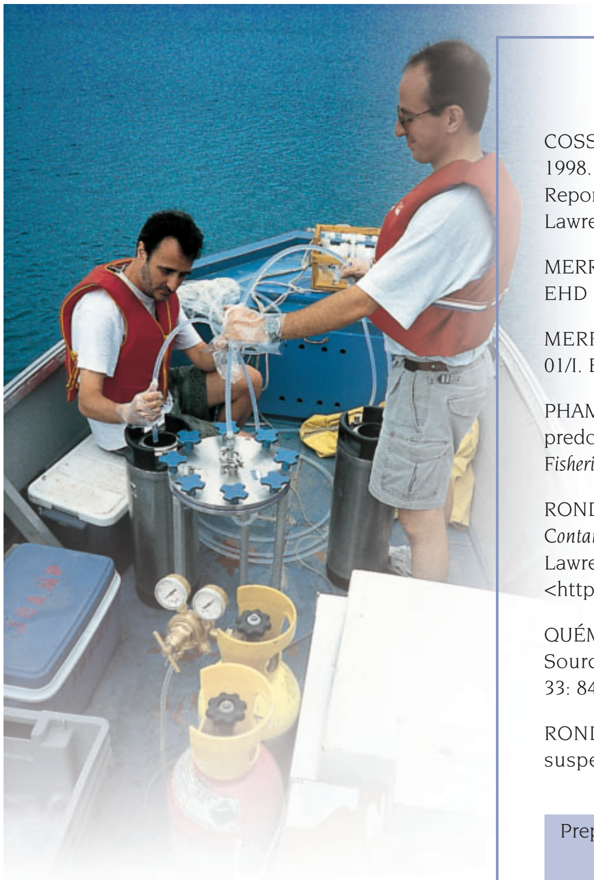


Photo: Christiane Hudon, St. Lawrence Centre

To Know More

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State of the St. Lawrence Monitoring Program

Six government partners — Environment Canada, Fisheries and Oceans Canada, the Canadian Space Agency, Parks Canada Agency, the Ministère du Développement durable, de l'Environnement et des Parcs du Québec, the Ministère des Ressources naturelles et de la Faune du Québec — and Stratégies Saint-Laurent, a nongovernmental 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 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, sediments, biological resources, uses and shorelines.

For more information on the State of the St. Lawrence Monitoring Program, please visit our Web site at <**www.planstlaurent.qc.ca**> or contact our offices at the following address:

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