Saint-Laurent Vision 2000

Tracking contaminants in the St. Lawrence River

What quantity of contaminants is exported annually from the Great Lakes to the St. Lawrence River? What quantity of contaminants is exported, in turn, by the St. Lawrence to its estuary?

A team of scientific researchers at the St. Lawrence Centre (SLC) set out to answer these two important questions as part of a project known as the "St. Lawrence River Mass Balance Study."

Under this project, the annual contaminant load (that is, the total quantity of contaminants transported) in the St. Lawrence River during the 1995-96 hydrological year was estimated. These calculations were performed from measurements taken at the two main inlets to the St. Lawrence (at Cornwall, Ontario and Carillon, Quebec) and at the outlet (Quebec City), in the Fluvial Section of the river (that is, that stretch of the river running from Cornwall to Quebec City). Cornwall is characterized by inflows from Lake Ontario to the St. Lawrence, whereas Carillon marks the inflow of water from the Ottawa River. The mouth, or outlet, of the St. Lawrence River is located at Quebec City. The study targeted 85 chemical contaminants divided into six classes: metals, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), organochlorine and organophosphorus pesticides, and triazines (see Table 1).

The accuracy of this type of mass balance study depends, first and foremost, on the quality and quantity of data available to calculate the chemical loads. The concentrations of contaminants found in the St. Lawrence River were so low that scientists had to employ sampling techniques normally adapted to the analysis of trace levels of chemicals. These levels corresponded to less than one billionth of one gram (and often to one thousandth of one billionth of one gram) of a contaminant contained in one litre of water. This is equal to one-half teaspoon in 2000 Olympic-size swimming pools! In order to obtain reliable and precise data, rigourous sampling and analysis techniques were employed.

Environment Canada Environnement Canada

Some Results

SOME BASIC CONCEPTS

To better appreciate the perspective of this study, a distinction should be made between two terms being used here: contaminant concentration and contaminant load. A contaminant concentration is the quantity of a contaminant found in a given volume of water (e.g. one litre), whereas the load (or flux) of a contaminant refers to the quantity found in the entire water mass being considered at any given time (in tonnes per year, for example). When we analyse a contaminant, we determine its concentration; the contaminant load, on the other hand, is the product of the concentration by the discharge (or flow) rate of a watercourse. The annual load therefore corresponds to the quantity of a contaminant that has moved through a section of the river during a single year. Thus, when the concentration of a contaminant is equal at two different sampling stations (e.g. Quebec City and Cornwall), the load of said contaminant will be higher at Quebec City because the volume of water transported by the river per unit of time is higher.

Contaminants are transported in the water in both the dissolved and particulate form (associated with suspended matter). All the contaminants targeted by this study were therefore analysed in both phases.

Depending on the metals being considered, concentrations may be from 10 to 100 times lower than levels measured in the most contaminated European rivers.

SUSPENDED MATTER

Suspended matter functions as a transport vessel for many contaminants. As such, it is essential that the quantity and origin of suspended matter in the river are known. Although inputs of water from the Great Lakes and the Ottawa River made up, respectively, 61% and 16% of water flowing past Quebec City, their combined load of suspended matter represented only 11% of the load of suspended matter at Quebec City in 1995-96. The south shore tributaries of the St. Lawrence are generally thought to be responsible for the input of particles, however, research carried out at the SLC suggests that a main source is erosion of the river's banks and bed.

By analysing and calculating contaminant loads in both the dissolved and the particulate phase, scientists have been able to define their main pathways at each sampling station. At Cornwall, most of the chemical contaminants are transported in the dissolved phase. The situation is reversed at Carillon and Quebec City, where most contaminants are carried in the particulate phase.

TABLE 1

LIST OF COMPOUNDS STUDIED UNDER THE MASS BALANCE STUDY

Metals	PCBs	PAHs	Triazine herbicides	Organophosphorus pesticides	Organochlorine pesticides
Aluminum	PCB 18	Acenaphthylene	Ametryn	Azinphos ethyl	Lindane
Arsenic	PCB 31	Acenaphthene	Atrazine	Azinphos methyl	Heptachlor
Cadmium	PCB 40	Fluorene	Cyanazine	Chlorpyrifos	Heptachlor epoxide
Calcium	PCB 44	Phenanthrene	Prometryn	Diazinon	Aldrin
Cobalt	PCB 49	Anthracene	Propazine	Ethion	Dieldrin
Copper	PCB 52	Fluoranthene	Simazine	Fonofos	o,p'-TDE
Iron	PCB 54	Pyrene	Metribuzin	Malathion	p,p'-TDE
Lead	PCB 60	Benzo (a) anthracene	Metolachlor	Parathion	p,p'-DDT
Lithium	PCB 101	Chrysene		Phosmet	p,p'-DDE
Magnesium	PCB 105	Benzo (b,j,k) fluoranthene			o,p'-DDT
Manganese	PCB 118	Benzo (e) pyrene			alpha-HCH
Mercury	PCB 128	Benzo (a) pyrene			beta-HCH
Nickel	PCB 138	Indeno (1,2,3-cd) pyrene			Mirex
Zinc	PCB 153	Dibenzo (a,h) pyrene			Eldrin
	PCB 170	Benzo (g,h,i) perylene			alpha-Endosulfan
	PCB 180				cis-Chlordane
	PCB 183				trans-Chlordane
	PCB 194				Hexachlorobenzene
	CO-planar PCBs				
	PCB 77				
	PCB 126				
	PCB 169				

METALS

The origin of toxic metals is sometimes difficult to determine, as they are naturally present in watercourses. Only when concentrations exceed a certain threshold can we point to the significant contribution of human activities. The metal concentrations measured at the three stations in this study are of the same order of magnitude as those found in environments deemed to be only slightly or not at all contaminated. Depending on the metals being considered, concentrations may be from 10 to 100 times lower than levels measured in the most contaminated European rivers. Natural phenomena related to the nature of the soil and sub-soil drained, the hydrological characteristics of the watersheds in question, and the chemical properties of the elements being considered would explain the differences observed in the concentrations measured at the three stations, as well as variations recorded over time.

Metal loads at Quebec City are higher than the sum of the loads calculated at Cornwall and Carillon. These results indicate that the Fluvial Section of the St. Lawrence is not a zone of permanent accumulation (or "sink") for the metals concerned, and that sedimentation in the fluvial lakes is lower, for the most part, than the input of metals within this river section. It is estimated that the input of natural-source metals coming from the tributaries and adsorbed to particles produced by erosion of the river's banks and bed constitute the biggest source of internal metal inputs.

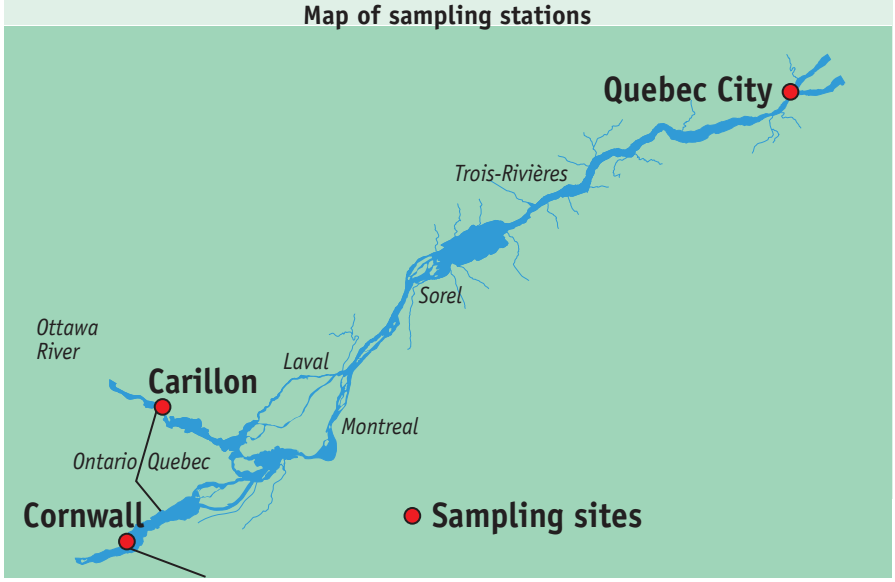
Management Perspective

The mass balance study of the chemical contaminants in the Fluvial Section of the St. Lawrence River was conducted by the St. Lawrence Centre of Environment Canada, as part of the five-year (1993-98), federal-provincial St. Lawrence Vision 2000 (SLV 2000) action plan. Carried out under the Decision Support component of SLV 2000, the aim of this project was to quantify the input of chemical substances to the St. Lawrence River from the Great Lakes and from its largest tributary, the Ottawa River, and to assess exports to the estuary. This was not an attempt to quantify all the contaminants within the fluvial corridor, but rather to acquire a general framework so as to estimate the relative contribution of internal sources of chemical contamination in Quebec. This study also made it possible to determine the concentrations of some chemical contaminants in the river water, to assess their seasonal variations by undertaking monitoring over time, and to produce an annual assessment report.

From May 1, 1995 to September 30, 1996, 48 samples were taken at each of the Cornwall and Carillon stations, and 83 samples were collected at the Quebec City station.

FIGURE 1

Map of sampling stations



ORGANIC CONTAMINANTS

With the exception of PAHs, the organic contaminants studied here have no natural source. Unlike metals, an increase in the load of organic contaminants between the river's two inlets and its outlet inevitably indicates an anthropic (human) source. The loads of PCBs and PAHs entering the St. Lawrence from Lake Ontario and the Ottawa River are essentially the same, but loads at Quebec City are five times higher than the combined load of the two inlet stations. This points to major inputs of PCBs and PAHs somewhere in between Cornwall and Quebec City. Nonetheless, if we compare the concentrations of PCBs measured in this study to those in other watercourses, we find that the St. Lawrence is one of the world's least contaminated rivers. PCB concentrations in the St. Lawrence are 5 to 10 times lower than concentrations measured in Lake Ontario in the 1980s, a clear indication of how the situation has improved. The concentrations of PAHs in the St. Lawrence fall about midway between those reported in contaminated water bodies and relatively pristine waters. PAH levels have not dropped relative to past data, but this is not surprising given the pervasiveness of PAHs in the environment.

As for the four herbicides detected (atrazine, simazine, metolachlor and cyanazine), loads at Cornwall and Quebec City are similar, which suggests that the Great Lakes basin is far and away the biggest source for such contamination in the St. Lawrence River. Generally speaking, levels of atrazine and metolachlor are of the same order of magnitude as the levels in Lake Ontario. Levels generally tend to be a little higher in summer, seemingly in response to manure spreading on the land, and they tend to be lower in spring, probably due to the dilution effect caused by snowmelt.

Recommendations

Given the low contaminant concentrations reported at this time in the St. Lawrence River, studies aimed at their detection should adopt and eventually improve upon the sampling, processing and analysis methodologies employed in this study. A similar mass balance study should be undertaken every ten years to trace the evolution of contaminant concentrations and fluxes coming from the Great Lakes and the Ottawa River. For the time being, the level of contamination in the St. Lawrence River at Quebec City should be monitored to keep track of any improvements and, likewise, any deterioration in the water quality. Lastly, the list of contaminants being studied should be broadened so as to take the environmental concerns of the day into consideration.

OUR FINDINGS; TAKING ACTION

While the mass balance study did indeed provide us with answers to some important questions regarding the chemical contamination of the St. Lawrence, it also raised a few new ones.

1. The substantial difference in the load of suspended matter recorded at the Cornwall station and the load at Quebec City leads inevitably to this question: what is the relative contribution of internal sources such as bank erosion, tributary inputs and erosion of the river bed? The answer is directly linked to the water level and the regulation thereof, and to ship traffic. This difference also points to natural sources for the major sources of metals examined in this study.
2. Estimates of loads at the inlets and the outlet of the river are proof that there are sources of PCBs and PAHs within the study area, thus highlighting the need for these sources to be characterized.
3. Our study sheds no light on what impact a given contaminant discharge might have within a limited geographical area if contaminants were to accumulate there. Local studies should therefore be carried out in the vicinity of such effluent discharges.
4. The relative importance of areas of contaminated sediment as a source of contaminants all along the river corridor has yet to be assessed.

This report is available at the Documentation Centre of the St. Lawrence Centre, 105 McGill Street, 2nd Floor, Montreal, Quebec H2Y 2E7.

Reference: Cossa, D., T. T. Pham, B. Rondeau, S. Proulx, C. Surette, and B. Quemerais. 1998. *Bilan Massique des Contaminants Chimiques dans le Fleuve Saint-Laurent*. Environment Canada - Quebec Region, Environmental Conservation, St. Lawrence Centre. Scientific and Technical Report ST-163. 258 pages.