Northern Exposures:

Cleaning up Canada

Olivia James

Canada, the second largest nation in the world, extends across almost 4 million square miles from the Atlantic Ocean westward to the rocky shores of the Pacific Ocean and from borders shared with the United States in the south 3,000 miles north to the frigid waters of the Arctic Ocean. The country's coastline, the longest in the world, spans more than 150,000 miles. Between coasts, Canada is rich in lakes, rivers, forests, and barren rocks that not only shape the landscape but also mold the economy. Pulp and paper production, agriculture, and mining are major industries. Unfortunately, emissions and runoff from these industries, from manufacturing processes, from hydroelectric plants, and from fossil fuel combustion have polluted the once pristine air and water. Persistent toxic compounds such as PCBs, dioxins, furans, DDT, and heavy metals have been polluting the Great Lakes, shared between the United States and Canada for more than 60 years. Pulp mill effluent has spread organochlorines into the waterways. Incinerators have spewed heavy metals into the atmosphere. All these contaminants are taking their toll directly or indirectly on the lives of Canada's 28 million residents, two-thirds of whom live close to the northern United States. Many of the indigenous peoples live in the Arctic archipelago.

A self-governing member of the British Commonwealth, Canada is a federation of ten provinces and two territories. Each level of government has clearly delineated powers spelled out in Canada's 1982 constitution. Environment Canada, much like the U.S. EPA, is responsible for environmental concerns of national importance such as international and interprovincial waters and interprovincial transport of substances. The provincial Ministries of the Environment have considerably more authority than U.S. state environmental agencies to legislate regulations, set standards and guidelines, and monitor substance emissions. The Canadian Committee of Resource of Environment Ministers, chaired by the federal Environmental Minister, meet to resolve provincial differences when they occur.

Environment Canada, unlike the U.S. EPA, does not make declarations on human health. That is the mandate of Health Canada. Similar to the U.S. Department of Health and Human Services, Health Canada concentrates only on human health issues. However, under the Canadian Environmental Protection Act (CEPA), enacted in 1988, Health Canada and Environment Canada jointly assess substances to determine if they are toxic. When, for example, fish are collected for study, a department of Environment Canada does the laboratory work, but Health Canada determines the risk to human health and issues the warnings. Pesticide use is governed by federal regulations, each approved for a specific use by the Pest Control Products Act, which regularly reviews pesticides in conjunction with Health Canada and Fisheries & Oceans.

Five years ago, the Canadian government committed $3 billion to a comprehensive five-year environmental cleanup program now extended to six years called the Green Plan. These monies are in addition to the estimated $730 million budgeted annually by Environment Canada for cleaning up the environment. Included in the Green Plan is the Health and Environmental Action Plan, under which human health hazards from acid rain, airborne toxins, and ground-level ozone, and drinking water safety, and waste management practices are assessed.

In 1995, the federal government instituted the Toxic Substances Management Policy. The policy has two components: one deals with persistent bioaccumulating toxic substances and explicitly targets them for virtual elimination or eradication to below the detection level, the other mandates that risk assessment be carried out under the aegis of the CEPA. Substances of natural origin such as heavy metals and polycyclic aromatic hydrocarbons are assessed for risk under the policy's second component. If the substance is found to cause harm to either humans or the environment, federal regulations are imposed to control its use.

"The Toxic Substances Management Policy is the first of its type that recognizes virtual elimination," says John Carey, director of the Aquatic Ecosystem Conservation Branch of Environment Canada. "I can't think of any other jurisdiction in the world that has selected compounds for virtual elimination."

"In Canada," says Ralph Daley, executive director of Environment Canada's National Water Research Institute, "environmental advocacy groups are major players in influencing public opinion. And, I guess, public opinion and actual science drives the federal government to set these policies.

"What's important about this policy," continues Daley, "is that

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Vancouver view. Canadians have made concerted efforts to improve the quality of the environment in their cities.

government, as a matter of national policy, has recognized that there are persistent, bioaccumulating substances which by virtue of their unpredictable impact on the environment simply cannot be tolerated by the environment. That issue has not been recognized before as a matter of national policy."

Industry has had specific and substantial roles in formulating this policy. When a compound is to be designated by the government as a persistent, bioaccumulating toxic substance subject to virtual elimination, it will be announced to the public. Industry may then challenge the government's position on that substance. Industry can request a "reverse onus" designation after presenting evidence to the government as to why the substance should be removed from the list.

"The government has provided a built-in opportunity for industry to do what it has requested," continues Daley. "Industry will also be consultants and consensus-makers in the policy's action plan to regulate virtual elimination."

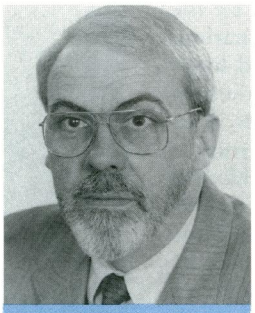
Not all of industry is happy with this policy. "Our fundamental concern is the definitions used by CEPA such as bioaccumulative and persistent," states Charles Ferguson, vice-president for Environment, Health and Safety at the International Nickel Corporation (INCO). "Those are great terms for defining chemicals, but we deal with natural metals, nickel, and copper. Those minerals are persistent, so the process says we're guilty because of that. Our problem with this policy is that it doesn't determine risk."

Purging Pulp Mill Effluent

Paper-making is a major industry in Canada. The abundance of forests in northern Ontario, Alberta, and British Columbia were ideally suited for launching the pulp and paper industry. Yet, while this industry contributes considerably to Canada's GNP, it has also contributed significantly to pollution of nearby waterways.

For years, pulp and paper mills were accused of discharging effluent with high concentrations of organochlorines such as chlorinated dibenzofurans and dioxins into adjacent rivers. Impaired reproduction in fish suggested that something in the effluent was affecting fish metabolism. PCBs, dioxins, and furans have been shown to alter thyroid function in laboratory animals and to exert estrogenlike activity, and scientists suggest that these changes may apply to humans as well. In 1992, a federal regulatory package for the pulp and paper industry was passed into law.

"As far as I know, Canada is the first country to establish controls on dioxin in pulp mill effluence," says Carey. "The regulatory package states that the level of dioxin in pulp mill effluence must be less than 10 parts per quadrillion. We established the limit for tetrachlorodibenzylfuran as well."



Environment Canada

Ralph Daley—In Canada, public opinion and science drive federal policy-making.

To meet the dioxin regulations, no mill can use elemental chlorine for bleaching. Since 1990, use of elemental chlorine has steadily dropped, and today it is only 30% of what it was five years ago. Most of Canada's 122 pulp and paper mills now use chlorine dioxide instead of elemental chlorine.

Preliminary results of a joint federal–provincial project investigating contaminants, drinking water quality, and hydrology show fairly low concentrations of organochlorinated compounds in Canada's water. "One reason for the lower levels may be that pulp mills are changing their chlorine bleaching process to chlorine dioxide," says Brian Brownlee, a research scientist with the National Water Research Institute, Canada Center for Inland Waters.

During the last three years, Ian Smith, coordinator for Lake-wide Management of the Ontario Ministry for the Environment estimates that Canadian pulp and paper mills have reduced their emissions of organochlorines between 60% and 95%.

"Ontario pulp mills have spent in excess of $250 million to virtually eliminate dioxin from their effluent," says Smith. "We won't see the changes in the environment very quickly. It might be 10 years before we see dioxin levels falling because dioxin is persistent and will linger a long time in the environment."

Freshening up the Great Lakes

Extending 1,160 miles in a unbroken line from Duluth, Minnesota, up to the St. Lawrence Seaway, the Great Lakes cover an area of 95,000 square miles. Except for Lake Michigan, the remaining four freshwater lakes flow along both the Canadian and U.S. borders. These lakes are vital to the economy of both countries, facilitating the flow of raw materials, agricultural goods, and manufactured products. The opening of the St. Lawrence Seaway in 1959 expedited the movement of autos, grain, lumber, minerals, and other products to and from world markets, enhancing the financial health of adjacent communities.

The shores of the Great Lakes are dotted with manufacturing, thermal and nuclear-generating, and chemical processing plants. Farmlands line the rivers emptying into the Great Lakes. While these industries benefit from proximity to shipping, they also contribute significantly to the pollution of these bodies of water. The most severe pollutants are persistent toxic chemicals, particularly PCBs. According to Michael Gilbertson, biologist for the

AP Wide World Photos

No more environmental logjams? Cooperation between the paper industries, government, and environmentalists has resulted in cleaner water.

International Joint Commission on the Great Lakes, industrial contamination, agricultural pesticide runoff, and long-range air-transported substances have been polluting the Great Lakes with PCBs, dioxin, DDT, and dieldrin for some 60 years.

Significant amounts of organochlorines were produced during the 1950s and 1960s. According to Gilbertson, large organochlorine manufacturing facilities up and down the Niagara River, some of which produced sources of dioxins such as the insecticide mirex and Agent Orange, discharged these substances directly into the Great Lakes or into tributaries that empty into the lakes.

Cleanup of the Great Lakes began in the early 1970s, precipitated by deformities in fish-eating birds such as osprey, cormorant, gulls, and herons, and by high bird embryo mortality. "Since then," Gilbertson says, "a large number of species have been monitored at a variety of locations. The results have given us a fairly complete view of the long-term effects organochlorines are having on fowl in the Great Lakes as well as a very good idea of how seriously affected they are. We know far more about how these chemicals affect birds than we know about how they affect humans. The research on human health is probably about 10 years behind the research that was done on wildlife in the Great Lakes."

The studies on waterfowl aroused concern about the effects of organochlorines on humans. Epidemiological studies showed that children whose mothers ate at least one pound per month of fish from Lake Michigan for a few years before pregnancy were smaller and had shorter gestational periods than children whose mothers had not eaten fish. At birth, the infants also showed neurological deficits. When tested again at 7 months and at 4 years, there were significant differences in startle reaction and the ability to process information. These findings, correlated with the levels of PCBs in the umbilical cord blood, indicated that the higher the PCB blood levels, the greater the neurological deficits.

In 1972, Canada and the United States formulated the first Great Lakes Water Quality Agreement under the Boundary Waters Treaty. The agreement, says Gilbertson, had more to do with eutrophication and building sewage treatment plants than with toxic substances. The agreement was renegotiated in 1978 to reflect the growing concern over toxic substances polluting the Great Lakes. Discharge of any or all persistent toxic substances was to be drastically curtailed.

Great Lakes United

Fish and fowl. Toxic effects on fish and birds in and around the Great Lakes prompted research on the human health effects of PCBs, dioxins, and other toxicants.

The Great Lakes Health Effects Program was created in 1989 as part of the Canadian Great Lakes Action Plan. The program conducted research and monitored toxic chemicals and their effects on human health. The five-year program was renewed in 1994 and renamed Great Lakes 2000. Its stated goal is to protect health and promote a healthy environment.

Gilbertson says, "We know we've done a pretty good job in getting rid of some toxic chemicals. But, I think evidence from the epidemiological studies suggests we still have quite a ways to go. The levels of these chemicals are still high enough to be affecting fetuses. I don't think there is any unequivocal evidence from the Great Lakes Basin that the incidence of cancer is better or worse around here. What we've really been showing is that there is a whole other area of toxicology that is important for the next generation."

International Joint Commission

Michael Gilbertson—Epidemiological studies show there is still a ways to go in cleaning up the Great Lakes.

Sprucing up the St. Lawrence

The St. Lawrence River, though not technically a part of the Great Lakes, is a conduit between these massive bodies of land-locked lakes and the Atlantic Ocean. Over the years, ships and industry emitting pollutants into this serpentine river have contaminated its waters. The Cornwall-Massena area of the river, riddled with PCBs, dioxins, and mercury, was declared an area of concern for cleanup by the International Joint Commission.

In 1988, the St. Lawrence Action Plan was developed between the federal government and Quebec. In 1994, Ottawa and Quebec jointly funded the renamed Lawrence Vision 2000 plan with $191 million. Embodied in the plan are methods to prevent pollution, conserve the river's ecosystem, and reduce industrial discharges into the river. The plan's long-term objective is to eliminate persistent and bioaccumulating toxic substances released by more than 55 plants along the river and its tributaries. Essential ingredients of St. Lawrence Vision 2000 are monitoring contaminants in human tissues and developing strategies to reduce risk to human health.

In addition, according to Alain Bebit, Information Officer for Environment Canada for the Quebec region, enormous cleanup projects are underway in the contaminated harbors of Montreal and Quebec City. "These harbors, over the years, have been greatly contaminated with heavy metals and organic compounds emitted from petroleum refineries, other industries, and ocean-going ships along the river," Bebit says.

Wiping out Waste

Substances buried in soil contribute to water quality problems. More than half of Canada's annual 8 million tons of hazardous waste goes untreated. Gilbertson describes the potential threat at one hazardous waste landfill. The Hyde Park Dump, located on the Niagara River in the

U.S., contains two tons of 2,3,7,8-tetrachloro-*p*-dibenzodioxin underground. This 16-acre area is the largest single storage site of dioxin in the world. The problem with Hyde Park and other waste sites like it, is its location on relatively permeable rocks that make up the Niagara Gorge. There is potential for these chemicals to seep into surrounding soil and migrate from the site where they were deposited closer to the gorge. "I don't think any dioxin has yet broken through the gorge, but fingers of nonaqueous-phase pollutants have made their way out of the site and into Canada" says Gilbertson.

The Ministry of the Environment in Ottawa faces a $2 billion cleanup bill for abandoned contaminated waste sites that are under federal jurisdiction. By contrast, the U.S. Congress in 1980 legislated $1.6 billion a year for five years to clean up hazardous waste sites.

Waste management is a continuing problem. According to Dwayne Moore, senior evaluator in the Commercial Chemicals Evaluation Branch of Environment Canada, old landfills are reaching their capacity. "We're having a very difficult time finding replacement sites," says Moore. "Whenever a site is selected, local residents, quite understandably, became very vocal and fight it."

The goal of the Canadian government is to cut overall waste production in half by the year 2000. Eliminating half of the nearly 30 million tons of garbage generated each year requires better disposal of waste as well as recycling and finding new markets for reusable materials.

John Jackson, president of Great Lakes United (a coalition of business, labor, and conservation organizations from the United States, Canada, and native Canadian tribes referred to as First Nations), says, "We have to realize that these are valuable resources that we're throwing away. Instead, we should be reusing them. Reuse is much more efficient energy-wise and material-wise."

Recycling programs have gained popularity in Canada. Municipalities are enjoying the economic windfall of recycling programs. The dollar value of used newspapers, for example, has risen considerably in the last few years. Centrally located bins or curbside pickup of newspapers, cans, and bottles significantly reduce the amount of waste that winds up in landfills or incinerators.

"The cost of recycling newspapers and other items is high because environmental costs are not being factored in," Jackson says. "For example, many Canadian pulp and paper companies rely heavily on sales in the U.S.; increasingly, U.S. newspapers are not buying newsprint unless it has a certain percentage of recycled content, putting pressure on our pulp and paper industry to acquire used newspaper. Otherwise, they might lose the U.S. market because of its procurement requirements."

According to Jackson, a lot of industrial waste from Canada is trucked by private haulers into Ohio and Michigan. Advocacy groups believe that instead of dumping, companies need to concentrate on reducing industrial waste. "Our concern is if companies ship the waste somewhere else, there is no incentive to stop producing it because local residents will not have to complain about living next to landfills or incinerators," Jackson says.

Similarly, reducing the need for hazardous waste sites begins by modifying the industrial production of toxic substances. "If we don't use these hazardous chemicals in the first place, then the waste they produce won't be hazardous," suggests Jackson. "[The waste will] still be a problem but it won't contaminate the environment."

Sweeping in Clean Air

Hazardous substances such as organochlorines and pesticides are found not only in water and soil but are also carried on prevailing winds. These substances are as much an air pollution problem in Canada as the carbon dioxide, nitrogen oxides, and particulate matter emitted by industrial smokestacks, automobile tailpipes, and natural decay. Legislative responsibility for air pollution is shared between the federal and provincial governments. The CEPA oversees national air quality, while the provinces directly manage most environmental and resource issues within their borders. In 1994, a Hazardous Air Pollutants Task Group was established to define hazardous air pollutants and design a long-term strategy to manage them.

Air pollutants in major Canadian cities have been monitored since 1969 by the National Air Pollution Surveillance (NAPS) Network. More than 100 monitoring stations located in industrial, commercial, and residential areas measure levels of sulfur dioxide, carbon monoxide, nitrogen dioxide, ozone, and total suspended particulates.

Sulfur dioxide is generated by ore smelting, coal and oil burning, and gas and oil processing. When sulfur dioxide levels are high, people with asthma and bronchitis suffer respiratory problems. Carbon monoxide is emitted from vehicles, heating homes, and industrial production. When carbon monoxide levels are high, cardiovascular symptoms increase in people with heart disease, blood chemistries change, and respiratory problems rise. Nitrogen dioxide forms when vehicular and industrial fuels are burned at high temperatures. A major contributor to smog, nitrogen oxide can irritate the lungs, reducing their resistance to infection as well as to asthma. The number of times that sulfur dioxide, nitrogen dioxide, and carbon monoxide exceeded their maximum acceptable levels fell from an average of 10 per station in 1979 to well below one per station in 1992, according to an Environment Canada bulletin.

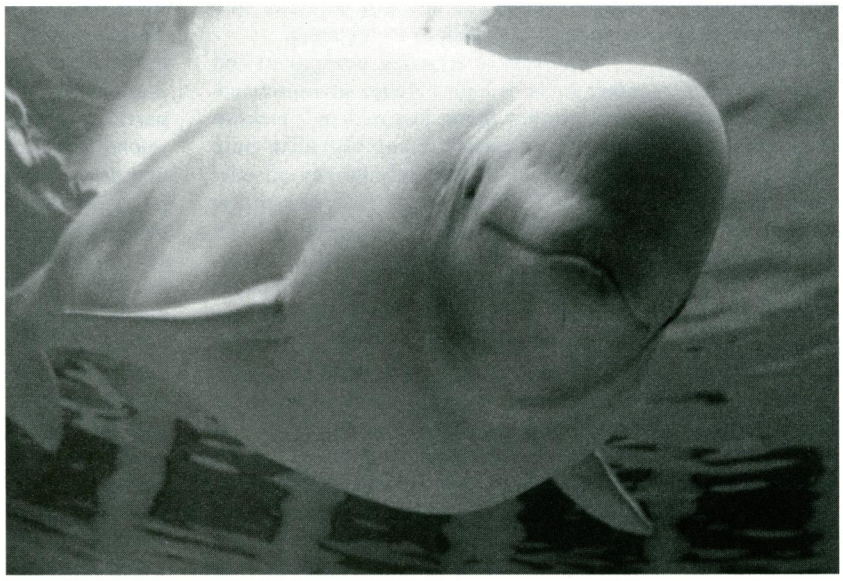
Ground-level ozone is a main component of smog. Ozone is formed by the reaction between volatile organic compounds and nitrous oxide in the presence of sunlight, and it causes pulmonary inflammation even in low doses. Studies have shown a positive association between daily hospital admissions for acute respiratory illnesses such as asthma and bronchitis and the level of ozone and sulfates.

Doug Russell, director of the Air Issues Branch of Environment

RCO

Bales of our existence. Recycling programs such as those that divert paper from the waste stream are reducing the need for landfills.

Canada, claims that ground-level ozone is responsible for much of the visible air pollutants in Canada. "We have identified three primary areas in Canada where ground-level ozone is most prevalent," says Russell. "Most of the smog is found in the Windsor to Quebec City corridor where we have major industry. The other two areas are the southwestern areas of Nova Scotia and New Brunswick and the lower Fraser Valley in British Columbia." Environment Canada is now targeting ground-level ozone and expects to reduce it by 40% by the year 2000.



Great Lakes United

A whale of a problem. Methylmercury and organochlorines bioaccumulate in fish and aquatic mammals like the beluga whale that make up a large portion of the diet of Canadian aborigines.

NAPS also monitors levels of total suspended particulates. Mining processes, vehicles, thermal power plants, and waste incinerators spew unacceptable levels of particulates into the atmosphere in Canadian cities such as Hamilton, Calgary, and Toronto, says David Bates, professor emeritus at the University of British Columbia School of Medicine. Particles smaller than 10 microns, known as PM_{10}, are generated by diesel as well as gasoline-powered vehicles. Health effects can be detected at concentrations as low as 100 $\mu g/m^3$.

"Data collected in the U.S. and Canada indicates a direct relationship between PM_{10} levels and daily mortality," suggests Bates. "A large study in Ontario shows that as aerosol sulfate levels rise, of which PM_{10} is a component, hospital admissions for cardiovascular disease increase as well. There is a direct link between mortality from heart disease and lung disease as the PM_{10} levels rise." According to Bates, this association holds for all of the 25 cities worldwide in which total suspended particulates have been studied. Canada is part of an international coalition working to reduce emissions of sulfur dioxide and the other pollutants that generate ground-level ozone.

Environmental Injustice

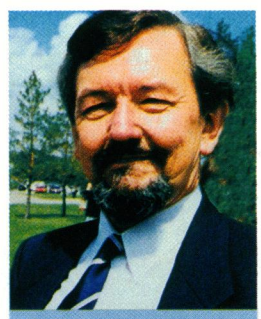
The aboriginal peoples of Canada—American Indians, Inuits, and metis (people of mixed Indian and French origins)—constitute about 1.5% of Canada's population. Yet, in spite of their relatively small numbers, Canada's native peoples are exposed more often to dangerous pollutants than Canadians in general.

"Aboriginal people, as part of their lifestyle, are frequently more exposed to environmental contaminants than the general population," reports Brian Wheatley, director for research and development of environmental contaminants for Health Canada. As an example, Wheatley cites his investigation of methylmercury levels carried out in 514 native communities across Canada. Of the 38,571 aboriginal people tested, 608 individuals had blood levels of methylmercury in excess of 100 parts per billion (ppb). Based on World Health Organization standards, Health Canada defines blood levels of methylmercury as "acceptable" if below 20 ppb and levels higher than 100 ppb as "at risk." The highest mean levels were found in the Inuit living in the Northwest Territories. In a study conducted by Éric Dewailly, director of Environmental Health Services, Quebec Community Health Department, the Inuit in northern Quebec had an average blood concentration of 22 ppb (reported as 104 nanomoles/liter) compared to 78% of Quebec City subjects who had a mercury level lower than 2 ppb (10 nanomoles/liter).

"The common link is almost certainly the traditional native lifestyle and the consumption of fish and sea mammals," Wheatley says. "Methylmercury, like organochlorines, bioaccumulates up the food chain in fish and aquatic mammals. Some cases can be associated with local industrial activity and the general increase in mercury in the global environment," said Wheatley.

Although the levels of mercury detected are too low to directly endanger adults, there is concern about neurotoxic effects on infants. In addition, there is great concern about the indirect effects of methylmercury on native peoples. Henry Lickers, director of the Environmental Division of the Mohawk Council of Akewsasne, says, "The Akewsasne reserve has been called the most polluted in Canada because of the multitude of contaminants such as PCBs, mercury, mirex, and more. People are no longer able to carry out traditional economies of fishing, hunting, trapping, and farming. Unable to share resources among our people by using traditional economies, we're seeing more non-traditional, disruptive economies coming from smuggling and gambling."

Wheatley also cites the impact of a recent survey of PCBs and other contaminants in breast milk from women on the Akewsasne reserve. The results showed PCB levels to be low, but the perception that their food was dangerous to eat caused many Akewsasne Mohawkes to change their lifestyle. Instead of eating a fish diet, high in protein, many have replaced fish with a relatively high carbohydrate diet. Such a change may lead to other problems. "We know there appears to be a predisposition in native people across Canada to develop adult-onset diabetes," Wheatley says. "Fifty years ago there was no diabetes in Akewsasne. The prevalence of diabetes on this reserve now is four times the Canadian average."



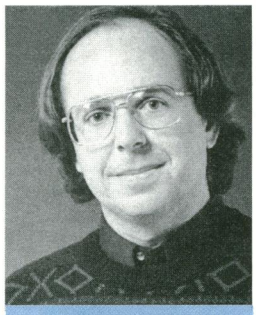
Health Canada

Brian Wheatley—Aboriginal people are more at risk from environmental contaminants.

The change from native foods has other health implications as well. "There are many benefits of traditional food," claims Dewailly. "The overall mortality and morbidity trends among the Inuit clearly show that heart disease and cancer are less prevalent among the Inuit. Their diet, high in lipids from sea mammals and fish, protects

them from these diseases. We have to balance the theoretical risk of the contaminants we're studying to the proven benefits of a traditional diet. We're pretty sure that the benefits of the food far outweigh the risks."

Breast milk has been monitored by Health Canada's Health Protection Branch since 1967 to determine infant exposure to environmental pollutants. W. Harvey Newsome of the Food Research Division of Health Canada recently reported the results of 497 human milk samples in a 1995 article in *Chemosphere*. Samples from across Canada were analyzed for 24 organochlorine pesticides and industrial chemicals as well as for 40 PCB congeners. "Compared to earlier surveys in Canada, concentrations of most residues determined declined and were lower than those reported recently in European countries," Newsome said.



Great Lakes United

John Jackson—If we don't use hazardous products, we won't create hazardous waste.

Future Trends

By most standards, Canada has done a remarkable job of cleaning up its environment. Pulp and paper mills, for example, have considerably reduced their emissions of organochlorines. The Great Lakes are being purged of pesticides as well as PCBs, dioxin, dieldrin, and heavy metals. Wildlife is beginning to return to the wetlands that had been damaged by toxic compounds. The volume of residential waste, along with industrial hazardous waste, is diminishing as communities and industry alike turn to recycling and reuse. The atmosphere is clearer and cleaner because leaded fuels were abolished in the early 1980s and provincial Environmental Ministries have enacted legislation limiting the number and kinds of pollutants that smokestacks can emit.

And this is only the beginning. Federal and provincial governments are working together on projects to clean up the St. Lawrence Seaway. The recently enacted Toxic Substances Management Plan will ensure that persistent, bioaccumulating toxic materials will be virtually eliminated. However, cautions Ontario's Smith, "In the future, toxic pollutants will come more from multiple, small sources such as transportation, combustion, and incineration. We're moving away from regulating heavy industry and moving into new areas and new threats to the environment."

Marilyn Citron

ISSX 1996 European Spring Workshop
Food Toxins and Host Mechanisms Conditioning Toxic Responses

Sitges, Spain
June 1–4, 1996

This European ISSX Workshop will take place Saturday, June 1–Tuesday, June 4 in the lovely seashore city of Sitges, located 30 km south of Barcelona. Workshop attendance will be limited.

The objective of the workshop is to bring together both senior and young scientists to present and discuss their latest contributions in diverse areas of host mechanisms, such as mechanisms of toxicity, role of biotransformation enzymes, and inhibitory and inducing effects which condition the response of xenobiotics. There will be particular emphasis on compounds present in diet. In addition to the opportunity for poster and oral presentations, the following subjects will be covered in scientific sessions:

- mechanisms of toxicity
- role of biotransformation enzymes
- inhibitory and inducing effects
- natural and artificial food toxins

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