Environment Canada Environnement Canada

Perfluoroalkyl Compounds in Sediments of Tributaries and Open-Water Areas of the Great Lakes

This fact sheet describes the occurrence and distribution of perfluoroalkyl compound concentrations in sediments across the Great Lakes basin. Spatial patterns reflect urbanization around the Great Lakes

CCGS Martin Karlsen

Canada

Introduction

The presence of persistent organic pollutants can adversely impact Great Lakes wildlife and biodiversity. Environment Canada conducts sediment research and monitoring programs to fulfill commitments under the Great Lakes Water Quality Agreement that include evaluating trends and identifying emerging issues. Sediment surveys have been carried out to measure the occurrence and spatial distributions of toxic substances including new chemicals such as the perfluoroalkyl compounds. Results of these investigations further our understanding of the role human activities play in discharging chemicals to the environment, and provide important information for developing effective strategies to mitigate deleterious effects.

Sediment surveys are conducted in both open-lake areas and rivers discharging the lakes. Locations of open-lake sampling sites reflect shore-based activities and inflows from tributaries. Tributary sampling is carried out to investigate sources of pollutants within the watersheds. Many contaminants are highly insoluble in water, and typically bind to sediments, allowing for assessment of recently deposited sediments in tributaries prior to discharge into the lakes. These sediments can provide time-integrated measures of the quality of particulate material being transported; virtually every accessible Canadian tributary discharging into the Great Lakes has been sampled, from Thunder Bay in the northwest to Cornwall in the east, which represents the upper reaches of the St. Lawrence River. Deep-water areas of the lakes correspond to depositional environments where contaminants are ultimately deposited, thereby becoming repositories through which aquatic biota may be exposed to toxic substances.

Jackfish Bay, Lake Superior

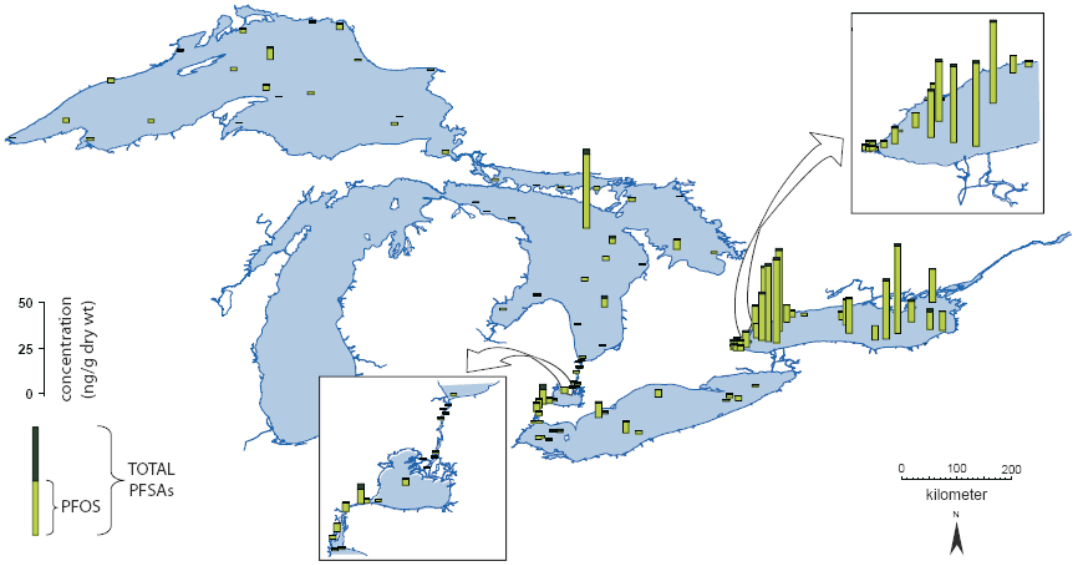
Perfluoroalkyl Compounds

Perfluoroalkyl compounds (PFCs) are a broad range of substances that have attracted much scientific and regulatory interest in recent years as a result of their detection globally in both humans and wildlife. PFCs are also routinely detected in rain, snow, and air in both urban and rural environments. These compounds have a myriad of applications, but have been primarily used as soil and liquid repellents for papers, textiles and carpeting. Other uses included metal plating and cleaning solutions, fire fighting foams, polyurethane production, inks, varnishes and lubricants. Production of PFCs as stain repellents in carpets historically exceeded $1 billion annually. Two classes of PFCs, the perfluorinated sulfonates (PFSAs), particularly perfluorooctane sulfonic acid (PFOS), and the perfluorinated carboxylates (PFCAs), particulary perfluorooctanoic acid (PFOA), are the most commonly monitored PFCs; these compounds are highly stable and persistent in the environment, and are potentially toxic. PFCs have been detected in environmental samples far from urban areas where their use is greatest, including remote areas such as the Canadian Arctic.

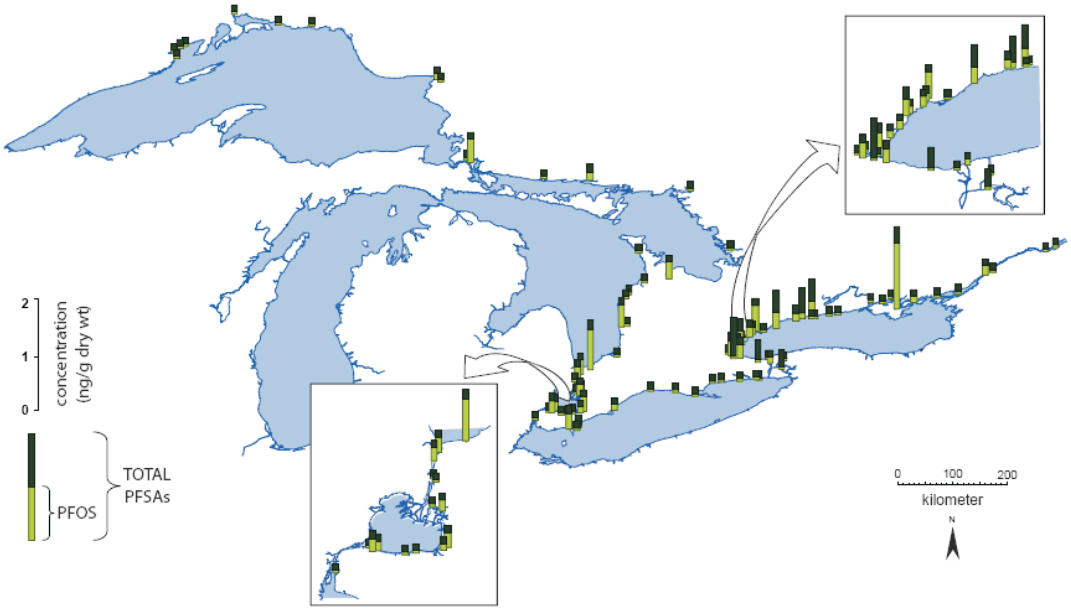
Open Lake Sediment Sampling

Total Perfluorosulfonates and Perfluorooctane sulfonic acid (PFOS)

Open Lake



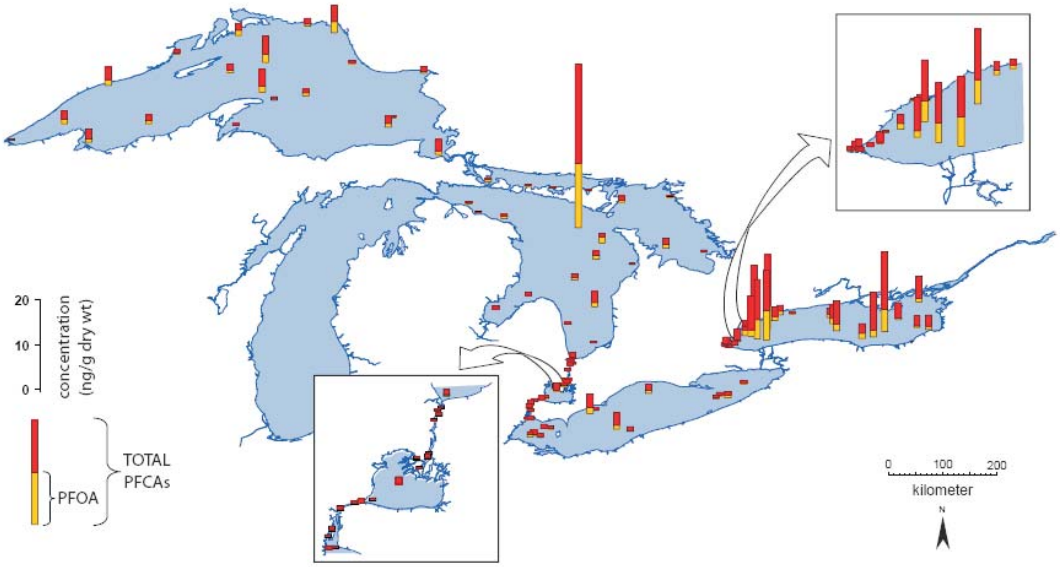
Tributaries



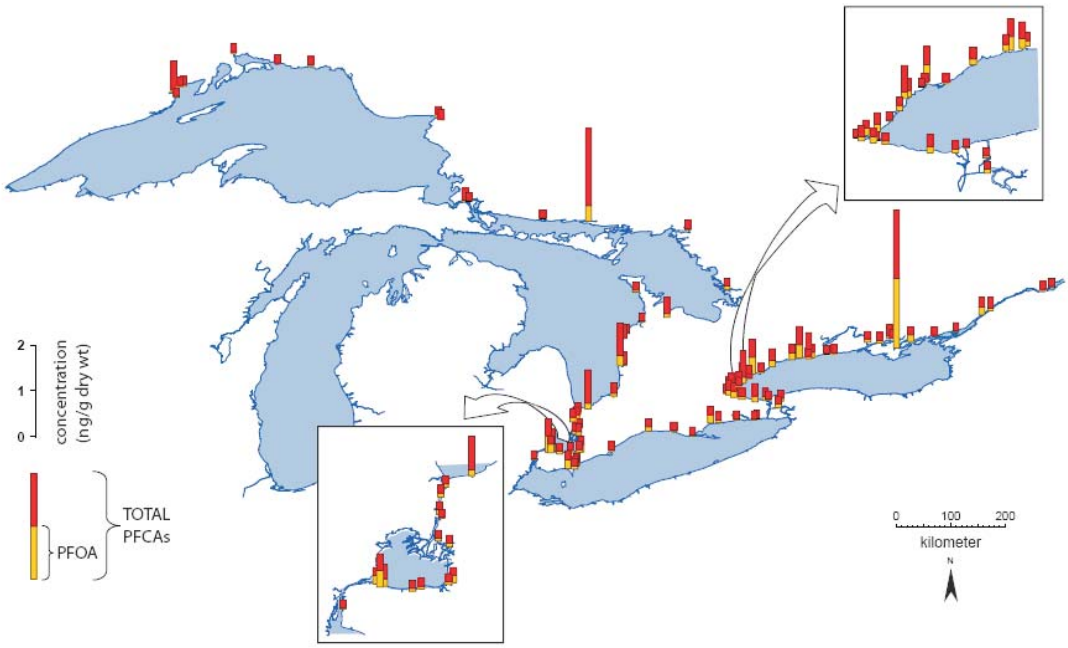
Total PFSAs and PFOS concentrations in surficial sediments in open water areas and tributaries of the Great Lakes. Source: Environment Canada and the Ontario Ministry of the Environment.

Total Perfluorocarboxylates and Perfluorooctanoic Acid (PFOA)

Open Lake



Tributaries



Total PFCAs and PFOA concentrations in surficial sediments in open water areas and tributaries of the Great Lakes. Source: Environment Canada and the Ontario Ministry of the Environment.

Findings

The physical and chemical properties of PFCs are different from many other semi-volatile pollutants in that many of these compounds have both hydrophobic and hydrophilic characteristics that can significantly influence their pathways through the environment. For example, PFOS partitions predominantly into the dissolved phase, thereby reducing the concentration in sediment. The solubility of PFOS also influences the relative contributions from sources such as sewage treatment plants (STPs), where the majority of PFOS would be associated with the effluent rather than biosolids. STPs can be a major source of PFCs to the aquatic environment.

As expected, concentrations of PFCs in sediments of Great Lakes tributaries are highest in urbanized and/or industrialized watersheds. In general, the highest levels of PFCs were found in areas of Lake Ontario and the western end of Lake Erie and the Detroit River corridor. There is a gradient toward increasing PFC contamination from the upper Great Lakes (Superior and Huron) to the lower Great Lakes (Erie and Ontario) for both tributary and open-lake sediments. Concentrations of PFCs in open-lake sediments are driven not only by proximity to source areas, but by physical processes and bathymetry as well. The highest PFC concentrations in open-lake sediments were found in Lake Ontario. The spatial distributions of PFCs in Lake Ontario are fairly consistent across the entire breadth, which is primarily due to the prevailing currents that evenly distribute suspended particles and their associated contaminant burdens among the three major depositional basins that represent most of the surface area of the lake.

The results of both the open lake and tributary PFC assessments corroborate the findings of other Environment Canada programs and those of partnering agencies. The spatial distributions of PFCs in Great Lakes sediments are heavily influenced by shoreline-based contemporary urban and industrial activities, which in some cases stand in contrast to distributions of legacy contaminants such as PCBs. These results suggest that large urban areas can act as diffuse sources of PFCs associated with modern industrial and consumer products, and therefore management action should focus on prevention of pollutant emissions from consumer and industrial products.

Management of Toxics in the Great Lakes

To address concerns about management of persistent, bioaccumulative and toxic substances in Canada, Environment Canada developed the Toxic Substances Management Policy in 1995. The policy promotes a precautionary approach to management. Canadian actions are derived from federal legislation with the Canadian Environmental Protection Act (CEPA) as the primary pillar, as it provides for assessment and management of

Canada Centre for Inland Waters

substances that may be released into the Canadian environment. The legislation was enacted in 1988 and updated in 1999. CEPA 1999 was strengthened by making pollution prevention the cornerstone of national efforts to reduce toxic substances in the environment, and shifted the focus from cleaning up environmental problems to preventing them. Several new mandates were introduced to establish more efficient processes of identifying and managing toxic substances.

Canada's new Chemicals Management Plan (CMP) improves management and regulation of hazardous chemicals. Taking action now will significantly reduce future costs associated with water treatment, clean-up of contaminated sites and treating illnesses related to chemical exposure. It will improve Canadians' quality of life and better protect our environment. The plan will also improve conditions for business in Canada by ensuring a level playing field within a predictable, science-based regulatory regime. This new plan will build on Canada's position as a global leader in safe management of chemicals, and will marshal better science to improve assessment and mitigation of risks.

As a result of the CMP, assessment of the occurrence and fate of new chemicals has been incorporated into Environment Canada's monitoring programs. Information from these programs will be a critical factor in development of sound science-based assessments of the threats posed by chemicals, and subsequently the best polices for management. These programs will also determine the environmental response to management actions on chemicals.

Bibliography

http://www.chemicalsubstanceschimiques.gc.ca/en/index.html

Acknowledgements

This fact sheet contains information produced in partnership with Anne Myers, Paul Helm, Eric Reiner and staff of the Ontario Ministry of the Environment.

For more information on Great Lakes water and sediment quality monitoring programs please contact:

Water Science and Technology Directorate
Environment Canada
Burlington, Ontario
L7R 4A6
Tel.: (905) 336-4641 Fax: (905) 336-4609
Email: Chris.Marvin@ec.gc.ca;
Debbie.Burniston@ec.gc.ca

Published by Authority of the Minister of the Environment

Locator No. WQMS 09005
Contribution No. 09755
ISBN No. 978-1-100-14025-4