Clearing the Air

Reducing Air Toxic Deposition in the Great Lakes

Great Lakes Commission
des Grands Lacs

Toxic chemicals are a serious threat to the health of the Great Lakes ecosystem. Preventing the entry of these chemicals into the lakes and mitigating their impact on human health were recently identified as major priorities for restoration of the Great Lakes ecosystem by both the Great Lakes Commission and the governors of the Great Lakes states. Chemicals such as mercury, polychlorinated biphenyls (PCBs), and dioxins pose threats to both human health and wildlife. These chemicals reach the lakes not only through discharges to water, but also through the deposition of airborne pollution via precipitation and other means. In addition to depositing onto a lake's surface, toxic contaminants can deposit on land and be washed into the lakes with surface runoff.

For many chemical contaminants, air pollution is the dominant route of entry into the Great Lakes system. For example, it is believed that more than 80 percent of the mercury that reaches the lakes is the result of direct deposition from the atmosphere. Safeguarding the Great Lakes ecosystem demands a multimedia focus, of which air quality management is a cornerstone.

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The Great Lakes Commission is leading several initiatives which take a multimedia approach to toxic substances management in the Great Lakes watershed and "airshed". For the past decade, the Commission has been coordinating the production of a comprehensive inventory of toxic air emissions. More recently, the Commission has begun administration of grant money under the federally funded Great Lakes Air Deposition (GLAD) Program, which supports innovative research into air toxic deposition. Combined, these efforts make the Commission an important partner in efforts across the basin to avert the threat of air toxic deposition in the Great Lakes.

The Threat

The most dangerous toxic contaminants in the Great Lakes basin are those that are persistent (do not degrade easily), accumulate in living things, and magnify as they move up the food chain. These persistent bioaccumulative toxics (PBTs) are known to cause serious harm to both humans and wildlife. Cancer, birth defects, mental impairments, and immune and hormonal dysfunctions are among the many effects that can be attributed to these toxic substances. Because many of the contaminants have their effects during fetal and childhood development, children and women of childbearing age are at highest risk. PBTs can accumulate in a women's body and be passed on to her children during both pregnancy and nursing. Also at high risk are populations whose diet centers around Great Lakes fish, including some Native American communities.

For most people in the Great Lakes basin, the most common means of exposure to these substances is by eating contaminated fish. This exposure can be worsened by additional exposures, such as through other types of food, air and drinking water. Fish consumption advisories have been issued for certain fish taken from the Great Lakes, their tributaries, and many inland lakes in the basin. Even pristine-looking lakes can contain highly contaminated fish because the major source for many contaminants is

through the air. Although adhering to fish advisories can reduce risk, current monitoring and advisory systems do not cover the entire basin adequately to ensure protection of the public's health. Even where fish monitoring and advisories are adequate, these exposure prevention efforts are not a permanent solution. Eliminating these substances from the ecosystem is the preferred solution.

Among wildlife, animals high on the aquatic food chain are at highest risk. Studies have shown that consuming fish from the Great Lakes increases wildlife mortality rates and impairs reproduction in such species as herons, eagles, gulls and terns.

The region's bald eagle populations are only recently recovering from the harm caused by dichlorodiphenyltrichloroethane (DDT) and PCB releases several decades ago. However, this recovery may be slowed or reversed due to increasing levels of other contaminants. Eliminating or reducing the emissions of these pollutants is essential in protecting the region's human and wildlife populations.

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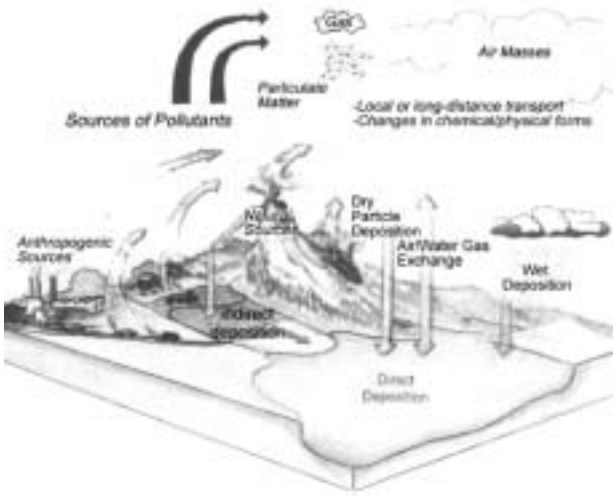

Figure 1: Air Toxic Atmospheric Transport and Deposition

Transport and Deposition

The pathway leading from PBT emissions to their entry into the lakes and their effects on humans and wildlife is long and complex. PBTs are emitted from a large variety of sources, both within the Great Lakes basin and beyond. For many PBTs, natural sources exist as well as human ones. Once emitted, these contaminants can travel long distances in the atmosphere, where they may undergo reactions, move between gaseous and particulate forms, and become dissolved in atmospheric water droplets.

The toxics deposit to the lakes by three major pathways: dry deposition (particulate matter), wet deposition (such as precipitation and fog), and gas exchange. The importance of each of these pathways varies with the type of contaminant and atmospheric conditions. Once they have entered the lakes, contaminants may be suspended again into the atmosphere, absorbed by biota, or settle in the lake sediment.

Bioaccumulation results in much larger concentrations of PBTs for those species, including humans, that are high on the food chain. PBTs have a high affinity for oils and fats and therefore accumulate in living things. At each stage in the food chain, concentrations of PBTs can be dramatically increased because an organism will retain the majority of the contaminants it consumes. As a

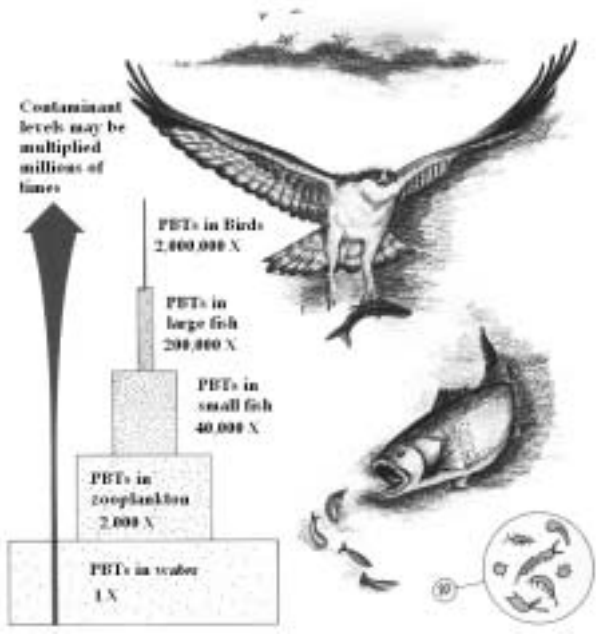

Figure 2: Bioaccumulation of PBTs in the food chain Adapted from College de l'Outaouais, Quebec

result, predators at the top of the food chain can have tissue concentrations of PBTs millions of times greater than PBT concentrations in water. The complexity of aquatic food chains makes this a greater problem than for land-based food chains.

Air Toxics Regulation

Air toxics are regulated in the United States under Section 112 of the Clean Air Act. This section gives the U.S. Environmental Protection Agency (EPA) the authority to regulate Hazardous Air Pollutants (HAPs), a group of 188 compounds containing most of those of highest concern in the Great Lakes. The main regulatory tool for HAPs is the requirement of Maximum Achievable Control Technology for all new and existing sources.

In Canada, toxic substances, including air toxic emissions, are regulated under Part 5 of the Canadian Environmental Protection Act (CEPA). CEPA requires "candidate substances" to be submitted to a substance assessment, where they are evaluated to determine if they are toxic, persistent, bioaccumulative and primarily the result of human activity. Substances that qualify are placed under regulation to achieve "virtual elimination," which requires actions to be taken to reduce environmental levels below the level of quantification. Substances failing in any of these categorizations may qualify for life-cycle management. In either situation, pollutants that are added to the list of toxic substances, which currently contains 68 substances or groups, can be subjected to a wide range of regulatory controls, including emission limits. In all cases, human and environmental risk, along with social, economic and technical factors, must be considered in developing regulations.

PCBs, as well as pesticides such as DDT and Lindane, have been banned in both Canada and the United States. However, many of these chemicals are still being used in other countries (e.g., DDT is still used for malaria control in many parts of Africa). International efforts to ban a number of persistent organic pollutants are being discussed at the United Nations.

Air toxic deposition programs in the basin over the last two decades have achieved notable results

In the Great Lakes basin, federal, state and provincial agencies have realized some success in addressing the threats of such chemicals to the Great Lakes ecosystem. These actions include regulations,

research, monitoring, and pollution prevention. The awareness of atmospheric contamination of the lakes led to the addition of Annex 15 to the Great Lakes Water Quality Agreement, and to establishment of the Great Waters Program as part of the 1990 Clean Air Act amendments.

Annex 15 commits the governments of the United States and Canada to take measures to combat the threat of persistent toxic substances in the Great Lakes basin through programs that monitor atmospheric levels of contaminants, research to determine the sources and total loadings of these chemicals to the lakes, and their health impacts on humans and wildlife. The pollution control and prevention provisions of Annex 15 are being implemented in part under the Binational Toxics Strategy, which has tasked the two nations with achieving substantial reductions in PBT emissions. These national efforts and activities complement the 1986 Great Lakes Toxic Substances Control Agreement signed by the Great Lakes governors. The governors and premiers have made prevention of PBT pollution and protection of human health priorities for Great Lakes restoration. Air toxic deposition programs in the basin have achieved notable results over the last two decades.

Regional Progress in Protecting Our Lakes

Control measures and bans on some of the most dangerous substances are having considerable positive effects. For several compounds, such as PCBs, DDT and dieldrin, the lakes are now releasing more of these contaminants than they are receiving from the atmosphere, resulting in a decrease in the levels of these chemicals in the lakes. This is a direct result of drastic decreases in emissions of these chemicals in the region and their consequent decrease in the region's air. The decrease in many of these chemicals is expected to level out in the future. Further reductions will depend upon elimination of sources elsewhere in the world, where many of these chemicals are still widely used.

New Dangers?
Progress has been made in addressing toxics such as DDT and PCBs over the past 20 years. However, new pollutants have emerged into the spotlight that may also pose large risks. One example is Polybrominated Diphenyl Ethers (PBDEs). These chemicals are used industrially as flame retardants in a wide range of consumer products and PBDEs can enter the environment during production, use, and disposal. The amounts of these chemicals in human blood and breast milk have been shown to have increased several-fold over the past two decades, and potential health effects for humans and wildlife have been identified and are being researched.

For many other toxic contaminants, significant local sources remain, although emissions and rates of deposition are decreasing. Examples of such sources are mercury, dioxins, and polycyclic aromatic hydrocarbons (PAHs). In addition, new threats to the region, such as from polybrominated diphenyl ethers (PBDEs), are rapidly becoming apparent.

Research, monitoring and modeling to predict current and future impacts on the basin ecosystem are all essential in understanding the complicated processes of emission, transport, deposition, sedimentation, bioaccumulation and exposure. Toward this end, the Great Lakes Commission is significantly increasing its role in regional air quality research, management, policy development and implementation. Among others, this includes administering the federally funded GLAD Program and enhancing the ongoing regional inventory of air toxics.

GLAD to be Part of a Basinwide Toxic Reduction Strategy

The GLAD Program involves the administration of grant funds designated for research projects relating to the deposition of air toxics. Specifically, this program supports scientific assessments of the contribution and impacts of air-deposited persistent bioaccumulative toxics and, in so doing, helps inform deposition reduction strategies. Under U.S. EPA direction, previous GLAD-funded projects include the Lake Michigan Mass Balance Study, the Integrated Atmospheric Deposition Network, and the Commission's Great Lakes Air Toxic Emissions Inventory project. Important progress has been made under such programs, and the Commission will continue to increase its involvement in these important issues.

A unified, basinwide approach to combatting the threat posed by air toxic deposition is essential. The Commission is pursing a wide range of priority actions. The GLAD Program intends to sponsor and closely integrate regional efforts under these areas of focus:

Air Deposition Monitoring
Provides needed information for determining spatial and temporal trends, benchmarking and measuring progress, and informing and validating other program components

Emission Inventory Development
Provides comprehensive and consistent information concerning the sources of toxic air emissions throughout the basin

> A unified, basinwide approach in combatting the threat posed by air toxic deposition is essential

Monitoring Toxics over Lake Ontario
A recent GLAD-funded project is the Lake Ontario Atmospheric Deposition Study (LOADS). LOADS researchers are monitoring a large number of PBTs both on the Lake Ontario shoreline and aboard a research vessel. The information gained will provide a basis for improved estimates of how much of these contaminants are moving between the air and water. In addition, researchers will be able to analyze these data along with meteorological data to determine what areas are contributing the largest portions of these contaminants.

Source Characterization / Emission Factor Development
Identifies additional sources and improves emission estimates

Atmospheric and Multimedia Modeling
Predicts the transport and fate of toxic substances throughout the environment, including air, water, sediments, soils and biota

Assessment of Effects on Wildlife and Human Health
Monitors indicator species, estimates exposures and provides awareness of the magnitude of impacts caused by deposited toxic substances

As a whole, this work will help clarify where toxic contaminants are coming from, where they go, and how they affect humans and wildlife. In so doing, the GLAD projects will help inform effective toxic emission reduction policies and related management initiatives. The Commission, under the guidance of a project management team comprised of officials from the eight Great Lakes states and with advice from a binational technical review team, will administer grants designed to fulfill these goals.

The GLAD Program guidelines and Request for Proposals (RFP) can be accessed at **www.glc.org/glad**

Inventorying Toxic Emissions

Over the past decade, the Great Lakes states and Ontario have been developing a system for tracking air releases of toxic compounds in Great Lakes jurisdictions. The Great Lakes Air Toxic Emissions Inventory project has continually improved the quality of its methods and results. This comprehensive regional effort has enhanced our ability to understand, and therefore respond to, the problems caused by air deposition of toxic contaminants in the Great Lakes.

The Great Lakes Air Toxic Emissions Inventory provides researchers, policymakers and the general public with regionwide data on the sources and emission levels of toxic contaminants. Point, area and mobile sources are tracked. In addition to its value as a research tool, it is also used to inform decisions about how to reduce toxic contamination levels in the lakes and prevent exposure to humans and wildlife. The latest inventory, covering 1999 data, was released in May 2003. Of the 213 compounds inventoried, toluene had the highest estimated release by weight, at more than 400,000 tons. Mobile sources, such as automobiles, contributed significant portions of the emissions of many non-metal compounds, such as toluene, benzene and xylene. For many metals, such as manganese, lead and nickel, primary metal industries accounted for more than half of the reported emissions. In all, more than 850,000 tons of emissions were estimated for 1999, including over 3,000 tons of metals and nearly 7,000 tons of PAHs. Selected results from the inventory are shown in figures 3 and 4.

Common Sources of Toxic Air Emissions

- Point Sources
  - Industrial facilities
  - Waste incinerators
- Area Sources
  - Dry cleaners and other small facilities
  - Agricultural chemicals
  - Construction activities
  - Landfill operations
- Mobile Sources
  - Automobiles
  - Diesel trucks
- Non-road Engine Sources
  - Lawn mowers
  - Construction equipment
  - Off-road vehicles
  - Boats
  - Trains
  - Airplanes

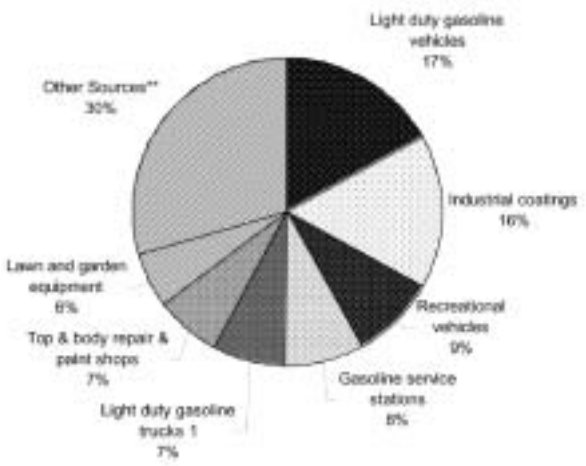

Figure 3: Regional Xylene Emissions by Source Category

The recent inventory reported that the largest source of mercury emissions in the region was coal combustion, primarily for electricity generation, totaling 44 percent of all mercury emissions. Heavy-duty diesel vehicles contributed 15 percent. Other large contributors were refuse incineration, chlor-alkali plants, and medical/hospital facilities, each contributing over 4 percent.

Understanding the sources of PBTs is an important first step for policymakers and resource managers. For example, U.S. federal legislation proposing reductions of mercury emissions from power plants to 10-55 percent of current values over the next 5-15

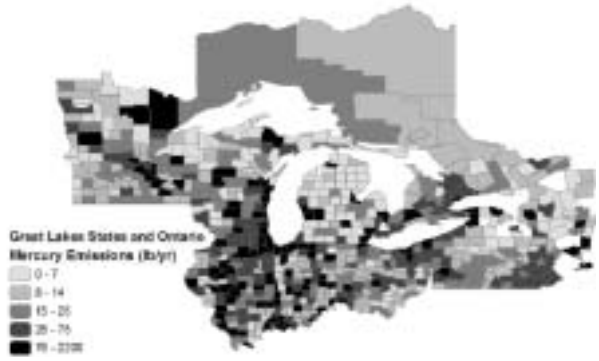

Figure 4: Regional Mercury Emissions by Geographic Area

The Regional Air Pollutant Inventory Development System (**RAPIDS)** software has set the standard for tracking toxic pollutant emissions. RAPIDS is widely used within the Great Lakes states and provinces and is also being recognized by the United Nations Institute for Training and Research. This tool allows for a consistent and common base of information, ensuring a compatibility of derived data between jurisdictional agencies and corporations. Ongoing development and enhancements will improve data accessibility and support air regulatory agencies nationwide.

years is currently making its way through Congress. The inventory results suggest that such legislation could significantly reduce emissions in the Great Lakes basin.

The Great Lakes Commission is planning to enhance decisionmaking by adding features to the Great Lakes Air Toxic Emissions Inventory that yield a more comprehensive, web-based, reporting system and a more convenient access point to information. Users will be able to query and view data by geography, source type and industrial process, among other variables. This new data interface will increase the availability of data from the inventory to both the public and the research community. Continued improvements in methodology will ensure that the Great Lakes Air Toxic Emissions Inventory remains the most comprehensive and accurate inventory of its kind. Continuous review and revision of the inventory protocol will help to ensure that the inventory is consistent among all eight states and the province of Ontario.

By providing scientific support for informed decisions, the Commission's air toxic initiatives will help achieve a cleaner environment, a more prosperous economy and a higher quality of life

Taking Action

Protecting the Great Lakes ecosystem from the continuing threat of airborne toxic contaminants is a priority of the Great Lakes Commission. The challenge is focused on two fronts: reducing emissions from sources within basin jurisdictions, and also working on a global level given that sources around the world affect the Great Lakes ecosystem.

Actions to reduce the loadings of toxic substances to the Great Lakes will require a strong scientific base and associated data and information. The GLAD Program and the Great Lakes Air Toxic Emissions Inventory are instrumental in supporting sound public policy decisions. By strengthening the scientific, technological, and information base for decisions, these initiatives will help achieve a cleaner environment, a more prosperous economy and a higher quality of life. The Great Lakes Commission is committed to working with its member states and provinces, and the entire Great Lakes community, toward this end.

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Great Lakes Air Deposition Program

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Image Credits

Figure 1: U.S. Environmental Protection Agency
Figure 2: College de l'Outaouais, Quebec
Figure 3: Great Lakes Commission
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