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Pollutants

Persistent Bioaccumulative Toxic Substances

Key Findings

- Persistent bioaccumulative toxic substances (PBTs) are chemicals that break down slowly in the environment, accumulate in humans and other species and are toxic. Although only a limited number of PBTs are currently receiving attention, more may be identified through ongoing screening activities.
- PBTs may be released intentionally (such as pesticides) or unintentionally (such as combustion or manufacturing byproducts). Some PBTs are dispersed globally by air currents and other environmental pathways, resulting in contamination even in regions far from their points of origin.
- Comprehensive biomonitoring data are not available for all of North America, but local and country-specific studies have measured PBT levels in humans and wildlife. The implications of these findings are under investigation in all three countries.
- The levels of certain PBTs in the environment have been reduced by eliminating or reducing releases and adopting alternatives, but recovery times are slow because these chemicals do not break down to harmless byproducts easily or quickly.

Persistent bioaccumulative toxic substances **(PBTs) are chemicals that do not degrade easily in the environment. PBTs typically accumulate in fatty tissues and are slowly metabolized, often increasing in concentration within the food chain. Certain PBTs have been linked to adverse health effects in both humans and animals.**

What Is the Environmental Issue?

There is substantial evidence that persistent bioaccumulative toxic substances (PBTs) cause long-term harm to human health and the environment. This evidence has provoked an international response to the problem (see box).

PBTs and Human Health

In North America, humans are exposed to many different environmental contaminants, including certain PBTs. Studies have linked various PBTs to a range of adverse effects in humans, including nervous system disorders, reproductive and developmental problems, cancer and genetic impacts. Certain PBTs mimic hormones, possibly altering sexual characteristics and other hormonal functions.

PBTs and Animal and Plant Health

Like humans, animals and plants are exposed to PBTs in the environment through air, water and food. The animals most likely to be exposed to toxic levels of PBTs are those higher up in the food chain, such as marine mammals, birds of prey and certain fish species. The fish consumption advisories issued by governments around the Great Lakes and elsewhere are designed to protect people from the risks of eating contaminated fish. Mercury, polychlorinated biphenyls (PCBs), chlordane, dioxins and DDT—the PBTs that commonly contaminate fish—accumulate in fish tissue at concentrations thousands of times higher than in the water. PBTs can stay in sediments for years, a source of contamination for bottom-dwelling creatures that are then eaten by predators (see illustration of bioaccumulation and biomagnification).

An International Response to PBTs

With 151 other nations, Canada, Mexico and the United States are all signatories to the Stockholm Convention on Persistent Organic Pollutants (May 2001). Canada and Mexico have ratified this treaty, but the United States has not.

The Convention identifies 12 organic PBTs for control. These chemicals fall into three categories:

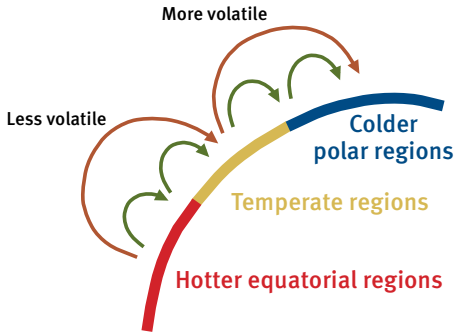
Pesticides—aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, hexachlorobenzene (HCB), mirex and toxaphene

Industrial chemicals and unintended byproducts—HCBs and PCBs

Unintended byproducts—dioxins and furans.

Many of the 12 chemicals covered by the Stockholm Convention are no longer produced, and yet they persist in the environment. Even though only a limited number of PBTs are currently receiving attention, more may be identified through ongoing screening activities.

The grasshopper effect and global distillation



Source: Environment Canada.

The persistence of these substances in the environment is considerable. Chlordane was banned in the United States in 1988, but 105 fish consumption advisories were still issued for this substance in 2006. Likewise, DDT has been banned since 1975, but 84 DDT-related fish consumption advisories were still issued in 2006 in the United States.

Why Is This Issue Important to North America?

PBTs are intentionally and unintentionally released into the environment. Once in the environment, some PBTs can readily disperse throughout specific regions and across international boundaries, both within North America and globally. PBTs are of particular concern to North America because they are found in environmentally sensitive areas, such as the Arctic (see illustration of pathways into the Arctic), the Great Lakes and the Gulf of Mexico.

Sources of PBTs

Worldwide, all industrial sectors use chemicals, but certain sectors are more likely to emit PBTs. These emissions may originate from either intentional releases—such as pesticides with PBTs as impurities—or unintentional releases—such as combustion byproducts (e.g., dioxins and furans).

PBTs continue to be released as the byproducts of industrial activities. Mercury releases through coal-fired electricity generation, for example, have increased since the beginning of the industrial age in the mid-1800s. Rates of mercury deposition from the atmosphere have increased globally 200–400 percent since the industrial revolution, increasing the potential human health and ecosystem effects of mercury worldwide.

Transport

A major concern with some PBTs is the ease with which they can move through the environment. PBTs make their way into remote regions by traveling long distances in a series of "hops" involving a complex cycle of long-range atmospheric transport, deposition and revolatilization, collectively called the "grasshopper effect." Eventually, they accumulate in cold regions such as the Arctic by a process called "global distillation" (see illustration).

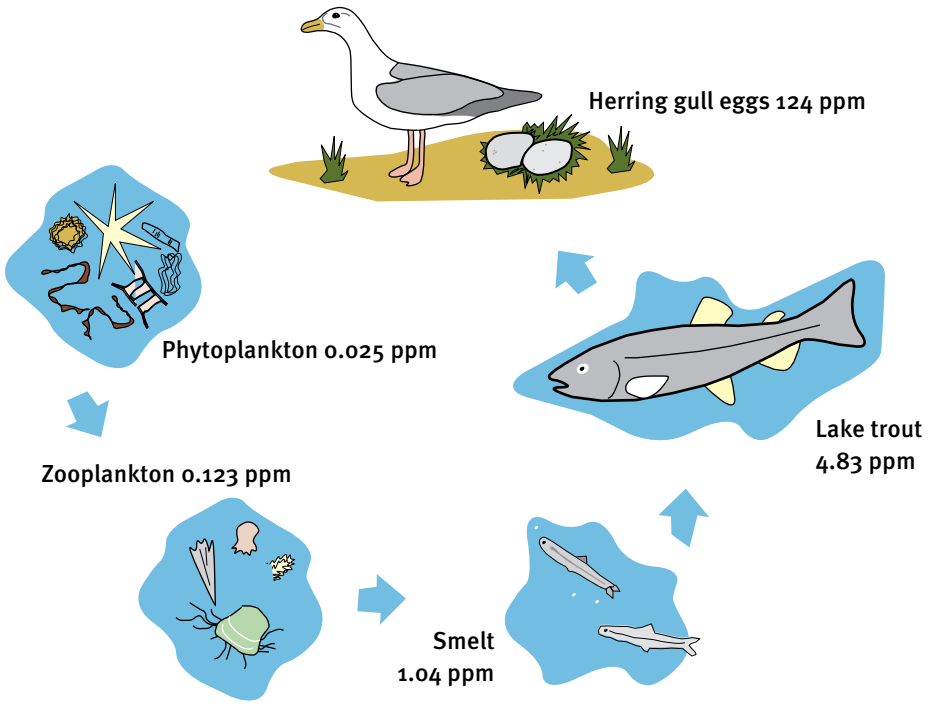
Because PBTs are often relatively volatile, they may enter the atmosphere where they can be carried with the winds, sometimes for long distances. Through atmospheric processes, either because the molecules are carried down with precipitation or because particulate matter settles, they are deposited onto land or into water ecosystems where they accumulate and may cause damage. From these ecosystems, they may evaporate, again entering the atmosphere, ultimately traveling from warmer temperatures toward cooler regions. Whenever the temperature drops, they condense out of the atmosphere, frequently reaching higher concentrations in circumpolar regions and in high altitudes because there is insufficient thermal energy to go through another evaporation cycle. Through these processes, some PBTs can move thousands of kilometers from their sources of emission and accumulate in polar latitudes. In addition to releases within the region, North America is also affected by the long-range atmospheric dispersal of PBTs from global sources.

Biomonitoring

The human populations exposed to PBTs include groups of special concern such as children and developing fetuses. Children are especially vulnerable to toxic chemicals because of their unique physiology and developmental and behavioral characteristics. The biomonitoring data needed to measure the occurrence of PBTs in humans are not readily available for North America as a whole, but some insights can be drawn from more localized studies:

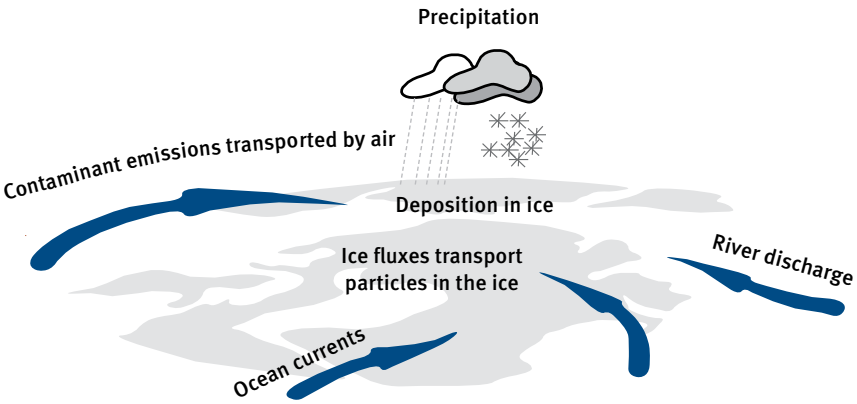
- In the Canadian Arctic, the Arctic Monitoring and Assessment Programme has determined that the high exposure levels found in some Arctic communities may have a negative influence on human health. Although there is still no direct evidence of adverse effects on health status (mortality and morbidity) at

Changes in the concentration of PBTs as they move up the food chain



ppm = parts per million. Adapted from: US Environmental Protection Agency.

Pathways of contaminants to the Arctic



Source: Arctic Monitoring and Assessment Programme.

the population level, there is reason for concern and a need to continue to reduce human exposure based on the weight of all available evidence.

- In Mexico, organochlorine (OC) pesticides, which are also PBTs, were measured in the ambient air of Chiapas during 2000–2001. Concentrations of some OC pesticides (DDTs, chlordane, toxaphene) in this area were elevated compared with levels in the Great Lakes region. This finding suggests that southern Mexico may be a source region for this group of chemicals, but comparably high levels have also been reported in parts of the southern United States, where their suspected sources are emissions from historically contaminated soil (DDTs, toxaphene) and past termiticide usage (chlordane). Agricultural workers may be at risk because of exposures to these PBT chemicals.
- In the United States, about 6 percent of women of child-bearing age had 5.8 parts per billion or more of mercury in their blood from 1999 to 2002. Concentrations below 5.8 parts per billion are unlikely to cause appreciable harm. Based on these survey results and the number of births each year, it is estimated that more than 300,000 newborns each year in the United States may have an increased risk of learning disabilities associated with *in utero* exposure to methylmercury.

What Are the Linkages to Other North American Environmental Issues?

Persistent bioaccumulative toxic substances are linked to biodiversity, international trade and climate change.

Biodiversity

The effect of PBTs on biodiversity in North America was first evident when peregrine falcons, eagles and other top predators began to disappear in the 1970s because of DDT in the food chain. Although these highly visible species have recovered through interventions and through the banning of some PBTs, other species may still be affected by the presence of PBTs in the continent's ecosystems.

Trade

International trade can introduce PBTs into North America despite rigorous efforts to prevent their release here. Consumer goods and products sold in North America are increasingly manufactured, grown or otherwise handled in nations whose requirements related to PBTs may differ from those in North America. An example is food imported from other countries that have been treated with pesticides still in use there such as DDT, aldrin and chlordane.

Climate Change

Normal atmospheric conditions carry mercury and some other PBTs emitted by fossil fuel combustion and other industrial activities northward, where these substances eventually settle on land or water surfaces. For example, the boreal forest region in northern Canada and Alaska is a resting place for years of past emissions. Because climate change affects northern forests and wetlands, mercury previously deposited into cold, wet soils may be released again through wildfires. In response to the drier conditions in northern regions, soil will relinquish its hold on hundreds of years of mercury accumulation, sending it back into the air. The projected increases in boreal wildfire activity stemming from climate change are expected to increase atmospheric mercury emissions, exacerbating exposure in northern food chains.

Selected Industries and Processes Associated with PBTs

Manufacturing	Thermal processes	Certain products with PBT impurities	Recycling processes
■ Production of chlorinated organic chemicals ■ Pulp and paper production ■ Oil refining and catalyst regeneration ■ Chlorine production using graphite electrodes	■ Iron ore sintering for blast furnaces ■ Primary copper smelting ■ Secondary scrap metal processing ■ Cement kilns ■ Mineral processing: lime, ceramic, glass, brick ■ Waste incineration: municipal, hazardous, medical/clinical ■ Coal and oil combustion vehicles and stationary motors	■ Pesticide/herbicide application ■ Preservatives for wood/leather/textile ■ Solvent use and application ■ Industrial bleaching processes ■ Textile/wool/leather dying and finishing	■ Metal, paper and plastics recycling ■ Sewage and paper sludge and effluent application on land ■ Solvent and waste oil recovery ■ Pentachlorophenol-treated wood

Source: United Nations Environment Programme.

Case Study – Toxics in Osprey Eggs: An Indicator of Contaminants in the Fraser and Columbia River Basins

Ospreys, which are fish-eating migratory birds, are exposed to pollutants that accumulate in aquatic food chains and, as a result, are a good indicator species of aquatic ecosystem health.

A long-standing monitoring study of the levels of chemicals found in migrating ospreys has provided information about the PBTs that have accumulated in the birds and the origins of the substances. The results also suggest important questions about exposure and bioaccumulation in humans.

Ospreys migrate between Latin America and the Fraser and Columbia River Basins in the Pacific Northwest of North America. The PBTs found in ospreys include industrial OCs (dioxins, furans and PCBs), OC pesticides (DDT metabolites, dieldrin, chlordane and toxaphene) and mercury. In particular, DDT, PCBs, and dioxins and furans are historically associated with reproductive failure and population declines in osprey.

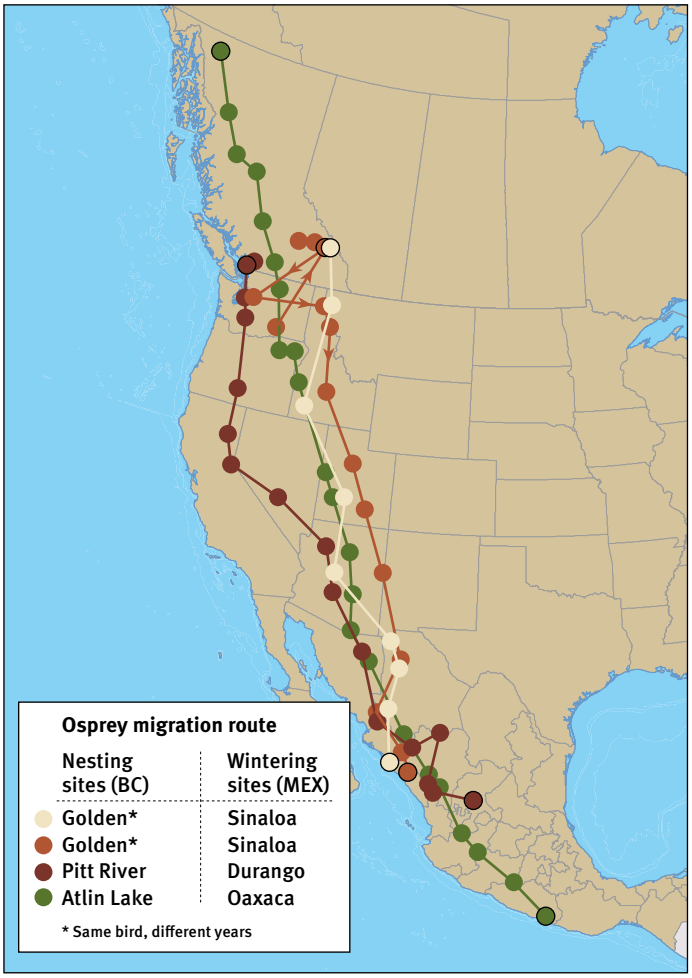
Researchers have found that some of the toxic contaminants in the ospreys originate from industrial sites still operating in the Fraser and Columbia River Basins and the sites of closed industries where residues remain. The remaining toxics originate in Asia and potentially in food sources at the osprey's wintering grounds in Latin America.

The Canadian Wildlife Service, along with Mexican and US agencies, has collected data on the migratory habits of ospreys. They were tracked from their nesting grounds in the Fraser River Basin to areas of intensive agriculture in Mexico (see map), and other Central American countries.

From 1997 to 2004, the osprey population along the lower portion of the Columbia River increased from 94 to 225 occupied nests, almost a 14 percent annual rate of increase. The rate of population increase was associated with higher reproductive rates than in previous years and significantly lower egg concentrations of most OC pesticides, PCBs, dioxins and furans. Indeed, the levels of observed egg residue concentrations in 2004 indicated that reproduction at few, if any, nests was adversely affected by the presence of such pesticides. As recently as 1997–1998, the DDT metabolite DDE was still causing reproductive failure for a portion of this population. Only mercury showed a significant increase in eggs over time, but the concentrations in 2004 remained below those established to have effects on birds.

Because ospreys feed on a variety of sport fish species, the ongoing monitoring of contaminant levels in this bird serves as an early warning about the toxic substances potentially consumed by humans.

Satellite telemetry of osprey migration routes



Adapted from: J. Elliott, D. P. Shaw and D. Muir, "Factors Influencing Domestic and International Sources of Chlorinated Hydrocarbons to Fish and Ospreys in British Columbia," Toxic Substance Research Initiative, Final Report, TSRI #224. Vancouver, (unpublished).

Osprey.