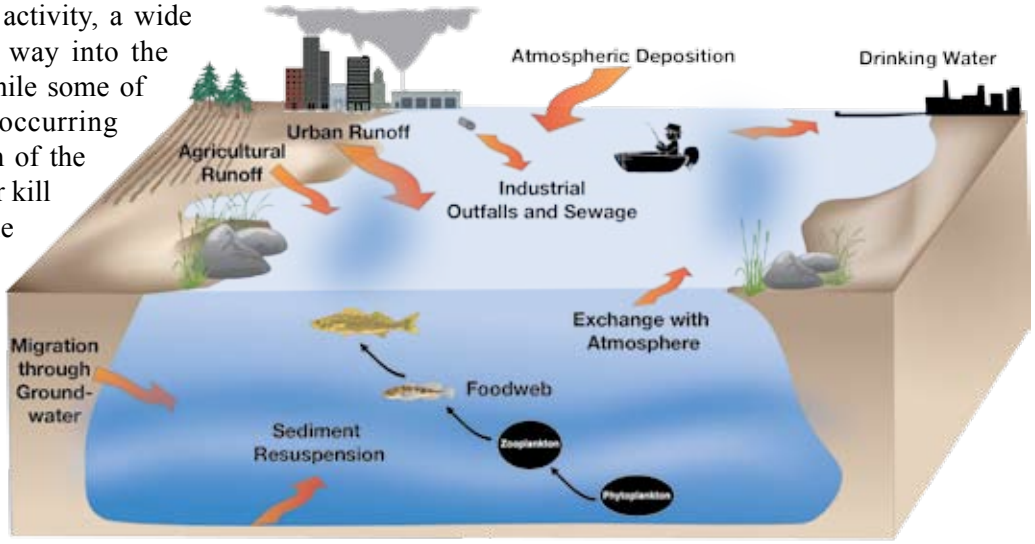
Waterborne Contaminants in the Great Lakes

What are Contaminants? Why are they a Problem?

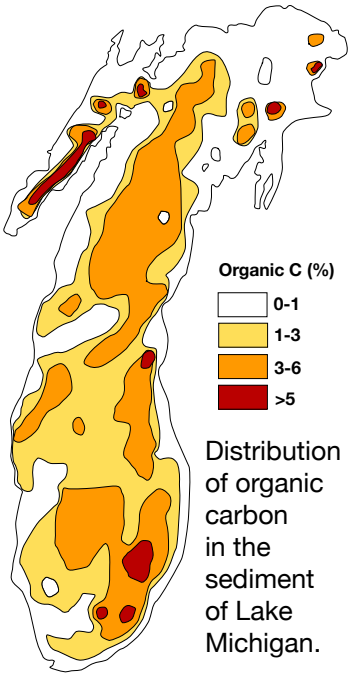
Every day, as a result of human activity, a wide variety of chemicals make their way into the Great Lakes by air and water. While some of these compounds are naturally-occurring and pose little threat to the health of the lake ecosystem, others can harm or kill plant and animals throughout the food chain, including humans. These compounds are commonly called "contaminants" and when they occur in high enough concentrations to injure, they become "toxic contaminants". Contaminants are highly varied in chemical composition and behavior. One large family called "organic contaminants" includes compounds made up mainly of chains, branches, or rings of carbon atoms as well as atoms such as chlorine, oxygen, nitrogen, etc. These materials have valuable applications in industry, transportation, energy production, and commerce. However, when carried into the Great Lakes ecosystem, organic contaminants may pose serious hazards. While environmental regulations over the past 25 years have helped stem the spread of these materials, the contaminants still reach Great Lakes waters via storm-drain runoff, leaking landfills, rivers and streams, accidental spills, or by fallout from polluted air.



Sources of contaminants within the Great Lakes ecosystem.

A second set of compounds called "inorganic contaminants" pose similar harmful threats to Great Lakes biota and may behave in similar ways to their organic counterparts. Inorganic contaminants include heavy metal compounds such as mercury and lead.

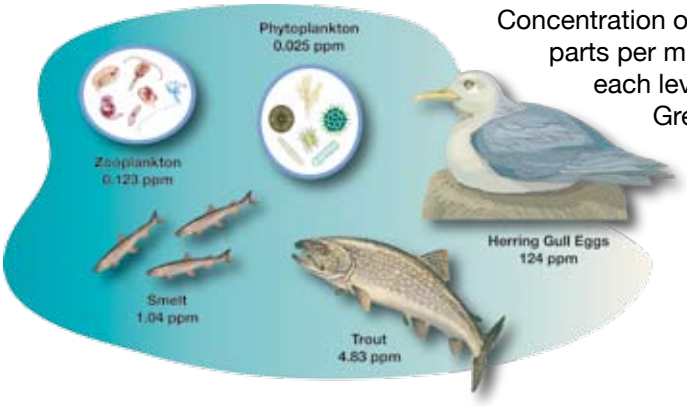
Organic Contaminants - What happens to them when they get into Great Lakes Water? Where do they Go? What's the Impact?



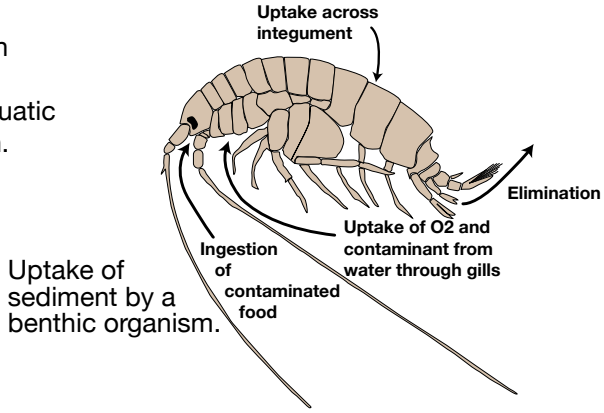
Distribution of organic carbon in the sediment of Lake Michigan.

When most organic contaminants reach Great Lakes waters, they do not readily dissolve or form chemical bonds with water molecules. Instead, they stick (adsorb) to any fine organic-rich particles that may be in the water. These particles are microscopic in size and are derived from erosion of rocks and soils, and biological processes. Eventually, the particles settle to the bottom, becoming part of lake sediments. Depending on water movement (currents) above the lake bottom, or human activities (dredging or shipping), the particles and their attached contaminants may be either picked up and moved elsewhere (resuspended) or may remain permanently on the lake bottom, eventually being buried beneath other particles settling to the bottom.

At NOAA's Great Lakes Environmental Research Laboratory (GLERL), scientists study how waves and currents act to transport fine particles and to determine the final destination of harmful contaminants that might be onboard. That's only part of the story however, because animals living in the lake's water column, or on the bottom, actively feed on these fine particles, digesting bacteria and other microscopic food sources carried on them. Unfortunately, during such digestion, animals often absorb harmful contaminants as the particles pass through their digestive tract. Contaminant exposure is more severe for benthic (bottom-dwelling) animals living in sediments at the lake bottom. In addition to a diet of contaminant-laden food, benthic animals are in constant contact with surrounding sediment particles and water (porewater). Under these conditions, contaminants can be absorbed across the animal's skin, or through their gills as they extract dissolved oxygen from water. With continued exposure through these routes



Concentration of PCBs (in parts per million, ppm) in each level of the Great Lakes aquatic food chain.



Uptake of sediment by a benthic organism.

over the course of an animal's life, contaminant concentrations accumulate within the body and may reduce growth rate, chances for successful reproduction, and long-term survival. Moreover, if the animal is eaten by a predator, its body burden of contaminants is transferred, beginning the process of biomagnification of contaminants up the food chain. This means that each higher level up the food chain faces a diet that is progressively richer in contaminants. At the top of the food pyramid, high levels of organic contaminants in the diets of fish-eating birds and mammals has produced abnormal deformities and prevented successful reproduction. Humans who consume Great Lakes fish are also at risk, prompting the issuing of government health advisories on what species and amounts of fish that can be eaten safely.

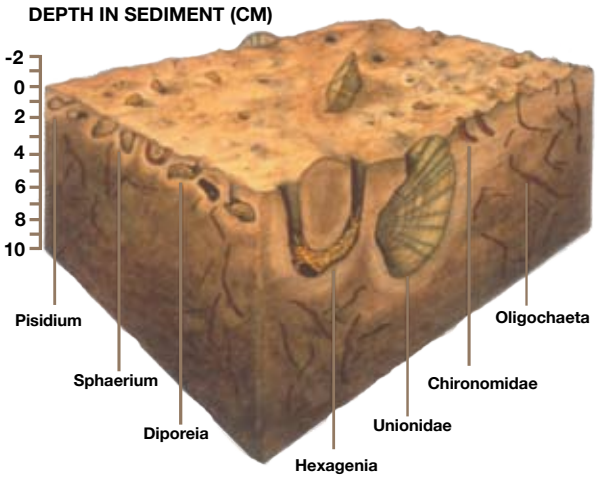
How much do we know about the Cycling of Organic Contaminants in the Great Lakes? What can be done to Reduce this Threat?

One key to eliminating contaminants as a threat to the Great Lakes ecosystem lies in developing a detailed scientific understanding of how such chemicals behave once they are released, with the goal of cleaning up the most harmful compounds, and preventing them from entering the lakes in the future. Such research is no easy task. The chemistry of how contaminants interact with water, sediment particles, and resident plant and animal species is complex. In addition, the chemical structure and behavior of a contaminant may change, particularly when it is incorporated into the chemical machinery of living things.

At GLERL, much work has focused on examining how groups of organic contaminants such as PCB's behave once they reach lake bottom sediments and their resident benthic animal populations. This research has shown that various species of invertebrates living in lake bottom sediments forage and feed differently with corresponding differences in the effects of organic contaminants. Oligochaetes (worms) feed on smaller particles and deposit fecal matter at the surface of the sediment. These organisms, therefore, move buried contaminated sediments to the sediment surface, maintaining high contaminant concentrations there. Amphipods are small crustaceans about a quarter-inch in size that freely burrow and feed in the uppermost inch and surface of the lake bottom. Many insect larvae build tubes in the sediment and filter out fine material that settles onto the surface of sediment. Bivalves (clams and mussels) sit in or on the sediment and filter the overlying water. All of these animals ingest some of the sediment particles and contaminants associated with them.

What's Ahead?

Thanks to increased scientific understanding of how contaminants enter and travel through the Great Lakes ecosystem, much has been done to stem their spread and reduce their harmful impact. With more effective control and management plans, the input of contaminants to the lakes over time should diminish. Moreover, since these compounds attach to particles and eventually settle to the lake bottom, fewer contaminants entering the lakes will mean that the "rain" of particles to the bottom will be cleaner. Over time, the build-up of this clean layer will effectively bury contaminants and further reduce their threat.



Location of organisms within the lake sediment.