

## Understanding Why Some Organic Contaminants Pose a Health Risk

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### Overview of the Problem

Chemicals have been discharged to water bodies from a variety of sources for decades. Sources include the production, use and disposal of numerous chemicals that offer improvements in industry, agriculture, medical treatment, and even common household conveniences (Figure 1). Concerns have been raised regarding the potential adverse impacts on human and ecological health resulting from these chemicals.



Figure 1. Common household chemicals

Natural biogeochemical processes that influence contaminant persistence and bioavailability control the fate and effects of these contaminants in an aquatic environment. Research has shown that many contaminants can enter the environment, disperse, and persist to a greater extent than first anticipated. Accumulation of contaminants in biological resources may occur via aqueous, sedimentary or dietary pathways.

Contaminants of ecological and human health concern, such as metals and some organic compounds, are chemically bound to particulate matter in the aquatic environment. Transport of particle-bound contaminants within water bodies occurs with sediment transport processes.

There is a wide array of transport pathways for many different chemicals to enter and persist in aquatic systems (Kolpin *et al.* 2002). Other compounds, such as industrial by-products, are released through regulated industrial discharges into the water and air. Some pesticides,

household chemicals, pharmaceuticals, and other consumables, as well as biogenic hormones, are released directly to the environment after passing through wastewater treatment processes. Wastewater treatment processes usually are not designed to remove these materials from the effluent. Veterinary pharmaceuticals used in open range and confined animal feeding operations (Figure 2) may enter the environment through animal wastes via natural processes or accidental overflow, leakage from storage structures, or land application.



Figure 2. Cattle crossing a stream.

Man-made organic compounds enter streams and lakes from atmospheric deposition, point-source outflows, non-point surface runoff, groundwater discharges, and gasoline-powered water craft. Generally, the concentrations are low. The concern is the potential effect of bioaccumulation.

### What is a contaminant? Is it a problem?

Contaminants are substances that are either present in an environment, where they do not belong, or are present at levels that may cause harmful or adverse health effects to the organisms and the environment in which the organisms live.

As a result of human and non-human activity, a wide variety of contaminants make their way into the nation's air and water supplies (Figure 3). Many



Figure 3. A forest fire burnout operation.

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contaminants are naturally occurring and pose no health threat to the ecosystem. However, other contaminants are harmful and may result in disease and/or death of plants and animals as the contaminants move through the food chain. This is known as **biomagnification**.

## Organic Compounds

Natural organic compounds originate from the decay of plant and algae matter, which is also referred to as by-products of algal metabolism (Figure 4). Man-made organic compounds are present in trace amounts in virtually all ground and surface waters due to pollution. More commonly known as contaminants, these compounds are considered toxic when found in



Figure 4. Blue-green algae at pond edge.

high enough concentrations to pose a health threat to humans, organisms, or ecosystems. Bioaccumulation may lead to chronic toxicity effects in the liver and kidneys, as well as be responsible for nervous systems problems in animals and humans. Contaminants are highly varied in chemical composition and behavior. These compounds can be toxic based on their chemical makeup (chain, branches, or rings of carbon atoms) and concentration levels.

Principal types of man-made organic compounds of concern include:

- ◆ Pesticides, herbicides, fungicides
- ◆ Volatile organic chemicals (VOC's)
  - Cleaning solvents used in degreasing and dry cleaning
  - Unchlorinated (e.g. benzene) and chlorinated (e.g. trichloroethylene)
- ◆ Other industrial chemicals (e.g. PCB's, [polychlorinated biphenyls] and PAH's, [polyaromatic hydrocarbons])
- ◆ Trihalomethanes (by-products of chlorine disinfection)

In the late 1970's there were few organic compounds listed as contaminants. Today,

many organic compounds are specifically identified on the Environmental Protection Agency's (EPA) contaminants list and have a specified maximum contaminant level considered safe for human consumption, in drinking water supplies and fish. The list of specific organic chemicals of concern is growing because of increased use and scientific expertise. For example:

- ◆ Use
  - Pesticides and herbicides
  - Organic chemicals used in industry and households
- ◆ Toxicology
  - Development of methods or improving methods
  - Development of a database of laboratory results listing chemical toxicity
  - Requirement for testing before chemicals are placed on the market
- ◆ Analytical Methods
  - Improved instrumentation for analysis
    - Gas chromatography
    - Mass spectrophotometry
  - Routinely analyze to part per billion and part per trillion level

## Contaminant Exposure

Contaminants may be absorbed across an animal's skin (Figure 5) or through a fish's gills as it extracts dissolved oxygen from water.



Figure 5. Wild beavers in their dam.

With continued exposure over the course of an animal's life, some contaminants will accumulate in the body. Exposure of this type may result in a reduced growth rate, reduced chances for successful reproduction, and reduced life spans. 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. As you move up the food chain, the diet becomes progressively higher in contaminants and contaminant concentrations.

## Contaminant Effects at the Top of the Food Chain or Pyramid

Deformities in fish and other aquatic wildlife may be the result of eating diets containing high levels of organic compounds (Figure 6). These deformities may also be repeated in birds and other mammals that consume fish. In addition to tissue damage, toxic effects of contaminants in aquatic organisms may include impairment of physiological processes. This may alter the energy available for growth and reproduction. Other effects on reproductive and developmental processes include the direct damage of the genetic material.



Figure 6. Bullhead catfish with tumor in mouth.

The transfer of toxic chemicals through aquatic food chains to fishery resources may impact the health of human consumers. Contaminants that demonstrate **mutagenic**, **carcinogenic**, or **teratogenic** potential to the human consumer are of particular concern because they pose a direct threat to human health. This has prompted government issued health advisories on species and amounts of fish that may be eaten safely by humans.

## Human Health Risks and Concerns?

Demonstrating health effects in humans exposed to persistent organic pollutants typically encountered in large bodies of water, such as lakes and oceans, is a challenge for researchers (Figure 7). Human epidemiological studies are limited in their ability to separate health effects attributable to contaminant exposures versus those effects related to smoking, alcohol intake, and a person's general health. In addition, exposure to contaminants from fish is dependent upon the amount eaten and species consumed.

There is substantial research being conducted focusing on toxic chemicals, with an emphasis on organic contaminants in the environment.

Knowledge gained is converted to useful information that is helping shape public policy, as well as management and regulatory actions. New laws and regulations addressing major acute toxicity concerns have been written based upon new research findings.

## For More Information See:

[www.epa.gov/safewater/](http://www.epa.gov/safewater/)

[www.smwg.org](http://www.smwg.org)

Bioavailability of contaminants in soils and sediments: Processes, tools and applications. National Research Council of the National Academies. Washington, D.C. 2003. ISBN: 0-309-08625-6

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Figure 7. County Health Department warning sign.

## Glossary of Terms

**Aqueous:** Describes substances dissolved in water.

**Bioaccumulation:** Bioaccumulation denotes the accumulation of a substance in a living organism as a result of its intake both in the food and also from the environment.

**Bioavailability:** The amount of a substance available to the body to be absorbed and circulated.

**Biogeochemical:** The chemical relationship between the geology of an area and its plant and animal life.

**Biogenic Hormones:** Synthetically produced hormones such as the Human Growth Hormone

**Biomagnification:** The accumulation of substances in a living organism with the intake of food. Simple organisms such as algae can absorb minute quantities of a substance which are then transferred through the food chain to higher living species such as fish, birds, etc. Biomagnification along the food chain will result in the highest concentrations of a substance being found at the top of the food chain.

**Carcinogenic:** Capable of causing cancer.

**Chromatography:** A process to separate the components of a mixture, based on size, charge, or other chemical properties.

**Contaminant:** Any physical, chemical, biological, or radiological substance or matter that may be harmful to an organism's or ecosystem's health.

**Dietary:** Relating to the diet.

**Mutagens:** Substances causing a permanent change in the genetic material (DNA).

**Particulate Matter:** Any material that exists as a solid or liquid in air or water that is less than 10 microns.

**Sedimentary:** A type of rock formed from sediment deposited by wind or water

**Spectrophotometry:** Measurements of the relative amounts of radiant energy at each wavelength of the spectrum

**Teratogenic:** Substances such as chemicals or radiation that cause abnormal development of an embryo.

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