National Institute of Environmental Health Sciences
Your Environment. Your Health.

Drinking Water and Your Health

Clean drinking water is essential for healthy life, but billions of people worldwide rely on water of unreliable quality. The United States is not immune to this problem and safe drinking water remains a public health priority.

Drinking water in the U.S. comes from a variety of sources, including public water systems, private wells, and bottled water. Although mechanisms are in place to keep water safe, contamination can result from:

- Corroded pipes that leach lead, copper, or other harmful chemicals.
- Hazardous waste sites and industrial discharges.
- Agricultural pesticides and fertilizers.
- Naturally occurring hazardous chemicals, such as arsenic and radon.
- Sewage and food processing waste.
- Plastic containers.

Negative health effects

Contaminants in drinking water can produce a broad range of health effects. Many of those impacts can be severe and long-lasting, depending on the chemical and the level of exposure. Contaminants of concern include:

Arsenic — A known human carcinogen associated with skin, lung, bladder, kidney, and liver cancer.[1]

Lead — Linked to behavioral and developmental effects in children, and cardiovascular and kidney problems.[2]

Hydraulic fracturing (fracking) chemicals — Used in the drilling of petroleum, some of these chemicals have been linked to damage to the immune[3] and reproductive systems.[4]

Microplastics — Can be ingested and absorbed into the body where they can accumulate in organs and the brain. They have been linked to reduced immunity[5] and fertility[6], and other health concerns.

Pesticides — Have long been linked to neurodevelopmental effects and Parkinson's disease.[7]

Per- and polyfluoroalkyl substances (PFAS) — Manufactured chemicals that endure in the environment and accumulate in living organisms. They have been linked to suppressed immunity,[8] reproductive concerns,[9] kidney and testicular cancer, and other concerns.[10]

Contaminants of emerging concern — Found in water but not covered by drinking water regulations. These substances — ranging from urban runoff particles to pharmaceuticals — pose an uncertain threat to the environment and human health and require additional research.[11]

Benefits and concerns

The presence of chemicals can be a complex issue. Some are added to drinking water for their health benefits. However, these same chemicals may produce negative consequences when present in too high a concentration or in conjunction with other substances.

Fluoride — The U.S. Public Health Service (USPHS) recommends 0.7 milligrams (mg) of fluoride per liter (L) of water to help combat tooth decay. Many municipalities and states mandate fluoridation of public drinking water.[12]

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But fluoridation of water also has raised concerns. The National Toxicology Program (NTP) — an interagency program located at NIEHS — found that exposure to fluoride at 1.5 mg/L and higher — twice the USPHS recommended level for water — may be linked to lower IQ in children.[13]

Chlorine — Although it is used to kill germs in drinking water, chlorine can also bind with organic matter in water, creating disinfection by-products. Although some of these by-products have been linked to bladder cancer and birth defects, it is generally understood that the health benefits of chlorination outweigh the risks. Rules and practices have been implemented to reduce disinfection by-products in drinking water.[14]

Differing exposures and impacts

Although clean drinking water is a concern for all, individual exposure to substances and chemicals varies. Those who rely on municipal systems are much more likely to consume water treated with chlorine and fluoride. Users of well water have a greater probability of exposure to arsenic and pesticides.

Water quality also varies greatly from one region to another. Sources, delivery systems, industrial activity in the area, and socioeconomic factors all play a role in determining the quality and safety of community drinking water.[15]

What is NIEHS doing?

The National Institute of Environmental Health Sciences (NIEHS) seeks to understand and address the public health concerns associated with drinking water. Staff members conduct in-house research and serve on federal working groups to better understand emerging contaminants and PFAS in water. NIEHS time-sensitive grants enable outside researchers to undertake timely studies of natural disasters, human-caused incidents, and emerging environmental public health threats.

Recent projects supported by NIEHS have:

- Measured exposure levels of residents of New Hanover County, North Carolina, and Colorado Springs, Colorado, living near water sources contaminated by PFAS.[16]
- Coordinated research efforts and provided scientific information about testing lead in drinking water for residents of Flint, Michigan.
- Studied groundwater contamination and public health impact of the 2023 train derailment and chemical spill in East Palestine, Ohio.[17]
- Documented that highly absorbable nanoplastics may be found in bottled water in much higher concentrations than previously suspected.[18]
- Indicated that events like hurricanes can contribute to elevated levels of pesticide contaminants in drinking water.[19]
- Found widespread presence of heavy metals, pharmaceuticals, disinfection by-products, and other contaminants in the private and public tap water sources of 11 states.[20]

Advancing solutions

In addition to documenting the causes and dangers of water contamination, NIEHS seeks ways to alleviate concerns and ensure safe drinking water for all. The Superfund Research Program (SRP) funds research centers at major universities. These centers study potential hazards and support efforts to increase awareness and reduce contamination.

Impact — Although state and local governments usually set standards and monitor public water supplies, NIEHS-funded research has informed efforts to improve water quality.

- Dartmouth College scientists examined sources of arsenic in the drinking water of New Hampshire, spurring a state law that lowered allowed limits.[21]
- The Superfund Research Center at the University of North Carolina at Chapel Hill successfully pushed the state Real Estate Commission to include well water quality information on disclosure forms associated with home sales.[22]

Outreach — Efforts funded by NIEHS help bridge the gap between researchers and communities, including underrepresented communities most affected by drinking water issues.

- Researchers at the University of California, Berkeley, used SRP funds to develop an interactive, web-based Drinking Water Tool — available in both English and Spanish — that documents water quality in disadvantaged communities in California.[23]
- In northern Maine, researchers from the Massachusetts Institute of Technology coordinated with communities and tribal groups to improve understanding of, and participation in, water sampling projects.[24]
- A partnership between the University of Kentucky and communities in the Appalachian region of the state seeks to improve communication and promote reduction of disinfection by-products in drinking water.[25]

Innovation — NIEHS SRP funding has supported a broad range of experimentation of effective ways to remove contaminants from water.

- Researchers at the University of North Carolina at Chapel Hill are developing a filtration device to remove arsenic and other chemicals from well water, an innovation that promises to benefit up to 3 million state residents.[26]
- Scientists from Texas A&M University and the University of Connecticut have developed strategies to trap PFAS in soil to prevent its spread into water supplies.[27]
- University of Iowa researchers have devised a method to clean harmful polychlorinated biphenyls (PCBs) from aquatic ecosystem, using biochar — a material made from bacteria and corn kernel ashes.[28]

NIEHS funding extends beyond academic research. The institute also awards Small Business Innovation Research and Small Business Technology Transfer to support commercial technology to reduce the dangers of contaminated water. Successes of the program include:

ANDalyze sensors — To detect heavy metals like cadmium, copper, and uranium in water supplies. https://seed.nih.gov/portfolio/stories/andalyze

Cyclopure test kits and filtration systems — To help identify and remove PFAS chemicals from drinking water. https://tools.niehs.nih.gov/srp/news/view.cfm?newsitem_ID=2728

NanoAffix detectors — To support real-time, on-site detection of lead in tap water with a hand-held format. https://tools.niehs.nih.gov/srp/news/view.cfm?newsitem_ID=2633

Learn more about drinking water

U.S. Centers for Disease Control and Prevention
Drinking Water Guide
www.cdc.gov/drinking-water

U.S. Environmental Protection Agency (EPA)
Drinking Water Requirements
www.epa.gov/dwreginfo

World Health Organization
Drinking Water
www.who.int/news-room/fact-sheets/detail/drinking-water

Treating PFAS in drinking water

Effective ways to remove PFAS from water include activated carbon treatment, ion exchange resins, and reverse osmosis. These technologies can be used in public treatment facilities, water systems in buildings, or homes. Read more from the EPA at www.epa.gov/pfas.

For more information on the National Institute of Environmental Health Sciences, go to **https://www.niehs.nih.gov**.

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