

Arsenic

What is arsenic?

Arsenic is a naturally occurring element that is widely distributed in the Earth's crust. It is found in water, air, food, and soil. There are two general forms of arsenic — organic and inorganic. Inorganic arsenic, which affects the drinking water of millions of people worldwide, has been shown to be a human carcinogen.

Scientists, pediatricians, and public health advocates are increasingly concerned about the more subtle and long-range health effects of low-level exposures to humans, especially for infants and children exposed to arsenic in water and some foods, such as rice-based products, during sensitive windows of development.

Because of its significance as a global public health problem, studies of arsenic, arsenic metabolism, and the health effects associated with arsenic exposure are a priority for the National Institute of Environmental Health Sciences (NIEHS), the National Toxicology Program (NTP), and several other organizations involved in research, regulation, and health care. NTP is an interagency testing program, administered by NIEHS.

Where is arsenic found?

Arsenic is found just about everywhere. It can leach into groundwater through rocks and soil, and is used in pesticides, wood preservatives, and tobacco. It is also



released into the environment by volcanoes and mining processes. Arsenic in groundwater is a widespread problem. Arsenic levels tend to be higher in drinking water that comes from ground sources, such as wells, than from water from surface sources, such as lakes or reservoirs.

How does arsenic get into the body?

Most arsenic gets into the body through ingestion of food or water. Arsenic in drinking water is a problem in many countries around the world, including Bangladesh, Chile, China, Vietnam, Taiwan, India, and the United States.¹

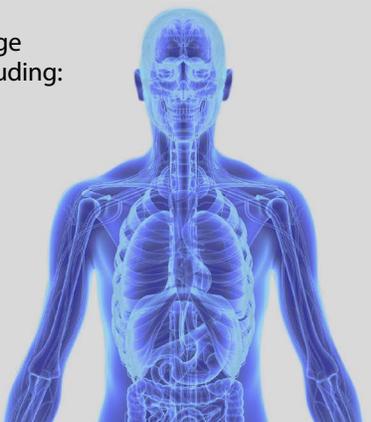
Arsenic may also be found in foods, including rice and some fish, where it is present due to uptake from soil and water. It can also enter the body by breathing dust containing arsenic, or through the skin, though this is not a major route of exposure.

How much arsenic can be in drinking water?

The maximum level of inorganic arsenic permitted in U.S. drinking water is 10 parts per billion (ppb). This standard was set by the U.S. Environmental Protection Agency (EPA). Some states, such as New Jersey, have more stringent drinking water standards for arsenic than 10 ppb. There are no arsenic water standards for private wells.

Arsenic affects a broad range of organs and systems including:

- Skin
- Nervous system
- Respiratory system
- Cardiovascular system
- Liver, kidney, bladder and prostate
- Immune system
- Endocrine system
- Developmental processes



Because arsenic is tasteless, colorless, and odorless, testing is needed for detection. Approximately 7 percent of wells in the U.S. are thought to have arsenic levels above the current EPA standard of 10 ppb.²

Arsenic levels in the U.S. tend to be higher in rural communities in the Southwest, Midwest, and Northeast. The levels of arsenic in countries like Bangladesh have been measured at over 3,000 ppb.¹

How can I find out whether there is arsenic in my drinking water?

If your home is not on a public water system, you can have your water tested for arsenic. Your state certification officer should be able to provide a list of laboratories in your area that will perform tests on drinking water for a fee.

How do I remove arsenic from my drinking water?

Do not try to remove arsenic by boiling it. Additionally, chlorine bleach disinfection will not remove arsenic. You may wish to consider water treatment methods such as reverse osmosis, ultra-filtration, or ion exchange. Contact your local health department for recommended procedures.

NIEHS areas of research

NIEHS and NTP in-house researchers and universities funded by NIEHS are conducting basic and translational research to understand arsenic, and are reaching out to broader audiences to share the findings. Researchers supported through the NIEHS Superfund Research Program, a network of universities seeking solutions to complex health and environmental issues associated with the nation's hazardous waste sites, are reporting findings that are having a global impact.

Fundamental

Researchers have learned that both short-term and long-term exposure to arsenic can cause health problems, but they are just beginning to understand how arsenic works in the body — what is referred to as its modes of action. This important area of research is being pursued at NIEHS.

Researchers are finding that arsenic, even at low levels, can interfere with the body's endocrine system. The endocrine system is what keeps our bodies in balance, maintaining homeostasis and guiding growth and



development. In several cell culture and animal models, arsenic has been found to act as an endocrine disruptor, which may underlie many of its health effects.³ Other mechanisms are also likely contributors to arsenic's health effects.

In a large-scale screen of protein levels in the cord blood of infants prenatally exposed to arsenic, researchers identified 111 altered proteins. They found that almost half of these proteins are regulated by tumor necrosis factor (TNF), a protein which plays a critical role in inflammation, cellular growth, and development-related cell signaling. This work is helping to identify proteins and pathways that may serve as biomarkers of arsenic exposure and disease risk.⁴

Researchers in the NTP Laboratory are also increasing our understanding of arsenic through the use of stem cells. The researchers found that when cancer cells are placed near, but not in direct contact with normal stem cells, the normal cells very rapidly acquire the characteristics of cancer stem cells. The malignant cells send signals that turn the normal stem cells into cancer stem cells, promoting tumor growth.⁵

Cancer

Arsenic is a known human carcinogen associated with skin, lung, bladder, kidney, and liver cancer.⁶ A new study from the NTP Laboratory that replicates how humans are exposed to arsenic through their whole lifetime found that mice exposed to low concentrations of arsenic in

drinking water developed lung cancer. The concentrations in the drinking water given to the mice were similar to what humans, who use water from contaminated wells, might consume.⁷

Also, because of the known expertise of the NTP Laboratory, they were recently asked to help design and implement a study to see if arsenic has the ability to change gene expression. They will be analyzing gene expression in blood samples from individuals that were known to be exposed to arsenic poisoning through contaminated infant formula in Japan in 1955.⁸ Some of these individuals developed cancer. This study will help determine if specific genetic changes can be associated with cancer development.

Early-life exposures and development

Not only is arsenic a known human carcinogen, but it can predispose children to other health problems later in life. Researchers supported by the NIEHS Superfund Research Program at the University of California, Berkeley, found increased incidence of lung and bladder cancer in adults exposed to arsenic early in life, even up to 40 years after high exposures ceased. These findings provide rare human evidence that an early-life environmental exposure can be associated with a high risk of cancer as an adult.⁹

NIEHS in-house researchers are conducting studies to determine if fetal exposure to arsenic in mice impacts the reproductive system and metabolism when the animals reach adulthood. The researchers have unexpectedly discovered that both high and low doses of inorganic arsenic cause early-onset puberty, obesity, and abnormal mammary gland development. These findings shed light on the understanding of fetal origins of adult diseases induced by fetal exposure to inorganic arsenic.

Ways to reduce arsenic risk

- Test your drinking water.
- Eat a well-balanced diet for good nutrition, and eat a wide variety of grains, to try to minimize the negative health effects that could come from eating an excess of any one food.



Researchers have previously shown that exposure to arsenic in drinking water in Bangladesh and other countries can impact a child's intellectual development. A new study by researchers at Columbia University also found a similar association among elementary school students in the U.S.¹⁰ Children who lived in homes where levels of arsenic were greater than 5 parts per billion in the well water that was used for drinking and cooking, showed a 5-6 point reduction in IQ, compared to those exposed to lower levels of arsenic.

Diabetes

Several studies, including a review of the literature by NTP, have suggested an association between low-to-moderate levels of arsenic and metabolic diseases, such as diabetes.¹²

Translational

At least 30 million people in Bangladesh are exposed to arsenic in their drinking water. Researchers have found that arsenic education, coupled with water testing programs, can increase knowledge in the population, and result in reduced arsenic exposures, when safe drinking water sources are made available.¹³

Researchers also found that folic acid supplements can dramatically lower blood arsenic levels in individuals chronically exposed to arsenic-contaminated drinking water. Just 400 micrograms a day of folic acid, the U.S. Recommended Dietary Allowance, reduced total blood arsenic levels in a Bangladesh study population by 14 percent.¹⁴

Future research directions

- Developing technologies that will remove or mitigate arsenic from drinking water.
- Determining other approaches for preventing exposure to arsenic, such as:
 - Identifying plants that are less likely to absorb arsenic from groundwater.
 - Changing irrigation practices to limit the amount of arsenic in food production.
 - Educating people about the need to test well water.
 - Using alternative sources of drinking water if arsenic is found.

Where can I find out more information about arsenic?

NIEHS Superfund Research Program

<http://www.niehs.nih.gov/research/supported/dert/programs/srp/about/index.cfm>

U.S. Food and Drug Administration

<http://www.fda.gov/ForConsumers/ConsumerUpdates/ucm352569.htm>

U.S. Environmental Protection Agency

<http://water.epa.gov/drink/index.cfm>

<http://water.epa.gov/drink/info/well/index.cfm>

<http://water.epa.gov/lawsregs/rulesregs/sdwa/arsenic/index.cfm>

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