Iodine

Iodine (chemical symbol I) is a nonmetallic solid element. There are both radioactive and non-radioactive isotopes of iodine. Iodine-129 and -131 are the most important radioactive isotopes in the environment. Some isotopes of iodine, such as I-123 and I-124 are used in medical imaging and treatment, but are generally not a problem in the environment because they have very short half-lives.

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The Basics

Who discovered iodine and radioactive iodine?

In 1811, Bernard Courtois discovered natural iodine in water that was used to dissolve certain parts of seaweed ash for use. Radioactive iodine-131 was discovered by Glenn T. Seaborg and John Livingood at the University of California - Berkeley in the late 1930's.

Where do iodine-129 and iodine-131 come from?

Both iodine-129 and iodine-131 are produced by the fission of uranium atoms during operation of nuclear reactors and by plutonium (or uranium) in the detonation of nuclear weapons.

What are the properties of iodine-129 and iodine-131?

Radioactive iodines have the same physical properties as stable iodine. However, radioactive iodines decay with time

Iodine is a nonmetallic, purplish-black crystalline solid. It has the unusual property of 'sublimation,' which means that it can go directly from a solid to a gas, without first becoming liquid. It sublimes to a deep violet vapor at room temperature. This vapor is irritating to the eyes, nose and throat. Iodine dissolves in alcohol and in water. It melts at 236 °F.

Iodine reacts easily with other chemicals, and isotopes of iodine are found as compounds rather than as a pure elemental nuclide. Thus, iodine-129 and -131 found in nuclear facilities and waste treatment plants quickly form compounds with the mixture of chemicals present. However, iodine released to the environment from nuclear power plants is usually a gas.

Iodine-129 has a half-life of 15.7 million years; iodine-131 has a half-life of about 8 days. Both emit beta particles upon radioactive decay.

What are iodine radioisotopes used for?

Iodines are among the most widely used radionuclides, mostly in the medical field. Because of its short half-life and useful beta emission, iodine-131 is used extensively in nuclear medicine.

> Its tendency to collect in the thyroid gland makes iodine especially useful for diagnosing and treating thyroid problems. Iodine-123 is widely used in medical imaging, and I-124 is useful in immunotherapy.
>
> Iodine's chemical properties make it easy to attach to molecules for imaging studies. It is useful in tracking the metabolism of drugs or compounds, or for viewing structural defects in various organs, such as the heart.
>
> A less common isotope, iodine-125, is sometimes used to treat cancerous tissue.

Iodine-129 has little practical use, but may be used to check some radioactivity counters in diagnostic testing laboratories.

Exposure to Iodine-129 and Iodine-131

How do iodine-129 and iodine-131 get into the environment?

Iodine-129 and iodine-131 are gaseous fission products that form within fuel rods as they fission. Unless reactor chemistry is carefully controlled, they can build up too fast, increasing pressure and causing corrosion in the rods. As the rods age, cracks or wholes may breach the rods.

Cracked rods can release radioactive iodine into the water that surrounds and cools the fuel rods. There, it circulates with the cooling water throughout the system, ending up in the airborne, liquid, and solid wastes from the reactor. From time to time, reactor gas capture systems release gases, including iodine, to the environment under applicable regulations.

Anywhere spent nuclear fuel is handled, there is a chance that iodine-129 and iodine-131 will escape into the environment. Nuclear fuel reprocessing plants dissolve the spent fuel rods in strong acids to recover plutonium and other valuable materials. In the process, they also release iodine-129 and -131 into the airborne, liquid, and solid waste processing systems. In the U.S., spent nuclear fuel is no longer reprocessed, because of concerns about nuclear weapons proliferation.

Currently, spent nuclear fuel remains in temporary storage at nuclear power plants around the country. If the nuclear waste repository at Yucca Mountain opens, it will provide permanent disposal for spent nuclear fuel and other high-level radioactive wastes. Wherever spent nuclear fuel is stored, the short-lived iodine-131 it contains will decay away quickly and completely. However, the long-lived iodine-129 will remain for millions of years. Keeping it from leaking into the environment, requires carefully designed, long-term safeguards.

The detonation of nuclear weapons also releases iodine-129 into the environment. Atmospheric testing in the 1950's and 60's released radioactive iodine to the atmosphere which has disseminated around the world, and is now found at very low levels in the environment. Most I-129 in the environment came from weapons testing.

How do iodine-129 and iodine-131 change in the environment?

Radioactive iodine can disperse rapidly in air and water, under the right conditions. However, it combines easily with organic materials in soil. This is known as ‘organic fixation' and slows iodine's movement in the environment. Some soil minerals also attach to, or adsorb, iodine, which also slows its movement.

The long half-life of iodine-129, 15.7 million years, means that it remains in the environment. However, iodine-131's short half-life of 8 days means that it will decay away completely in the environment in a matter of months. Both decay with the emission of a beta particle, accompanied by weak gamma radiation.

How do people come in contact with iodine-129 and iodine-131?

Radioactive iodine can be inhaled as a gas or ingested in food or water. It dissolves in water so it moves easily from the atmosphere into humans and other living organisms. People are exposed to I-129 from the past testing of nuclear weapons, and I-131 from nuclear power plant emissions. Some industrial facilities also emit radioactive iodine to the environment, as well as medical institutions. Radioactive iodine is usually emitted as a gas, but may contaminate liquids or solid materials as well. If a family member has been treated with I-131, you may have increased exposure to it through their body fluids.

How do iodine-129 and iodine-131 get into the body?

Radioactive iodine can enter the body by ingestion or inhalation. It dissolves in water so it moves easily from the atmosphere into humans and other living organisms. For example, I-129 and -131 can settle on grass where cows can eat it and pass it to humans through their milk. It may settle on leafy vegetables and be ingested by humans. Iodine isotopes also concentrate in marine and freshwater fish, which people may then eat.

Also, doctors may give thyroid patients radioactive iodine, usually iodine-131, to treat or help diagnose certain thyroid problems. The tendency of iodine to collect in the thyroid makes it very useful for highlighting parts of its structure in diagnostic images.

Exposure from Iodine 131 (Centers for Disease Control)

What do iodine-129 and iodine-131 do once they get into the body?

When I-129 or I-131 is ingested, some of it concentrates in the thyroid gland. The rest passes from the body in urine.

Airborne I-129 and I-131 can be inhaled. In the lung, radioactive iodine is absorbed, passes into the blood stream, and collects in the thyroid. Any remaining iodine passes from the body with urine.

In the body, iodine has a biological half-life of about 100 days for the body as a whole. It has different biological half-lives for various organs: thyroid - 100 days, bone - 14 days, and kidney, spleen, and reproductive organs - 7 days.

Health Effects of Iodine-129 and Iodine-131

How can iodine-129 and iodine-131 affect people's health?

Radioactive iodine can cause thyroid problems, and help diagnose and treat thyroid problems. Long-term (chronic) exposure to radioactive iodine can cause nodules, or cancer of the thyroid. However, once thyroid cancer occurs, treatment with high doses of I-131 may be used to treat it. Doctors also use lower doses of I-131 to treat overactive thyroids.

Low doses can reduce activity of the thyroid gland, lowering hormone production in the gland. Doctors must maintain the fine balance between the risks and benefits of using radioactive iodine. On one hand, this small, additional exposure may tip the balance in favor

of cancer formation. On the other, this small additional exposure can restore health by slowing an overactive thyroid and improve health conditions.

Is there a medical test to determine exposure to iodine-129 and iodine-131?

Since iodine is concentrated in the thyroid gland, a radioassay of the thyroid can determine the level of exposure to many of its isotopes. However, I-129 has very low activity and emits extremely low energy beta particles, making a radioassay much more difficult. Tests for I-131 in the body should be available through most major medical centers.

Protecting People from Iodine-129

How do I know if I'm near radioactive iodine?

Living near a nuclear power plant may slightly increase your annual exposure to I-131. Detecting radioactive iodine in the environment requires specialized equipment. Most major medical centers can test for isotopes of iodine in your body.

What can I do to protect myself and my family from iodine-129 and iodine-131?

The thyroid cannot tell the difference between radioactive and non-radioactive iodine. It will take up radioactive iodine in whatever proportion it is available in the environment.

If large amounts of radioactive iodine are released during an nuclear accident, large doses of stable iodine may be distributed by government agencies to keep your thyroid gland from absorbing too much radioactive iodine: Raising the concentration of stable iodine in the blood, increases the likelihood that the thyroid will absorb it instead of radioactive iodine. (Note: Large doses of stable iodine can be a health hazard and should not be taken except in an emergency. However iodized table salt is an important means of acquiring essential non-radioactive iodine to maintain health.

"What is EPA doing about iodine-129 and iodine-131?

EPA has issued a variety of regulations that limit the release of radionuclides, including I-129 and I-131, to the environment. These regulations address airborne and liquid releases from nuclear reactors, airborne emissions from a variety of industrial and governmental facilities, and allowable radioactive releases from radioactive waste disposal systems.

EPA has established Maximum Contaminant Levels that limit the concentration of radioactive iodine and other radionuclides in drinking water from public water suppliers.

Recently, EPA issued its environmental standards for the potential waste repository at Yucca Mountain, Nevada. Iodine-129 is one of the more important radionuclides of concern in the large inventory of spent reactor fuel and defense high-level waste. This standard limits the radiation exposure of individuals, and radionuclide concentrations in ground water from the release of I-129 and other radionuclides in the vicinity of Yucca Mountain.

http://epa.gov/radiation/radionuclides/iodine.html
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Radionuclides in Drinking Water
This site provides information about radionuclides in drinking water and guidance to help states and water systems comply with the standard.
National Emission Standards for Hazardous Air Pollutants
This site provides information about radioactive contaminants in the air.
Yucca Mountain
This site provides information about EPA's development of public health and environmental radiation protection standards for the repository.