

Iodine

What Is It? Iodine is a bluish-black, lustrous solid that mainly occurs in nature as stable iodine-127. A small amount of radioactive iodine-129 is produced naturally in the upper atmosphere by the interaction of high-energy particles with xenon. Iodine volatilizes at ambient temperatures into a pretty blue-violet gas with an irritating odor. Iodine exhibits some metal-like properties and is only slightly soluble in water. It occurs in nature as iodide ions, and it is in this form that it is taken into our bodies.

Symbol:	I
Atomic Number:	53 (protons in nucleus)
Atomic Weight:	127 (naturally occurring)

Of the fourteen major radioactive isotopes of iodine, only iodine-129 has a half-life sufficiently long to warrant concern for Department of Energy (DOE) environmental management sites such as Hanford.

(Isotopes are different forms of an element that have the same number of protons in the nucleus but a different number of neutrons.) Iodine-129 decays by emitting a beta particle with a half-life of about 16 million years; the half-lives of all other

Radioactive Properties of Key Iodine Isotopes						
Isotope	Half-Life	Specific Activity (Ci/g)	Decay Mode	Radiation Energy (MeV)		
				Alpha (α)	Beta (β)	Gamma (γ)
I-129	16 million yr	0.00018	β	-	0.064	0.025
I-131	8.0 days	130,000	β	-	0.19	0.38

EC = electron capture, Ci = curie, g = gram, and MeV = million electron volts; a dash means the entry is not applicable. (See the companion fact sheet on Radioactive Properties, Internal Distribution, and Risk Coefficients for an explanation of terms and interpretation of radiation energies.) Values are given to two significant figures.

iodine radionuclides are less than 60 days. The very long half-life of iodine-129 (with its subsequent low-specific activity) combined with the low energy of its beta particle and minimal gamma radiation limit the hazards of this radionuclide. Iodine-131 has a short half-life (8 days) and is not generally a major isotope of concern for DOE environmental management sites. However, information is included here for this radionuclide because it was released during past operations of nuclear reactors at Hanford.

Where Does It Come From? Stable iodine (iodine-127) is naturally present in seaweeds, sponges, and other materials. Radioactive isotopes of iodine are produced by nuclear fission. When an atom of uranium-235 (or other fissile nuclide) fissions, it generally splits asymmetrically into two large fragments – fission products with mass numbers in the range of about 90 and 140 – and two or three neutrons. (The mass number is the sum of the number of protons and neutrons in the nucleus of the atom.) Iodine-129 and iodine-131 are two such products. The fission yield of iodine-129 is about 1% and the yield of iodine-131 is close to 3%. That is, about one atom of iodine-129 and three atoms of iodine 131 are produced per 100 fissions. Iodine-129 is present in spent nuclear fuel, high-level radioactive wastes resulting from processing spent nuclear fuel, and radioactive wastes associated with the operation of nuclear reactors and fuel reprocessing plants.

How Is It Used? Iodine is used to treat cuts and scrapes on the skin as a tincture of iodine, which is a dilute mixture of alcohol and iodine. Iodine is also used in photography and lasers (silver iodide), in dyes, and as a nutrient added to table salt. Iodine-131 is used for a number of medical procedures, including to monitor and trace the flow of thyroxin from the thyroid. With its short half-life of 8 days, it is essentially gone in less than three months. Iodine-129 has no important commercial uses.

What's in the Environment? Iodine is present in nature in various materials, with soil, rock, and all living organisms containing low concentrations. Iodine is assimilated by seaweeds and sponges (from which it may be recovered) and is found in Chilean saltpeter, caliche, and brine associated with salt deposits. The ratio of stable iodine-127 to radioactive iodine-129 in the environment is more than 10 million to 1. The human body contains 10 to 20 milligrams of iodine, of which more than 90% is contained in the thyroid gland.

Iodine-129 is present in soil around the world as a result of fallout from past atmospheric nuclear weapons tests; any iodine-131 that may have been present in soil from fallout has long since decayed away. Iodine may also be found as a contaminant at facilities where spent nuclear fuel was processed.



Iodine-129 is one of the more mobile radionuclides in soil and can move downward with percolating water to groundwater. Iodine concentrations in sandy soil are about the same as in interstitial water (in the pore spaces between soil particles). It binds more preferentially to loam, where the concentration in soil is estimated to be 5 times higher than in interstitial water. Iodine-129 represents one of the largest groundwater plumes at the Hanford Site, extending from the 200 Area to the Columbia River. Very low concentration gradients of iodine-129, less than 100 attocuries per liter, have been detected in the river. (An attocurie is a millionth of a picocurie [pCi], or a billionth of a billionth of a curie.)

What Happens to It in the Body? Iodine can be taken into the body by eating food, drinking water, or breathing air. It is a constituent of thyroid hormone and as such is a required element for humans. Iodine is readily taken into the bloodstream from both the lungs and the gastrointestinal tract (essentially 100%) after inhalation and ingestion. Upon entering the bloodstream, 30% is deposited in the thyroid, 20% is quickly excreted in feces, and the remainder is eliminated from the body within a short time (per simplified models that do not reflect intermediate redistribution). Clearance from the thyroid is age-dependent, with biological half-lives ranging from 11 days in infants to 23 days in a five-year-old child and 80 days in adults.

What Are the Primary Health Effects? Iodine is an essential component of the human diet, and lack of dietary iodine is a cause of goiter. Elemental iodine (I₂) can be toxic, and its vapor irritates the eyes and lungs. While iodine is generally a health hazard only if it is taken into the body in substantial doses, iodine-131 emits fairly high-energy beta particles and a number of gamma rays. The gamma rays are of sufficient energy to be measured outside the body if deposited in tissue such as the thyroid. Because iodine selectively deposits in the thyroid, the primary health hazard for iodine is thyroid tumors resulting from ionizing radiation emitted by iodine-129 and iodine-131. Historically, the major exposure pathway has been ingestion of milk from cows grazing on iodine-contaminated crops. Other pathways include ingestion of fruits and vegetables and inhalation.

What Is the Risk? Lifetime cancer mortality risk coefficients have been calculated for nearly all radionuclides, including iodine (see box at right). Additional values are also available, including for inhalation of iodine vapor and methyl iodide. Similar to other radionuclides, the risk coefficients for tap water are about 75% of those shown for dietary ingestion.

Thyroid cancer is the main risk associated with radioactive iodine. Based on epidemiological studies for external radiation, children are more susceptible than adults to cancer from thyroid irradiation. Data available for iodine-131 have not shown it to be carcinogenic in the human thyroid. While certain studies have indicated a potential effect from exposures to iodine-131 (e.g., at Chernobyl, where external radiation was also quite high), others have not.

Radiological Risk Coefficients

This table provides selected risk coefficients for inhalation and ingestion. Recommended default absorption types were used for inhalation of particulates, and milk consumption values were used for ingestion. Risks are for lifetime cancer mortality per unit intake (pCi), averaged over all ages and both genders (10⁻⁹ is a billionth, and 10⁻¹² is a trillionth). Other values, including for morbidity, are also available.

Isotope	Lifetime Cancer Mortality Risk	
	Inhalation (pCi ⁻¹)	Ingestion (pCi ⁻¹)
Iodine-129	6.2 × 10 ⁻¹²	3.3 × 10 ⁻¹¹
Iodine-131	2.1 × 10 ⁻¹²	1.4 × 10 ⁻¹¹

For more information, see the companion fact sheet on Radioactive Properties, Internal Distribution, and Risk Coefficients and the accompanying Table 1.