Understanding Tritium

Tritium is a radioactive isotope of hydrogen (3H, or hydrogen-3). Its nucleus contains one proton and two neutrons, whereas the nucleus of the far most abundant hydrogen isotope contains no neutrons.

Properties

Tritium, which combines with oxygen to form a liquid called tritiated water (sometimes written HTO), is a gas at standard temperature and pressure. Tritium is difficult to confine. Rubber, plastic, and some kinds of steel are all somewhat permeable.

Production

Tritium is primarily produced in light-water nuclear reactors by neutron activation of lithium (a small amount is produced in heavy-water reactors (such as the Canadian 'CANDU') when a deuterium nucleus captures a neutron). It figures prominently in studies of nuclear fusion; deuterium-tritium fuel will be used in the experimental fusion reactors ITER and NIF.

Commercially, tritium is an unwelcome by-product of the nuclear fission of uranium and plutonium.

Extremely rare trace amounts of naturally occurring tritium are formed on Earth by the interaction of the atmosphere with cosmic rays; this global inventory is approximately constant due to natural decay.

Tritium was produced in special heavy water reactors at Savannah River, SC until their close-downs in 1988. The production of tritium was resumed with irradiation of special control rods containing lithium at the TVA's commercial Watts Bar reactors in 2003, followed by extraction of tritium at the new Savannah River Tritium Extraction Facility beginning in 2006.

Use

Tritium is an important component in nuclear weapons, hence the Savannah River Facility. The radioactive decay of small amounts of tritium cause phosphors to glow thus taking the place of radium (banned in most countries for decades) in making self-powered lighting used in firearm night sights, watches, exit signs, map lights, knives and other devices. Tritium costs approximately US $30,000 per gram.

Legally permissible doses

The EPA has set a Maximum Contaminant Level Goal (MCLG) for all radionuclides, including tritium. EPA's value for MCLG is ZERO. Yet the EPA permits doses to the general public up to15 mrem per year to any organ from tritium, iodine-13, and all particulate radionuclides with half-lives greater than 8 days.

The Environmental Protection Agency's (EPA) maximum threshold for safe **drinking water** is 20,000 picocuries per liter, whereas Ontario Canada's standard is 540 picocuries per liter, and California's recommended goal for tritium in drinking water is 400 picocuries per liter.

The Department of Energy agreed to an action level of 500 picocuries per liter for tritium in **surface water** in the clean up at Rocky Flats, which corresponds to Colorado's standard for surface water.

Health

Tritiated water is a radioactive form of water where the usual hydrogen atoms are replaced with tritium.Tritium also readily binds to carbon atoms. Since tritium is a low energy beta emitter, it is not dangerous externally (beta particles are unable to penetrate the skin), but it is a significant hazard when inhaled, ingested via food or water, or absorbed through the skin.

Tritium can pass through our skin while we are showering or even washing our dishes. According to the father of Health Physics, **Karl Z. Morgan**:

> *Tritium "is the only radionuclide for which we assume as much is taken into the body via skin penetration as by inhalation.* ***It is the MOST invasive of all radionuclides and distributes itself rather uniformly to all organs and all body tissues*** *on a microCurie per gram basis. It presents a somatic, genetic and teratogenic [cancerous] risk. It cannot be separated from liquid waste by evaporation, a process used to concentrate most radionuclides."*

The National Academies of Science developed a report on the risks from ionizing radiation. The BEIR VII report on "Health Risks from Exposure to Low Levels of Ionizing Radiation" found that there is no safe level of exposure to radiation - even low doses can cause cancer.

According to the Nuclear Regulatory Commission (NRC) a study of biological half life in occupational radiation workers in India, half of all consumed tritium is excreted within approximately 10 days after exposure. **However, Dr. Rosalie Bertell**, possibly the most-expert authority on low-dose radiation effects, rejected International Commission on Radiological Protection (ICRP) methodology for calculating the internal absorbed dose from inhaled, ingested and skin-absorbed tritium (the ICRP is a self-appointed and self-perpetuating non-governmental organization that does not accommodate peer review). Her assessment of dose-response takes into consideration exchangeable organic bound tritium (OBT) which has been consistently ignored by ICRP, claiming that the biological half-life of carbon-bound (or fixed) OBT is significantly underestimated in ICRP methodology. OBT may cause damage to adjacent cells and DNA for the rest of one's life (the 12 year half-life means that after 24 years 1/4 of the tritium will still be present).

By Dr. Bertell's calculation, this longer exposure time will increase the estimated deposit of energy in tissue by a factor of three. Non-homogeneous distribution of OBT in the body means higher localized absorbed doses, increasing the estimate of energy deposit by another factor of three. She urges a correction of the relative biological effectiveness (RBE) of tritium, based on a consensus of scientific research, by a factor of two to three, and believed that the internal chronic dose from tritiated water to Canadians was 20 times that estimated by ICRP, and also demonstrated that accepted ICRP methodology is biased against women and children who will bear the burden of the risks. Tritium easily crosses the placenta, raising concern for spontaneous abortions, stillbirths, congenital malformations and diseases, and teratogenic risks for tritium have been calculated to be six times higher than the risks of fatal cancers. When tritium disintegrates into a helium atom, there is a recoil excitation which disrupts the chemical bonds, causing chronic disease.

Tritium in the Environment

Tritium travels faster in groundwater than other radionuclides and is often an indicator of other radionuclides to come.

High levels of tritium oxide introduced into upper layers of the oceans by atmospheric nuclear weapons testing have been used to measure the rate of mixing of the upper and lower levels of the oceans, and tritium concentrations were found in 1963 at all sampled locations throughout the Mississippi River Basin and correlate well with the concentrations in precipitation following nuclear bomb tests in 1962.

According to the NRC, tritium has leaked from at least 48 of 65 nuclear sites in the U.S., exceeding the federal drinking water standard at at least 45 sites. A leak in Alabama contained 2 million picocuries of tritium per liter, and Excelon's Braidwood, IL reactor leaked 6 million gallons of tritium-tainted water, polluting resident's wells. The NRC states that in normal operation in 2003, 56 pressurized water reactors released 40,600 curies of tritium via liquid effluent (1.50 PBq) and 24 boiling water reactors released 665 curies (24.6 TBq).

Entergy lied about tritium leaks at its Vermont Yankee (VY) reactor in 2005 and later from a separate leak. Late in 2010, in an aquifer that was used for drinking water up until Feb. of that year, tritium contamination from VY was reported over 200 feet below ground.

In January 2014 the public was informed that 875 trillion becquerel (Bq) of tritium is onsite in contaminated water at Fukushima Daiichi and this amount is increasing by approx. 230 trillion Bq per year. According to TEPCO "Tritium could be separated theoretically, but there is no practical separation technology on an industrial scale."

Tritium from the Pilgrim Nuclear Power Station

Entergy established the groundwater monitoring program at Pilgrim Nuclear Power Plant (PNPP) in November 2007 to monitor for tritium in groundwater beneath and around the facility. They did not monitor groundwater before this because the NRC did not require it; therefore we do not know when tritium leakage at PNPS began.

Tests from groundwater wells at Pilgrim in the fall of 2012 found tritium levels as high as 3,088 picocuries per liter. Entergy informed the NRC that a Dec. 30, 2013 sample taken from a new groundwater monitoring well at the PNPS indicated a tritium concentration of 69,000 picocuries per liter. Background levels for radioactive tritium are typically in the 6.4 to 12.8 picocurie per liter range. See Legally permissible doses, above.

The Massachusetts Department of Public Health (MDPH) has identified 11 locations at Pilgrim that are potential sources of the tritium entering the aquifer. Recently, the watchdog group Pilgrim Watch asked the DPH to investigate yet another source - cracks in the concrete of the "torus" part of the reactor. The torus is a suppression pool used to remove heat released in an abnormal reactor event.

MDPH recently reported that since the tritium levels were "consistently above background levels established for this monitoring effort" more samples must be collected from the wells every month. Taxpayers are bearing a good portion of the cost of overseeing this monitoring, and for independent testing of the well samples.

Sources

Sourced primarily from Wikipedia, the NRC, and news reports, this was compiled by David Agnew, Cape Downwinders, Feb. 2015. http://capedownwinders.org/understanding-tritium/

See also:
MDPH's radiation monitoring data
Health Effects of Tritium by Dr. Rosalie Bertell
Chronology of Pilgrim's Tritium Leaks: What's the Latest? by Karen Vale