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Danger Posed by Radioactivity in Japan Hard to Assess

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The different radioactive materials being reported at the nuclear accidents in Japan range from relatively benign to extremely worrisome.

The central problem in assessing the degree of danger is that the amounts of various radioactive releases into the environment are now unknown, as are the winds and other atmospheric factors that determine how radioactivity will disperse around the stricken plants.

Still, the properties of the materials and their typical interactions with the human body give some indication of the threat.

“The situation is pretty bad,” said Frank N. von Hippel, a nuclear physicist who advised the Clinton White House and now teaches international affairs at Princeton. “But it could get a lot worse.”

In Vienna on Saturday, the International Atomic Energy Agency said Japanese authorities had informed it that iodine pills would be distributed to residents around the Fukushima Daiichi and Daini plants in northeast Japan. Both have experienced multiple failures in the wake of the huge earthquake and tsunami that struck Friday.

In the types of reactors involved, water is used to cool the reactor core and produce steam to turn the turbines that make electricity. The water contains two of the least dangerous radioactive materials now in the news — radioactive nitrogen and tritium. Normal plant operations produce both of them in the cooling water, and they are even released routinely in small amounts into the environment, usually through tall chimneys.

Nitrogen is the most common gas in the earth’s atmosphere, and at a nuclear plant the main radioactive form is known as nitrogen-16. It is made when speeding neutrons from the reactor’s core hit oxygen in the surrounding cooling water. This radioactive form of nitrogen does not occur in nature.

The danger of nitrogen-16 is an issue only for plant workers and operators because its half-life is only seven seconds. A half-life is the time it takes half the atoms of a radioactive substance to disintegrate.

The other radioactive material often in the cooling water of a nuclear reactor is tritium. It is a naturally occurring radioactive form of hydrogen, sometimes known as heavy hydrogen. It is found in trace amounts in groundwater throughout the world. Tritium emits a weak form of radiation that does not travel very far in the air and cannot penetrate the skin.

It accumulates in the cooling water of nuclear reactors and is often vented in small amounts to the environment. Its half-life is 12 years.

The big worries on the reported releases of radioactive material in Japan center on radioactive iodine and cesium.

“They imply some kind of core problem,” said Thomas B. Cochran, a senior scientist in the nuclear program of the Natural Resources Defense Council, a private group in Washington.

The active core of a nuclear reactor splits atoms in two to produce bursts of energy and, as a byproduct, large masses of highly radioactive particles. The many safety mechanisms of a nuclear plant focus mainly on keeping these so-called fission products out of the environment.

Iodine-131 has a half-life of eight days and is quite dangerous to human health. If absorbed through contaminated food, especially milk and milk products, it will accumulate in the thyroid and cause cancer. Located near the base of the neck, the thyroid is a large endocrine gland that produces hormones that help control growth and metabolism.

Dr. von Hippel of Princeton said the thyroid danger was gravest in children. “The thyroid is more sensitive to damage when the cells are dividing and the gland is growing,” he said.

Fortunately, an easy form of protection is potassium iodide, a simple compound typically added to table salt to prevent goiter and a form of mental retardation caused by a dietary lack of iodine.

If ingested promptly after a nuclear accident, potassium iodide, in concentrated form, can help reduce the dose of radiation to the thyroid and thus the risk of cancer. In the United States, the Nuclear Regulatory Commission recommends that people living within a 10-mile emergency planning zone around a nuclear plant have access to potassium iodide tablets.

Over the long term, the big threat to human health is cesium-137, which has a half-life of 30 years.

At that rate of disintegration, John Emsley wrote in “Nature’s Building Blocks” (Oxford, 2001), “it takes over 200 years to reduce it to 1 percent of its former level.”

It is cesium-137 that still contaminates much of the land in Ukraine around the Chernobyl reactor. In 1986, the plant suffered what is considered the worst nuclear power plant accident in history.

Cesium-137 mixes easily with water and is chemically similar to potassium. It thus mimics how potassium gets metabolized in the body and can enter through many foods, including milk. After entering, cesium gets widely distributed, its concentrations said to be higher in muscle tissues and lower in bones.

The radiation from cesium-137 can throw cellular machinery out of order, including the chromosomes, leading to an increased risk of cancer.

The Environmental Protection Agency says that everyone in the United States is exposed to very small amounts of cesium-137 in soil and water because of atmospheric fallout from the nuclear detonations of the cold war.

The agency says that very high exposures can result in serious burns and even death, but that such cases are extremely rare. Once dispersed in the environment, it says, cesium-137 “is impossible to avoid.”