concerned citizens for nuclear safety

107 Cienega St.
Santa Fe, NM 87501
(505) 986-1973 Tel
(505) 986-0997
ccns@nuclearactive.org
www.nuclearactive.org

Tritium in Water and Bioaccumulation of Cesium and Strontium

By Bernd Franke, Institut für Energie und Umweltforschung, Heidelberg, Germany

Tritium in Water

Tritium (hydrogen-3) can replace hydrogen atoms in water, which then becomes tritiated water. When taken into living tissues, tritium can be metabolized, resulting in organically bound tritium. This change of chemical form has to be accounted for in environmental pathway analyses.

Regulations by the U.S. Environmental Protection Agency (EPA), pursuant to the federal Safe Drinking Water Act (SDWA), establish a concentration of 20,000 picocuries per liter (pCi/L) for tritium. The EPA 2002 Radionuclide Preliminary Remediation Goals (PRGs) for Superfund for tritium in water is 43 pCi/L. Continued exposure to that level would result in an additional cancer risk of one in one million (1 in 1,000,000). Compared to this, the SDWA level appears to be quite high.

A number of surface water samples in the Los Alamos National Laboratory (LANL) region exceed the standard established in the SDWA, as well as the PRG value for Superfund, as shown in Table 1. The highest concentration found in the surface water of Mortandad Canyon is 175 times the SDWA limit and about 81,000 times the PRG value. It is evident from the data that current and past LANL emissions of tritium have contributed to the tritium contamination in the region.

Table 1. Tritium in surface water in the LANL region for 1998 (Source: *Environmental Surveillance at Los Alamos during 1998*, LA-13633-ENV

Station	**Tritium concentration pCi/L**
Pajarito Plateau	
Acid/Pueblo Canyon	from <DL to 700,000
DP/Los Alamos Canyon	300,000 to 330,000
Sandia Canyon	from <DL to 360,000
Mortandad Canyon	from 60,000 to 3,500,000
Cañada del Buey	<DL
Pajarito Canyon	from <DL to 230,000
Water Canyon	150,000
Ancho Canyon	90,000

Frijoles Canyon	50,000 to 440,000

Runoff Stations	
Los Alamos Canyon near Los Alamos	from <DL to 280,000
Cañada del Buey at White Rock	from <DL to 90,000
Area G	from 140,000 to 860,000
Rio Grande	from <DL to 82,000
Detection limit	700
EPA Drinking Water Standard	20,000
EPA PRG for Superfund in tap water	43

Bioaccumulation of Cesium and Strontium

What is bioaccumulation?

Bioaccumulation is an important process through which chemicals or radionuclides can affect living organisms. Bioaccumulation means that there is an increase in the concentration of the chemicals or radionuclides in an organism over time as compared to the concentration of the chemical or radionuclide in the environment. Compounds accumulate in living things any time they are absorbed and stored faster than they are excreted or metabolized, which means broken down by the body. Understanding the dynamic process of bioaccumulation is very important in protecting human beings and other organisms from the adverse effects of exposure to chemicals or radionuclides. It has become a critical consideration in the regulation of chemicals and radionuclides alike.

How does cesium-137 and strontium-90 bioaccumulate?

The radionuclides cesium-137 and strontium-90 are both fission products with a radiological half-life of about 30 years. If released into the environment, they can both concentrate again at various steps of the food chain. The way they accumulate depends on their chemical behavior.

Cesium-137 has chemical properties that are similar to potassium. Because the cells in plants, animals and in the human body cannot distinguish between cesium-137 and potassium, cesium-137 can be mistaken by the body to be potassium and absorbed as such. Because most potassium in the human body is found in the blood, cesium-137 can be found in all parts of the human body.

Strontium-90, on the other hand, has chemical properties similar to that of calcium. Hence, strontium-90 concentrates in milk and bones.

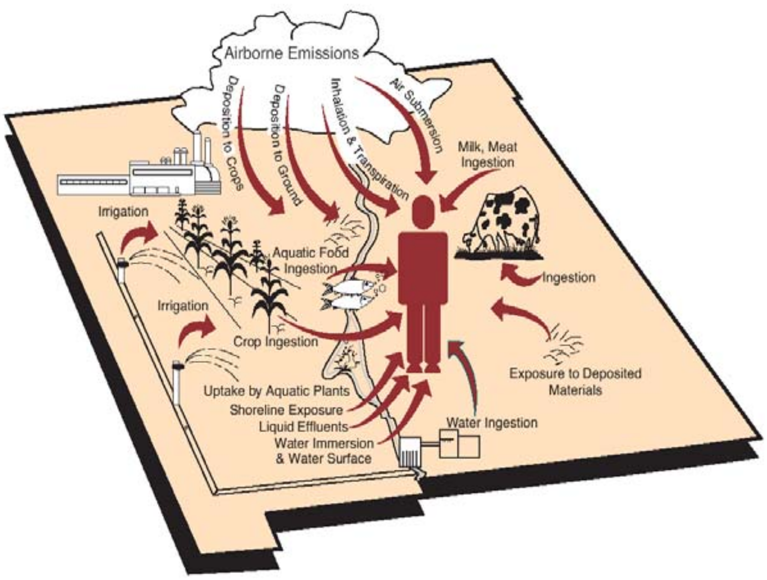

Figure 1. Environmental pathways for radionuclides (Source: Environmental Surveillance at Los Alamos during 2002, LA-14085-ENV)

How does cesium-137 and strontium-90 behave in the food chain?

The transport of radionuclides in the environment is a complex matter and depends on many conditions, including climate, precipitation, plant and animal species and type of agriculture. For example, the same concentration of cesium-137 or strontium-90 in soil at two locations can lead to widely different concentrations in food grown in the soil, depending on the environmental conditions. Scientists describe the behavior in computer models with different complexity. An example is shown in Figure 1.

There are many parameters that are entered into such a model that describe the behavior of radionuclides in the environment and the human body, such as:

- Dry deposition rate from air to soil
- Wet deposition rate from air to soil
- Resuspension from soil into air
- Fraction that is initially deposited on plant surfaces
- Removal rate from plant surfaces
- Leach rate from the surface soil into deeper soil layers
- Transfer from roots to plant tissues
- Ingestion rate of soil and plants to animals
- Loss during food preparation
- Uptake from the gut into the bloodstream
- Accumulation in body organs
- Excretion from body organs

Which pathways are typically important?

The environmental pathway that is most relevant for humans or animals depends on the amount and type of food that is ingested. The following table provides some information about cesium-137 and strontium-90 concentrations that were found in the regional environment around LANL. The values shown correspond to the Regional Statistical Reference Levels (mean plus two standard deviations), based on data from 1994 to 1998. Much of the cesium-137 and strontium-90 in the environment around LANL is from fallout of atmospheric nuclear weapons tests, with an additional contribution due to historical and current releases from LANL. Only a limited number of environmental media are sampled at LANL. The predominant pathway for the communities in Northern New Mexico is likely to be the consumption of produce because the typical individual consumes more produce than meat or fish.

Table 2. Cesium-137 and Strontium-90 and in the soil and food in the LANL region (Source: Id.)

Environmental medium	Cesium-137	Strontium-90
Surface soil	600 pCi/kg	710 pCi/kg
Produce	74 pCi/kg dry	82 pCi/kg dry
Eggs	23 pCi/kg	8.4 pCi/kg
Goats' milk	44 pCi/kg	2.2 pCi/kg
Free range steer, muscle	123 pCi/kg dry	39 pCi/kg dry
Free range steer, leg bone	95 pCi/kg dry	1,950 pCi/kg dry
Honey	305 pCi/kg	5 pCi/kg
Mushrooms	12 pCi/kg dry	247 pCi/kg dry
Game fish	277 pCi/kg dry	170 pCi/kg dry

What dangers are presented by cesium-137 and strontium-90?

The risk from a given ingestion of cesium-137 and strontium-90 depends on the age of the person and their metabolic conditions. The EPA provides risk estimates for a typical adult that breathes contaminated air or incorporates radionuclides with food or water using a simplified model (EPA 2002, Federal Guidance Report No. 13, Cancer Risk Coefficients for Environmental Exposure to Radionuclides, Washington, DC). The values for incorporation with food or water are shown in the table below. The risk level of one in one million (1 in 1,000,000) is usually considered negligible, whereas a risk of greater than one in ten thousand (1 in 10,000) is typically deemed to be unacceptable. Based on this, the annual ingestion of greater than 15,000 pCi of strontium-90 over 50 years would result in an unacceptable risk.

Table 3. Cancer risk due to ingestion of cesium-137 and strontium-90

	Cesium-137	Strontium-90
Cancer risk factor for ingestion (EPA, 2002)	3.7×10^{-11} per pCi	6.9×10^{-11} per pCi

Amount of radionuclide ingestion for a cancer risk of: - one in one million (1 in 1,000,000) - one in ten thousand (1 in 10,000)	 27,000 pCi 2,700,000 pCi	 15,000 pCi 1,500,000 pCi