There is No Need to Vitrify the Nuclear Waste at Hanford

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During 1945-1971 the Columbia River was awash with harmless radioactivity

The Hanford site encloses a 586 square mile area in eastern Washington. The 9 plutonium-producing nuclear reactors that line the Columbia River produced 67 metric tons of plutonium from 1944-1994, leaving 110,000 tons of spent reactor fuel. Following the chemical separation of plutonium, the high level waste (HLW) was stored in 177 tanks surrounded by a fence enclosing 65 acres. Of these tanks, 67 contain no water while 60 tanks have measureable but miniscule leaks of radioactive materials.

During the first 25 years of Hanford, the AEC wanted to build nuclear weapons. It claimed that there were no radiological health risks at the site. Later DOE policy turned 180 degrees; it emphasized the health risks associated with HLW. The AEC was right; the DOE was wrong. During all of this time, political ideology appeared more important than scientific credibility. Today the anti-nuclear agenda of the media, politicians, contractors and regulatory agencies exploit the Linear-No-Threshold (LNT) assumption, which fits neatly into their strategies of promoting radiophobia.

From 1945 until 1971, some 30-60 million curies of beta-gamma radionuclides were released into the Columbia River, including 1.7 Ci of Pu^{239}. Herb Parker estimated that 8,000 Ci were discharged per day into the river, during 1954, from pumped water over the cores of 8 reactors lining the river. In radioecology studies, no harm to plants, invertebrates, birds or mammals was noted, even though selected biota concentrated some radionuclides up to 100,000-fold. (Robertson DE et al. 1973. Transport and depletion of radionuclides in the Columbia River. In: Radioactive contamination of the marine environment, IAEA, Vienna, Austria, STI/PUB/313, p. 141-158; Becker CD. 1990. Aquatic bioenvironmental studies: The Hanford exposure 1944-84. Studies in Environmental Science 39. Elsevier, Amsterdam, Netherlands).

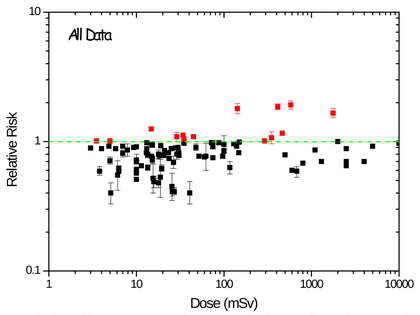
Several epidemiological studies of the Hanford nuclear workers and residents of surrounding communities failed to show adverse health effects associated with radioactivity, but did show evidence of benefits from radiation exposures. (Wing S. et al. 2004. Plutonium-related work and cause-specific mortality at the United States Department of Energy site. Amer J Industr Med 45:153; Gilbert et al. 1993. Mortality of workers of the Hanford site 1945-1986. Health Phys 64:577; Wing S et al. 2005. Age of exposure to ionizing radiation and cancer mortality among Hanford workers: Follow up through 1994. Occup Environ Med 62:465; Baillargeon J et al. 1999. Characteristics of the healthy survivor effect among male and female Hanford workers. Amer J Industr Med 35:343; Boice JD et al. 2006. Cancer mortality among populations residing in counties near the Hanford site, 1950-2000. Health Phys 90:431.)

There were no deleterious effects on the ecology of the Columbia River or risk of cancer or any other health effects associated with high radioactive releases into the Columbia River. The amount of radioactivity released today by leaking tanks at Hanford are at least a billion times less than in the past. In fact, the risk to the health of nuclear workers at Hanford was similar to that seen in other nuclear workers throughout the world; the workers were healthier than the surrounding populations. The maximum amount of radioactive materials discharged into the Columbia River per day (1954) reached 160,000,000,000,000,000 pCi. The amount reaching the river today is in the 1-10 pCi/L per day range, a very small comparative volume.

United States Transuranic Registry (TUR)

The U.S.TUR was established in 1968 in Richland, WA. It accepted volunteer donations of whole or partial body (organs) from individuals exposed to high levels of plutonium-239. Autopsy and tissue distribution studies of radionuclides were carried out by pathologists. An analysis of 319 U.S.TUR deceased plutonium workers found no association between radiation dose from plutonium deposition and death due to cancer or any other disease. In fact, death rates for U.S.TUR registrants were significantly lower than expected using life tables for the U.S. general public, with participants exceeding life table longevity expectation by an astounding average of 10.4 years. (Fallahian NA. 2007. Does exposure to plutonium affect worker's longevity? Health Phys 93:S11 (U.S.TUR-0228-07); Fallahian NA. 2012. Cancer deaths and occupational exposure in a group of plutonium workers. Health Phys 102:443).

Occupational exposure to ionizing radiation in nuclear workers does not result in increased mortality but does result in health benefits. The use of the healthy worker effect (HWE) to explain the obvious health benefits of low dose radiation is not supported by science and is a scandal in itself.

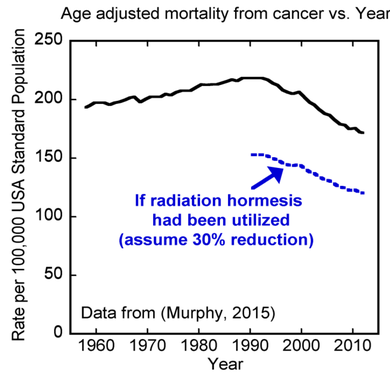


Relative risk for all cause mortality in radiological workers; red is harm and black is benefit. (CL Sanders. 2010. Radiation Hormesis and the Linear-No-Threshold Assumption. Springer, Heidelberg, p. 67)

Thresholds

Lifespan dog studies have consistently shown dose thresholds of > 5 Gy for tumor formation in lung and skeleton of dogs that ate, inhaled, or were injected with beta-gamma-emitting radionuclides (Sr-90, Cs-137, Ce-144, Y-90) . The threshold for bone tumors in radium dial painters is 10 Gy. The dose threshold for inhaled Pu-239 dioxide in rats, dogs and humans ranges from 0.5-1.0 Gy for lung tumor formation. This threshold is equivalent to >500,000 particles of 300 nm diameter PuO_2 particles per gram lung retained in the lung for over a year. These thresholds are many orders of magnitude greater than the dose anyone would have received at Hanford. Several other epidemiology studies have also shown health benefits in plutonium workers.

Lauriston Taylor, president of NCRP for its first 48 years, called the LNT "a deeply immoral use of our scientific knowledge". Both Lauriston Taylor and Robley Evans believed that the 1934 NCRP standard of 1 mGy/d would not result in any health risk. Don Luckey wrote books on radiation hormesis in 1980 and 1991. He showed that the average mortality of nuclear workers was significantly less than the controls.



CL Sanders. 2017. Radiobiology and Radiation Hormesis. New Evidence and its Implications for Medicine and Society. Springer-Nature, Cham, Switzerland. Figure is courtesy of Mohan Doss.

Vitrification Technology

. Glassification is an ancient technology seen in the archaeological findings of civilizations millennia ago. Modern vitrification technology with borosilicates for isolation and containment of high level nuclear wastes (HLW), is a mature technology used for over the last 40 years. It has been successfully implemented in a safe, simple and efficient way in France, Germany, Belgium, Russia, Japan and the United States, the latter at the West Valley Demonstration Project (1969-1996) and at the Savannah River Project starting in 1987. A small project was even carried out at Hanford several decades ago. The glass blocks are stable, impervious to the environment, meeting all leach-resistant requirements. West Valley had vitrified 15 million Ci by 1972. Savannah River has vitrified over 100 million Ci, and it continues today. By 1995, France had vitrified 1490 million Ci. Idaho National Laboratory chose to calcine its 36 million Ci, and this was completed by the year 2000.

Vitrification at Hanford should have started decades ago, as was successfully performed by several other nuclear entities in the world. The cleanup of Hanford HLW was initiated in 1989. The current schedule by Bechtel is to begin vitrification by 2022 and complete the project by 2064. Meanwhile, from 1989-2002 , ~130 million Ci decayed in place. In 2022, the HLW inventory will be 120 million Ci and natural decay will leave only 40 million Ci at Hanford by 2064. Over 50% of the radionuclide inventory at Hanford has decayed in place since 1989. Why not just leave the remaining HLW in place? The cost of completing the vitrification of all the HLW at Hanford by 2064 is projected to exceed $200 billion.

Will radioactive atoms migrate in any radiologically significant amount through the desert soil to find the river in the distant future? Natural radiation in the river is far above that seen from phantom contaminants. Have Bechtel and DOE truly estimated the risks of hydrogen gas buildup and plutonium criticality in the tanks? They would be incompetent if they could not guarantee the safety of the tanks at Hanford.

Therapeutic Benefits of Low Dose Radiation

There is a substantial literature indicating that low-dose radiation is not only healthy but can be effectively utilized to treat a variety of inflammatory diseases. Herodotus and other Roman physicians recognized this 2600 years ago. In 1903, inhaled radon was used to treat tuberculosis. Books in German (1912-3) documented the use of radium therapy. The journal *Radium* founded in 1913 provided many cases that responded to radium and x-rays, such as arteriosclerosis, arthritis, diabetes, heart disease, senility, infections, and cancer.

Today, hundreds of thousands patients a year, many under prescription order from physicians, are treated in radon/radium spas, particularly in Europe, Russia and Japan. Low-dose radiation is the treatment of choice for non-Hodgkin's lymphoma. Published case reports have recently shown remarkable recoveries for patients with advanced cancer and with Alzheimer's dementia and Parkinson's disease.

The prevention and therapy of many inflammatory conditions by low radiation has been documented in hundreds of publications. (Sakamoto K. 2004. Radiobiological basis for cancer therapy by total or half-body irradiation. Nonlinear Biol Toxicol Med 2:293; Pollycove M. 2007. Radiobiological basis of low-dose irradiation in prevention and therapy of cancer. Dose-Response 5:26; Takatori M et al. 2010. Clinical significance of low-dose radiation therapy: radiation hormesis. Int J Low Radiat 7:511; Sanders CL. 2012. Potential treatment of inflammatory and proliferative diseases by ultra-low doses of ionizing radiation. Dose-Response 10:610; Cuttler JM et al. 2016. Treatment of Alzheimer disease with CT scans: A case report. Dose-Response (DOI: 10.1177/1559325816640073)).

Conclusions

DOE contractors failed to use proven vitrification or calcination technologies. They do not credit natural decay and the option of leaving the HLW in place at Hanford. Another possible solution, used by coal-fired plants, is the return of waste (coal fly ash) to the mines from where the fuel was obtained. HLW could be diluted with tailings and returned to abandoned uranium mines. The radioactivity of returned coal ash is a 100 times that placed into the environment by nuclear plants of the same power level.

Radioactive leaks into the Columbia River today are miniscule. There was no observed environmental damage or human health risk from enormous radioactive releases during 1944-1971. There is clear evidence of large radiation dose thresholds for cancer formation from exposure to a wide variety of radionuclides. Thousands of published papers demonstrate the prevention and potential therapy of proliferative and inflammatory diseases by low-dose radiation.

The future, proposed legacy of DOE and Hanford can be hundreds of billions of dollars wasted to solve a problem that does not even exist. LNT-based regulations defy the credibility of science. LNT-induced radiophobia is destructive to human health and government economic health. As scientists, what the authors feel most concerned about is the intentional disregard of thousands of peer-reviewed publications by the DOE, NCRP and many other radiation protection organizations in the world.