SCIENCE FOR DEMOCRATIC ACTION

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# Human Radiation Experiments in the United States

by Arjun Makhijani[1] and Ellen Kennedy

*Our scientific power has outrun our spiritual power. We have guided missiles and misguided man.*
–Martin Luther King, Jr., 1963

Secretary of Energy Hazel O'Leary announced on December 7, 1993 that the nuclear establishment had conducted radiation experiments on humans since the 1940s. It was a stunning admission — the first time that the head of a nuclear weapons agency had stood before the people it was pledged to protect to admit the awful truth that it had experimented on them. "The only thing I could think of was Nazi Germany," she told *Newsweek*.[2] Similar thoughts undoubtedly crossed the minds of millions, who wondered how the citizens of a country with democratic checks and balances could have been used as unwitting guinea pigs.

It was soon apparent that other agencies, beyond the Department of Energy, had been involved in human radiation experiments.[3] For example, the Department of Defense deliberately released

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PHOTO COURTESY OF EILEEN WELSOME, *ALBUQUERQUE TRIBUNE.*

**In 1947, railroad porter Elmer Allen was injected with plutonium as part of a secret experiment.**

[1] This article is partly derived from an article in the March 1994 issue of the *Bulletin of Atomic Scientists.*

[2] *Newsweek*, December 27, 1993, p. 15.

[3] Also involved were the Department of Defense (DOD), the National Aeronautics and Space Administration (NASA), the Department of Veterans Affairs, the Central Intelligence Agency, and the Veterans Administration.

[4] U.S. GAO, "Nuclear Health and Safety: Examples of Post World War II Radiation Releases at U.S. Nuclear Sites." (GAO/RECD-94-51FS), Washington, D.C., November 1993.

# Radiation Clean-Up Standards

by Annie Makhijani and Bret Leslie

As the Cold War grinds to a halt, the U.S. is forced to turn its attention from the production of nuclear weapons to the cleanup of the nuclear weapons complex and other sites contaminated by radioactivity. One of the common buzzwords from this new period is "D & D," which is not a fantasy game (one hopes) but "Decontamination and Decommissioning". Decontamination is the "cleaning up" process in which radioactive contamination at a site is reduced to acceptable levels for future public use. For example, by scraping up contaminated soil, consolidating and storing radioactive materials appropriately, and taking other

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THIS IS REALLY & TRULY YOUR

LAST ISSUE

UNLESS...

(DETAILS ON BACK COVER)

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radionuclides into the air from 1948 to 1952 in order to design and test radiation weapons.[4] Such weapons, discussed as far back as the Manhattan Project, are designed to create temporarily high radiation fields to kill or debilitate enemy soldiers. Secretary O'Leary, in effect, opened a Pandora's box of U.S. radiation testing on humans.

## Purposes of the Experiments

The accompanying table on pages 4 and 5 shows a list of many of the human radiation experiments categorized according to the five goals of the funding agencies. Some experiments may have had more than one purpose; for example, some involving external exposure to sick people were purportedly to treat cancers. The objectives of the experiments will not be entirely known until we have more documentation.

## Nameless Subjects

This is not a new story, despite the impression that recent, intense media coverage conveys. In 1986, Congressman Edward Markey of Massachusetts released a report called "American Nuclear Guinea Pigs," documenting many of the radiation experiments on U.S. citizens and calling for further investigation.[5] Yet at the time, the Department of Energy denied that anything unethical had been done, and the report went largely unnoticed.

There are several reasons why the experiments have generated a public outcry in 1993-94 and did not in 1986. First, the Department of Energy is slowly trying to redefine itself according to post Cold War reality, thanks in large part to Secretary O'Leary. Second, the 1986 Markey report released information about *nameless* human subjects. It took a reporter from the *Albuquerque Tribune* — Eileen Welsome — uncovering the identities of some of the subjects for the public to listen. Somehow the thought of "Cal-3" being injected with plutonium was less offensive to the public than "Elmer Allen," a down-on-his-luck railroad porter being injected in his injured leg, in which he was told he had bone cancer; his leg was then amputated.

*Somehow the thought of "Cal-3" being injected with plutonium was less offensive to the public than "Elmer Allen" ...being injected.*

## A Question of Ethics

The names of the experimenters are also integral to understanding and redressing the experiments. As more information about the experiments comes to light, disturbing ethical questions also arise.

*See "Experiments"—p. 3*

[5] Subcommittee on Energy Conservation and Power of the Committee on Energy and Commerce, U.S. House of Representatives, "American Nuclear Guinea Pigs: Three Decades of Radiation Experiments on U.S. citizens." Washington, D.C, November 1986. Also known as the "Markey Report."

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***Science for Democratic Action*** Managing Editor: Ellen Kennedy

**Experiments**
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Many of the experimenters are still alive and most are now scrambling to defend their actions. A number are joined by sympathetic colleagues. One physics professor recently claimed in a letter to the *Boston Globe* that "our real danger is not from gamma radiation...but from the pandering to fear and ignorance of gullible journalists and ambitious politicians."[6] However, scientists defending the experimenters are finding slippery footing on the moral high ground.

Many of the human experimenters now claim that not enough was known about radiation to recognize that it might harm the subjects of the experiments. While it is true that risk estimates of exposure to low levels of radiation have increased over the decades, the dangers of radiation exposure were well known during the era of the experimentation, which extended into the early 1970s.[7] In the late 1950s, radiation standards for workers were set at 5 rem per year, the same as they are today.

Even the dangers from lower levels of radiation — comparable to downwind fallout from atmospheric testing — were well recognized. For instance, Colonel Stafford L. Warren, chief of radiological safety, studied the widespread fallout produced by the very first nuclear weapons test in New Mexico on July 16, 1945 and recommended that no tests be conducted within 150 miles of human habitation.[8]

Despite the experimenters' protestations that the doses were low and therefore not dangerous, many of the experiments were designed to induce harm. Among these was the irradiation of the testicles of prisoners. The irradiation levels ranged up to 600 rads, known even during the Manhattan Project to be very dangerous. Another example was the injection of uranium salts into subjects at the University of Rochester in 1946 and 1947 at levels that would produce injury to the kidneys.[9]

Finally, many of the experiments are especially upsetting because of the type of human subjects chosen to receive the radiation. In case after case, the subjects were in a compromised or powerless position. For example, some subjects were prisoners, others poor, pregnant, children, elderly, people of color, or believed to be mentally retarded. Some were soldiers or military personnel who

*See "Experiments"—p. 4*

[6] Alan Cromer, "Radiation experiments: Why all the uproar?" *Boston Globe*, 7 January 1994.

[7] For instance, the amounts of plutonium injected in the human experiment conducted by Los Alamos and the University of Rochester School of Medicine and Dentistry during 1945-47 ranged from 0.095 to 5.9 microcuries, which were about 2.4 times to 14.7 times the "tolerance dose" of 0.04 microcuries set for workers in 1944 in the Manhattan Project; the average dose was 0.35 microcuries, or almost nine times the "tolerance dose" according to Patricia Durbin of the Lawrence Berkeley Laboratory. She stated in testimony that this standard for "tolerance dose" was established at a level at which "no clinically detectable biological damage would result" during an exposed worker's entire lifetime. The standard was based mainly on animal studies and on analysis of the deaths of radium dial painters in the early part of this century. In other words doses greatly in excess of those thought not to produce damage were given to all the plutonium-injection experimental subjects. Patricia Durbin, testimony before the House Subcommittee on Energy Conservation and Power, House Committee on Energy and Commerce, U.S. House of Representatives, January 18, 1994.

[8] Colonel Stafford L. Warren, "Report on Test II at Trinity, 16 July 1945," memorandum to Major General Groves, July 21, 1945. Located in the Modern Military Branch of the National Archives, Washington, D.C.

[9] Subcommittee on Energy Conservation and Power, 1986, p.2.

## LETTERS

SDA is a great publication. I love and admire the way you guys work to de-mystify nuclear physics/power/weapons. As a math guy and former math teacher who also tried to make math meaningful, fun and accessible, I particularly appreciate what you do. Most of my work these days is advocacy of bicycling, car-reduction and "full-cost pricing" of cars and trucks.

Charlie Komanoff
New York, NY

...What an array after reading SDA's report. What kind of a country (and world) did my folk bring me into in 1910? I think I love my country! But why? For what it could be, and the good people in it, I guess.

Harvey G. Baker,
Daytona Beach, FL

Many thanks for the back issues of your newsletter. As an information source for my Sierra Club work,...it is extremely valuable!

Anne H. Ehrlich,
Dept. of Biological Sciences,
Stanford University

***Experiments***
*continued from p. 3*

felt they had to follow orders. In many cases, no informed consent was given, or the subjects did not even know they had been exposed to radiation.

### Deceit in the System

Clearly, many of the experimenters were not concerned with the health or well-being of their subjects. This lack of concern for the U.S. public was mirrored in the nuclear establishment that employed them.

By 1947, spreading fallout on enemy territory was considered potentially a major part of atomic warfare. A special board was formed to explore the use of "radioactive mists" generated after an underwater nuclear explosion as a means to create terror among civilians in enemy countries. Ironically, the same terror of radioactive mists afflicted U.S. citizens living downwind of test sites (downwinders), who were exposed to fallout from atmospheric testing. But instead of conducting their testing program in conformity with

*See "Experiments"—p. 6*

## Some Examples of Radiation Experimentation on Humans[1]

compiled by David Kershner

| DATE | DESCRIPTION | INSTITUTION |
|---|---|---|
| | Experiments to develop instrumentation for spying on the Soviet Nuclear Weapons Complex | |
| 1949 | intentional release of iodine-131 to environment | AEC[a], Air Force[1] |
| 1950 | intentional release of radioactive material to the environment | Los Alamos Lab., Air Force[1] |
| | Experiments to develop radiation weapons | |
| 1948 | intentional release of lanthanum-140 to environment | AEC[1] |
| 1949-52 | intentional release of tantalum-182 and possibly other radioactive material to the environment | Army, AEC, Air Force[1] |
| | Experiments to determine the effects of radiation on ability of military personnel to function on the nuclear battlefield and/or effects of radiation on astronauts | |
| 1943-44 | whole body irradiation by x-rays | Univ. of Chicago[2] |
| 1953 | exposure of hands to radioactive material | Foster D. Snell (consulting firm), Monsanto[2] |
| 1956 | exposure of pilots to mushroom clouds from nuclear tests | Air Force[2] |
| 1960-71 | whole body irradiation by x-rays | Univ. of Cincinnati[3] |
| 1960-1974 | whole body gamma irradiation | Oak Ridge Inst. of Nuclear Studies (TN)[4] |
| early 1970s | neutron and ion beam irradiation | Lawrence Berkeley Laboratory[2] |
| | Occupational exposure to external radiation | |
| 1945 | exposure of skin to beta rays | Clinton Lab. (Oak Ridge, TN)[2] |
| 1947 | exposure of fingers to radioactive material | Univ. of Chicago[2] |
| 1955 | exposure of skin to radium-224 | New York Univ.[2] |
| 1963-1971 | irradiation of the testicles of prisoners by x-rays | Pacific Northwest Research Found., Univ. of Wash.[2b] |

* Categories are those considered most appropriate from publicly available evidence. The purpose is not always explicitly stated and in this case represents judgments made by IEER staff.

| DATE | DESCRIPTION | INSTITUTION |
|---|---|---|
| | Experiments to determine the effects on metabolism of radioactive materials[b] | |
| 1943-47 | polonium injections | Univ. of Rochester[2] |
| 1945-47 | plutonium injections | Manhattan District Hospital (Oak Ridge), UCSF[a], Univ. of Rochester, Univ. of Chicago[2] |
| 1946-47 | injections of U-234 and U-235 uranium nitrate to induce renal injury | Univ. of Rochester[2] |
| late 40s | administration of radioactive iron to pregnant women | Vanderbilt Univ.[5] |
| 1946-56 | ingestion of radioactive iron and calcium | MIT[a], Harvard[4] |
| 1950, 1952 | exposure of skin to tritium; also some by ingestion and inhalation | Los Alamos Scientific Lab.[2] |
| 1953-57 | uranium injections | Mass. General Hospital (Boston), ORNL[a,2] |
| ? (results published '59) | calcium-45 and strontium-85 injections | Columbia Univ., Montefiore Hosp. (Bronx, New York)[2] |
| 1960s | U-235 and manganese-54 ingestion | Los Alamos Sci. Lab.[2] |
| 1961-63 | ingestion of real and simulated fallout from nuclear tests | Univ. of Chicago, Argonne National Laboratory[2] |
| 1961-1965 | radium and thorium injections/ingestion | MIT[2] |
| ? (results published '62) | ingestion of lanthanum-140 | Oak Ridge Inst. of Nuclear Studies[2] |
| 1963 | phosphorus-32 injections | Battelle Memorial Institute (Richland, Washington)[2] |
| 1962-65 | intentional release of iodine-131 to environment/ingestion | ORNL, Nat'l Reactor Testing Station (ID)[2] |
| 1965 | technetium-95 (metastable) and technetium-96 injections/ingestion | Pacific Northwest Lab.[2] |
| 1965-73 | inhalation of argon-41/ingestion of various radioactive isotopes | AEC[2] |
| 1967 | promethium-143 injections/ingestions | Hanford Env. Health Found., Battelle Memorial[2] |
| ? (results published '68) | lead-212 ingestions/injections | Univ. of Rochester[2] |

**Notes:**

[a] AEC=U.S. Atomic Energy Commission, UCSF=Univ. of California, San Francisco, MIT=Massachusetts Institute of Technology, ORNL=Oak Ridge National Laboratory

[b] Some of these experiments may fit into other categories, and some may have had military applications

**Sources:**

[1]U.S. GAO, *Examples of Post World War II Radiation Releases at U.S. Nuclear Sites*, GAO/RCED-94-51FS, November 1993;
[2]U.S. House of Representatives, "American Nuclear Guinea Pigs: Three Decades of Radiation Experiments on U.S. Citizens," November 1986;
[3]*Congressional Record-Senate*, S 16371, October 15, 1971,
[4]Rosenberg, Howard, "Informed Consent," *Mother Jones*, Sept./Oct. 1981, pp. 31-37,44;
[5]Hahn, Paul F., et al, *Journal of Obstetrics and Gynecology*, Vol. 61, No. 3, March 1951.

**Experiments**
*continued from p. 4*

the recommendation of the chief of radiological safety, the nuclear establishment waged a campaign to convince the people of the United States that fallout from testing was not harmful. One document deemed it "a matter of reeducation" to convince the U.S. public to "accept the possibility of an atomic explosion within a matter of a hundred or so miles of their homes."[10]

The legal maneuvering of the nuclear establishment also reveals a general lack of concern for the public. The fear of liability so haunted the U.S. nuclear weapons establishment that contractors to the AEC demanded and got complete immunity from liability, even for gross negligence or violation of contract. Concern about liability seems to have carried over to the human experiments. For instance, Dr. Charles Edington wrote the following when he approved the irradiation of the testicles of prisoners in Washington and Oregon State prisons in from 1963 to 1971:

"All of our mammalian work has been carried out to get a better idea of radiation effects on germ cells and spermatogenesis, etc., with the hope of extrapolating the results to man. This proposal is a direct attack on our problem. I'm for support at the requested level as long as we are not liable.

*"I wonder about the possible carcinogenic effects of...treatments."*
*–Dr. Charles Edington, Human radiation experimenter*

"I wonder about the possible carcinogenic effects of such treatments."[11]

### The Road From Here

There are a number of ways the DOE and the Clinton administration can respond to outcry over the experiments. Stepping back from full disclosure by all the institutions involved, both public and private, is not one of them. It is too late for that. But they could choose to treat the experiments as a narrow matter, resolved by releasing a minimum of documentation and by treating and compensating a few hundred or a few thousand victims. In doing so they would let an historic opportunity slip by.

First, the scope of the inquiry needs to include atomic veterans, downwinders and workers who were exposed to radiation and other dangers from weapons production and testing. Second, scientific issues as well as ethical ones are involved. The quality of the science that the DOE and its contractors did on health and environmental issues has often been poor and sometimes appalling. Even after clear evidence of fabricated data and shocking mistakes of basic math have been exposed, neither the DOE nor its contractors have analyzed the nature of the underlying problems that have led to the poor work.

The Clinton administration should use this occasion to open a sorely needed national debate on science, ethics, environmental protection and clean-up, and nuclear weapons. There are at least six dimensions to such a debate:

1. The causes of the poor quality of much of the science involving health and environmental issues within the nuclear weapons complex and its impact on the prospects for clean-up, waste management, and protection of workers and off-site populations.
2. The ethics of using science and technology to produce weapons of mass destruction.

*See "Experiments"—p. 7*

[10] U.S. Joint Chiefs of Staff, Final Report to Joint Chiefs of Staff Evaluation Board for Operation Crossroads (JCS-1691/7, RG-218) Modern Military Branch, National Archives, Washington, D.C, 1947.

[11] Charles C. Edington, "Effec.ts of Ionizing Radiation on the Testicular Function in Man," Summary Review of Research Proposal, 14 April 1963.

## COMMUNITY CORNER

On June 12-18, 1994, Student Pugwash USA will hold its 8th International Conference at Johns Hopkins University in Baltimore, Maryland. The Conference will bring together 100 students from around the world with leaders from academe, government and NGOs for a week of intensive exploration of the social and ethical implications of science and technological advancement. For more information, call (202) 328-6555 or 1-800-WOW-A-PUG (students only).

Three Mile Island national nuclear waste and radiation monitoring conference for activists. March 26–27. For info call (717) 233-7892.

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3. The ethics of building, threatening to use, and actually using such weapons.
4. The effects upon universities and other institutions of research and learning resulting from secrecy and dependence on military contracting.
5. The ways in which scientific inquiry and technological innovation impose risks upon populations and the environment, and the nature of the democratic processes necessary for informed consent. Such a debate must include cases where there may be uncertainty about the dimensions of the risk, and who bears the burden of proof in case of suspected injury or ecological damage — those doing and financing the experiments or those upon whom the risk is imposed.
6. The subjective aspects of the scientists' role in these human experiments must be re-examined. In most cases the health of the subjects was not of enduring or substantial interest to the researchers or to their colleagues in the professions of radiology, radiobiology, and health physics who knew about these experiments and used their results. Normally, the interplay between the needs and desires of scientists and their observations is hidden. But it is dramatically transparent in the conduct of these human experiments. It should become a part of the historic debate on science and policy occasioned by them.

*The Clinton administration should use this occasion to open a...national debate on science, ethics, environmental protection and clean-up, and nuclear weapons.*

Secretary O'Leary has already taken the highly unusual step of asking ethicists to assist her department in the process of evaluating the human experiments, releasing the information, and doing justice to the victims. It would be fitting if such a wide-ranging fundamental enquiry were to be vigorously advocated by the DOE.

The Departments of Energy and Veterans Affairs have established hotlines for people who believe they may have been subjects of radiation experimentation. The volume of the calls is tremendous; the DOE now has 36 operators. If you believe you were a subject in a radiation experiment, you can call 1-800-493-2998. Veterans should call 1-800-827-0365.

## SELECTED IEER WORK

- Project to support grassroots groups working on nuclear weapons production, testing and clean-up issues.
- Portsmouth Residents lawsuit, for neighbors of this DOE uranium enrichment facility.
- Project to declare plutonium a waste.
- Rongelap Rehabilitation Project to assess the habitability of Rongelap Atoll.
- Mound lawsuit for neighbors of the DOE's Mound Plant, near Dayton, Ohio.
- Production of *The Nuclear Power Deception,* a book on nuclear power issues.
- Production of source-book on global environmental and health effects of nuclear weapons production for IPPNW.
- Work on clean-up and decommissioning issues for Native Americans for a Clean Environment.

**Credits for this Issue**

1. Photographs: Robert del Tredici, Eileen Welsome
2. Review of tables on cleanup standards: Michael Boyd, EPA and Christine Daily, NRC
3. Production: Sally James of Cutting Graphics, Washington, D.C.

# A SPECIAL CENTERFOLD FOR TECHNO-WEENIES

## Radiation Clean-Up Standards

Note that for all tables, when more than one radionuclide is present, the limit for each is lowered so that the combined dose is approximately constant.

**SOIL**
(Current EPA and NRC Standards and Guidelines)

| NUCLIDE | CONCENTRATION (picocuries/gram) | | DESCRIPTION |
|---|---|---|---|
| | OPTION 1 (NRC Action Plan has two options) | OPTION 2 | |
| Natural Thorium (Th-232 and Th-228) with daughters present and in equilibrium | 10[a] | 50[b] | NRC Guidelines |
| Natural Uranium (U-238 and U-234) with daughters present and in equilibrium | 10[c] | | |
| Depleted Uranium | | | |
| • Soluble | 35[a] | 100[b] | |
| • Insoluble | 35[a] | 300[b] | |
| Enriched Uranium | | | |
| • Soluble | 30[a] | 100[b] | |
| • Insoluble | 30[a] | 250[b] | |
| Transuranic elements | 11 picocuries/gram | | EPA Guidelines |
| Radium-226 in soils of inactive uranium mill areas | There are two required limits<br>1) 5 picocuries/gram in the first 15 cm of soil below the surface (in addition to background levels)<br>2) 15 picocuries/gram average in each layer of soil that is deeper than 15 cm thick 15 cm below the surface (in addition to background levels) | | EPA Standards |

[a] The concentration of natural thorium is based on limiting individual doses to 10 microrad/hour, while the concentrations of depleted and enriched uranium are based on limiting individual doses to 1 millirad per year to the lung and 3 millirad per year to the bones. The latter concentrations are derived from EPA guidelines for protection against transuranic elements in the environment.

[b] These concentrations were based on limiting individual doses to 170 millirem per year if the buried material is disturbed. Current calculated doses for those concentrations may be significantly higher.

[c] Natural uranium decays into radium. For this reason, the maximum concentrations for this nuclide is based on EPA standards for radium in mill areas, given at the bottom of the table.

*Sources:* 46 FR 52061, October 23, 1981; 42 FR 60956, November 30, 1977; 40 CFR 192, 12, July, 1989.

## WATER
(EPA Standards)

| CURRENT STANDARDS | | PROPOSED STANDARDS | | |
|---|---|---|---|---|
| **Nuclide** | **MCL[1]** | **Nuclide** | **MCLG[2]** | **MCL** |
| Combined radium-226 and radium-228 | 5 picocuries/l | Radium-226 | zero | 20 picocuries/liter |
| | | Radium-228 | zero | 20 picocuries/liter |
| Gross alpha activity (including radium-226 but excluding radon and uranium) | 15 picocuries/l | Radon-222 | zero | 300 picocuries/liter |
| | | Uranium | zero | 30 picocuries/liter |
| | | Beta and photon emitters (excluding radium-228) | zero | 4 millirem TEDE yr[3] |
| Beta and photon emitters | 4 millirem TEDE/year | Adjusted gross emitters (excluding radium-226, uranium, and radon-222) | zero | 15 picocuries/liter |

[1] MCL is the Maximum Contaminant Level. This is the permissible level of a contaminant in public water.
[2] MCLG is a Maximum Contaminant Level Goal. The level of a contaminant in public drinking water at which no known or anticipated adverse effect on the health of persons would occur, and allowing an adequate margin of safety. MCLGs are not enforceable.
[3] TEDE is the Total-body Effective Dose Equivalent (also written EDE). A TEDE is a weighting factor for regulatory purposes that converts the dose received by an organ to a whole body dose.
*Sources:* For current concentrations, 41 FR (Federal Register) 28404, July 9, 1976. For proposed concentrations, 56 FR 33050, July 18, 1991.

## SURFACE
(Equipment and Building Surfaces, NRC Guidelines)

| NUCLIDE[a] | CONCENTRATION (in disintegrations per minute[b] / 100 square centimeters)[c] | | |
|---|---|---|---|
| | **Average[d]** | **Maximum[e]** | **Removable** |
| Natural Uranium, Uranium-235, Uranium-238, and associated decay products | 5,000 alpha | 15,000 alpha | 1,000 alpha |
| Transuranics, Radium-226, Radium-228, Thorium-230, Thorium-228, Protactinium-231, Ac-227, Iodine-125, Iodine-129 | 100 | 300 | 20 |
| Natural Thorium, Thorium-232, Strontium-90, Radium-223, Radium-224, Uranium-232 Iodine-126, Iodine-131, Iodine-133 | 1,000 | 3000 | 200 |
| Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Strontium-90 and others noted above. | 5,000 | 15,000 | 1000 |

[a] Where surface contamination by both alpha and beta-gamma emitting nuclides exists, the limits established for alpha and gamma emitting nuclides should apply independently.
[b] As used in this table, dpm (disintregations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.
[c] One picocurie is about 2 disintegrations per minute (dpm). 100 square centimeters is about 0.1 square foot.
[d] Measurements of average contaminants should not be averaged over more than 1 $m^2$.
[e] The maximum contamination levels applies to an area of no more than 100 $cm^2$
*Source:* U.S. NRC. "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use of Termination of Licenses for Byproduct, Source, or Special Nuclear Material." Policy and Guidance Directive FC 83-23, Division of Industrial and Medical Nuclear Safety, Washington, DC, August 1987.

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***Clean-up***
*continued from p. 1*

measures, radioactive contamination at a site may be lessened or eliminated. Decommissioning is the process of removing a facility from service, "cleaning up" a site and terminating a license.

Decommissioning at many sites is routine, straightforward and does not involve residual contamination (contamination left over after the clean-up process). For instance, sites such as cancer treatment centers where radioactive materials are used in "sealed sources" can be decommissioned simply by removing the sealed source, leaving a clean site.

In contrast, some sites have soils and structures with considerable levels and volumes of contaminated soil, water, and/or buildings. Yet there are no comprehensive clean-up standards governing the decommissioning, clean-up and remediation of radioactively contaminated sites in the United States. There is a patchwork of guidelines and standards covering some issues and situations, but the vast majority of problems have yet to be addressed. The centerfold on pages 8 and 9 explains the current status of cleanup standards for decommissioning.

The difference between guidelines and standards lies in their legal power. Standards (also called "regulations") have been officially promulgated with public comment and have the force of law. Guidelines, on the other hand, are generally created on an ad hoc basis. They may assume the force of standards for specific sites if the concerned agency arrives at an agreement with the site's owner.

*See "Clean-up"—p. 11*

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Present guidelines and standards do not cover risks from disposal or wastes resulting from cleanup; they only apply to risks from residual contamination after a site has been cleaned up, and to the risks for clean-up operations themselves.

The centerfold describes the guidelines of the Environmental Protection Agency (EPA), and the Nuclear Regulatory Commission (NRC) as they apply to various sites that are currently undergoing decommissioning and clean-up.

Currently there are five sets of guidelines or standards:

1. EPA standards on radium contamination near uranium mills;
2. EPA guidelines limiting soil contamination of transuranics (elements of higher atomic number than uranium);
3. Nuclear Regulatory Commission (NRC) guidelines for decommissioning uranium and thorium processing sites;
4. NRC residual surface contamination guidelines; and
5. EPA's drinking water standards.

These guidelines and clean-up standards have been split into three tables in the centerfold of this issue. The tables show the maximum level of contamination in the soil, water or surface (of buildings or equipment) at a given site. The text below explains the five broad categories of guidelines or standards.

## 1. Radium near uranium mills[1]

Under the Uranium Mill Tailings Radiation Control Act (UMTRCA) of 1978, the EPA sets a limit of 5 picocuries of radium-226 per gram of soil (in addition to background levels)[2] for the top 15 centimeters of soil. For soil 15 centimeters and below, the limit is 15 picocuries per gram, in addition to background.[3] Background levels are generally in the range of 1 to 2 picocuries per gram. These regulations only apply to sites recognized as falling under UMTRCA, though they may be applied to other sites, as determined on a site-by-site basis.

*There are no comprehensive clean-up standards governing the decommissioning, clean-up and remediation of radioactively contaminated sites in the United States.*

## 2. Transuranium elements contamination

EPA recommends that a reasonable "screening level" for transuranic elements (elements heavier than uranium) could be reached by a soil contamination of no more than 0.2 microcuries per square meter for samples collected at the surface to a depth of 1 centimeter and for particle sizes under 2 millimeters. This level of contamination is derived from a continuous annual dose rate of 1 millirad per year to the lung. According to EPA, this dose rate would result in 10 premature cancer deaths for a population of 100,000. The continuous annual dose rate to the bones would be about 3 millirad per year, resulting in about 6 premature cancer deaths for the same population.[4]

## 3. NRC guidelines for uranium and thorium contamination at processing sites

In 1981 the Nuclear Regulatory Commission came out with a paper known as the "Branch Technical Position"(BTP)[5] which gave guidance for disposal or on-site storage of soil contaminated with thorium and uranium. These guidelines were developed in particular for sites where large volumes of contamination existed but where radioactivity was believed to be low enough to justify disposal.

Of the five original disposal and storage options in the BTP, only the first 2 options (requiring release of the site for unrestricted use) have been retained in the 1992 "Action Plan" (see "SDMP" sites, below). These options are known as "option 1" and "option 2." Under option 1 there are no restrictions regarding the method of burial, whereas under option 2 the material has to be buried at a depth of at least 4 feet below the surface if it can be demonstrated that there will be no migration of

*See "Clean-up"—p. 12*

[1] Standards for Cleanup of Land and Buildings Contaminated with Residual Radioactive Materials from Inactive Uranium Processing Sites. 40 CFR 192.12.

[2] "Background level" is the amount of radium-226 present in the soil due to naturally ocurring uranium.

[3] UMTRCA is Public Law 95-604. The EPA regulations are outlined in 40 CFR 192. The DOE has used this regulation in the remediation of some sites under its "Formerly Utilized Sites Remedial Action Program" (FUSRAP).

[4] "Persons Exposed to Transuranium Elements in the Environment: Federal Radiation Protection Guidance on Dose Limits" (42 FR 60956; November 30, 1977). We assume a soil density of 1.6 grams/c.c. This level of contamination corresponds to an average of about 11 picocuries/gram of soil.

[5] Disposal or On-site Storage of Residual Thorium and Uranium from Past Operations. (46 FR 52061, October 23, 1981).

*Clean-up*
*continued from p. 11*

contamination. Natural uranium is not included in option 2 because of possible radon-222 (a uranium daughter) emanations, which would result in higher-than-allowable exposure of individuals in private residences if houses were built over buried materials.

### 4. Building and Equipment Contamination[6]

As with soil contamination, the NRC requires the licensee to make a reasonable effort to eliminate residual contamination from the site. Upon request the NRC may allow the licensee to give up ownership of buildings and equipment with contamination in excess of the limits specified. In that case, the licensee must give detailed information on the nature, location and degree of residual contamination and show that this contamination is unlikely to result in health and safety risks to the public.

Along with acceptable surface contamination levels, the NRC gives instructions for assessing levels of contamination for the interior of equipment not accessible to measuring instruments. The inside of a pipe, for example, must be assessed in this way, since the radioactivity within the pipe will not be directly measured.

### 5. Water contamination[7]

The NRC proposes that EPA's maximum contaminant level standards for radionuclides in public water (cited in EPA's "National Primary Drinking Water Standards"[8]) should be used for protection of surface water and groundwater. New standards have been proposed by EPA for the radionuclides.[9] The new standards are scheduled to be put into force on April 30, 1995.

### SDMP Sites

The NRC provided decommissioning guidance in the 1990 "Site Decommissioning Management Plan" (SDMP) and in the April 1992 document "NRC Action Plan to Ensure Timely Cleanup of SDMP Sites." Both documents, published as "NUREG-1444" in October 1993, provide a cleanup strategy for sites where no production operations are taking place and which meet certain criteria, among them: 1) there are large amounts of contaminated soil that are difficult to remediate, and 2) there is contamination or potential contamination of the groundwater from on-site wastes. The five standards and guidelines listed above apply to these sites.

Nuclear power reactors and thorium mills are excluded form this plan, since they are already covered by separate regulations. The five standards and guidelines listed above (excluding number 1, "radium near uranium mills") apply to these sites.

### The Future of Cleanup

In addition to the cleanup standards described above, the Department of Energy (DOE) has dose

*See "Clean-up"—p. 13*

**Low-level radioactive waste burial markers in Barnwell, S.C. Each headstone marks a large trench containing commercial, industrial and medical radioactive waste.**



[6] Guidelines for Decontamination of Facilities and Equipment Prior to the Release for Unrestricted Use or Termination of Licenses for By-product, Source, or Special Nuclear Material. Policy and Guidance Directive FC 83-23, Division of Industrial and Medical Nuclear Safety, August 1987.

[7] Maximum contaminant levels for radium-226, radium-228, gross alpha particle radioactivity in community water systems. Maximum contaminant levels for beta particle and photon radioactivity from man-made radionuclides in community water systems. (41 FR 28404, July 9, 1976).

[8] National Primary Drinking Water Standards. (40 CFR Part 141).

[9] National Primary Drinking Water Regulations; Radionuclides. (56 FR 33050, July 18 1991).

**Clean-up**
*continued from p. 11*

standards in effect to protect the public from DOE facilities still in operation. These standards do not currently apply to cleanup, or even to low-level waste disposal for materials with half-lives in the hundreds of years or more. How these standards may be applied to future cleanup operations of DOE sites is unclear.

As the centerfold shows, there are some proposed standards for water, but not for soil or surfaces. The process of developing standards is a complex one, potentially involving a number of approaches. For example, standards may be based on risk or dose limits, limits on concentration of radionuclides, or a combination of these methods.

The EPA currently plans to publish draft cleanup standards in the fall of 1994 and to release its final standards in the fall of 1995. The NRC "staff draft" of proposed clean-up standards would establish a dose limit of 15 millirem/year, with a target of 3 millirem/year, and are in sharp contrast to the 170 millirem/year dose allowed under Option 2 in the BTP. Until that time, cleanup will rely on the standards and guidelines listed in the centerfold.

### Additional Information

Mahoney, K., and Murakami, L. 1993. *Farewell to Arms: Cleaning Up Nuclear Weapons Facilities*. National Conference of State Legislatures: Denver, CO and Washington, DC. $15.00. Call (303) 830-2200.

Makhijani, A. and Saleska, S. 1992. *High-level Dollars, Low-level Sense*. A report for the Institute for Energy and Environmental Research. Apex Press: New York. Send a check for $15.00 to: IEER, 6935 Laurel Ave., Takoma Park, MD 20912.

U.S. Environmental Protection Agency. 1993. *Issues Paper on Radiation Site Cleanup Regulations*. (EPA 402-R-93-084) September 1993. Office of Radiation and Indoor Air: Washington, DC. Call (202) 233-9354.

Dr. Egghead, IEER's expert on technical jargon, remains in the Galapagos Islands for a few more days of invigorating investigation. We presume he will return quite soon.

## ERRATA

## *Plutonium: Deadly Gold of the Nuclear Age*

Please note the following changes for *Plutonium: Deadly Gold of the Nuclear Age*, International Physicians Press, Cambridge, Mass., 1992. Some of these changes are corrections, while others are necessitated by more recent information. The changed words or phrases are underlined.

**p. 4:** The third line from the bottom should explain that plutonium has 15 isotopes, not 13.

**p. 37:** The first line of the second paragraph under China should read: Replace the word Lanzhou with Guangyuan.

**p. 43:** Table 2.3, the figures for La Hague, France should read: Belgium 1.17; France 15.7; Germany 14.58; Japan 1.17; Netherlands 0.67; Switzerland 1.11, for a total of 34.4 metric tons.

**p. 43:** Table 2.3, the figures for Marcoule should read: France 5.6 metric tons; Spain zero (plutonium from the Vandellos reactor in Spain belongs to France). The total for civilian plutonium from Marcoule is 5.6 metric tons.

**p. 43:** The date on the last line in the notes should be 1991.

**p. 69:** Second to last line from the bottom, the plutonium production figures for Marcoule, should be 11.6 tons, including an estimated 6 tons of plutonium for military purposes.

**p. 71:** Table 3.3, under heading "Sr-90+Cs-137 curies" for La Hague should be 204 million, and for Marcoule should be 70 million curies.

**p. 75:** In the first line of the third paragraph, the figure 223 million was an error in the English translation. It should be changed to 22.3 million. This does not include wastes discharged to Lake Karachay.

**p. 85:** Second to last line, change 1 kilogram to 10 kilograms.

For new plutonium data refer to: Albright, D., F. Berkhout, and W. Walker. 1993. *World Inventory of Plutonium and Highly Enriched Uranium, 1992*. Oxford University Press.

# Arithmetic for Activists #6

**Solution to the Problem in *SDA* volume 2, number 3**

Last issue's Science Challenge introduced readers to "dose conversion factors." The Challenge was as follows:

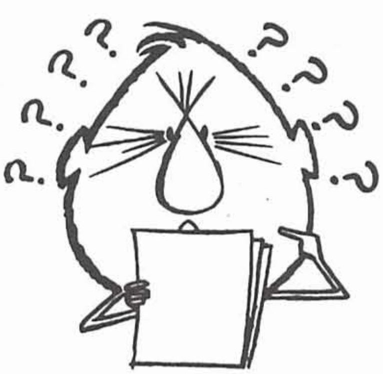
Suppose you spent 8 hours walking in the vicinity of a uranium mill where the concentration of insoluble natural uranium in the air was known to be 3 picocuries per cubic meter. While you were out walking, you realized that you forgot your water-bottle at home. You stumbled across a well, where you drank 2 liters of water. As luck would have it, the well was contaminated with insoluble natural uranium (uptake fraction of 0.002) at a concentration of 1,000,000 picocuries per liter. What would be the dose due to inhalation? Due to ingestion?

ANSWER: **(A) Inhalation**. As explained in the last issue of *SDA*, the average adult male inhales almost 1 cubic meter per hour during the typical day. Since you were walking for 8 hours, we assume you inhaled about 8 cubic meters of contaminated air (8 hours x 1 cubic meter/hour). Given a concentration of 3 picocuries per cubic meter, we know you inhaled 24 picocuries during the day (8 cubic meters x 3 picocuries/cubic meter). Turning to the techno-weenie pinup in the last newsletter, you will see that insoluble natural uranium has a dose conversion factor of 0.125 millirem/picocurie (1,000 millirem equals 1 rem) for inhalation. So your dose was 24 picocuries x 0.125 millirem/picocurie, or **3 millirem**.

**(B) Ingestion**. You ingested a total of 2,000,000 picocuries of insoluble natural uranium (2 liters of water x 1,000,000 picocuries). By turning to the pinup, you will find that insoluble natural uranium has a dose conversion factor of 0.0000249. So your dose from drinking the water would be the number of picocuries you ingested (2,000,000) times the uptake fraction (0.0000249), giving a dose of **49.8 millirem, or 50 millirem when rounded**.

**Oops!** The uptake fraction, or the rate at which your body absorbs the uranium, is 0.002. However, this is already built into the dose conversion factor, which is based on the amount ingested. The uptake fraction is given as an added bit of information, not to be used in the equation. Because a number of people used the uptake fraction in the equation, we decided not to count this part of the science challenge. The uptake fraction simply identifies the solubility of the material in a way that is more meaningful when ingestion is considered.

Nine people sent in replies to the *Science Challenge* in the last issue. There were 5 correct answers (we didn't count the ingestion question since most readers found it confusing; see "Oops!"). Congratulations! We drew lots for the $25 prize from among the correct answers, and the winner is Ernest Goitein of Atherton, CA. Everyone who entered the contest will receive a $10.00 prize. Be sure to solve the new problem in this issue of *Science for Democratic Action* and send it in.



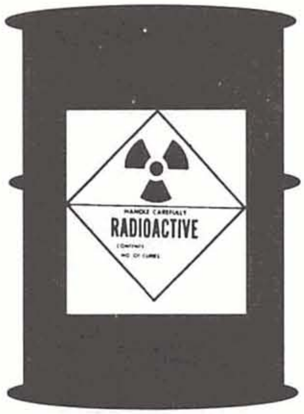
# Science Challenge

You just bought a new home with a view of a lake. After you close the deal, you learn that the lake may have been contaminated by a nearby natural thorium-232 processing facility. You take a sample from the lake, which reads 10 picocuries of radium-228 per liter (radium-228 is a "daughter" of thorium-232, or a product of the decay of thorium-232). Is the lake water above or below current Maximum Contaminant Level (MCL) standards? Proposed MCL standards? If so, by how much in each case?

***How to solve the problem and WIN SOME BUCKS....It's easy!***
Look at the technoweenie centerfold, found on pages 8–9. There you will find three tables; they show the levels at which contaminated water, soil, and surfaces need to be cleaned up. Look first at the table on water. There are both current and proposed cleanup standards, given in "picocuries per liter." Remember that picocuries are a measure of radioactivity. All you need to do now is read the table and compare the cleanup standards to the picocuries per liter of radium-228 in the lake water sample.

**The Science Challenge is a regular *Science for Democratic Action* feature. There is no way to learn arithmetic except to do it! We offer 25 prizes of $10 to people who send in solutions to all parts of the problem, right or wrong. There is one $25 prize for a correct entry. Work the problem and submit the answer to Ellen Kennedy, IEER, 6935 Laurel Avenue, Takoma Park, MD 20912. If more than 25 people enter and there is more than one correct entry, the winners will be chosen at random. The deadline for submission of entries is April 15, 1994. People with science, math, or engineering degrees are not eligible.**

The Institute for Energy and Environmental Research (IEER) provides the public and policymakers with thoughtful, clear, and sound scientific and technical studies on a wide range of issues. IEER's aim is to bring scientific excellence to public policy issues to promote the democratization of science and a healthier environment.

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