SAFE AND ENVIRONMENTALLY SOUND MANAGEMENT OF RADIOACTIVE WASTES IN CANADA AND THE USA

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Contents

Summary

A brief primer on radioactivity is presented then some examples of the beneficial applications of radioactive materials in several fields including medicine, pharmaceutical research, agriculture, industry and environmental sciences. These applications produce radioactive wastes which are classified as exempt, low and intermediate level, high level and transuranic wastes. Both countries are already disposing of their low and intermediate level wastes within their borders, but high level wastes are stored mostly at sites of production, pending provisions for permanent disposal. A model program for waste management is presented, with major elements listed as generate, treat, store, release, package/ship, dispose and monitor. The programs in both countries conform quite well to this model and descriptions of these programs are presented.

It is notable that the programs in both countries are progressing very slowly because government officials seem to require more public support than is feasible in these democratic societies in a reasonably short period. Any such public support requires a significant amount of public education to overcome the negative, misleading information already spread through the political arena and the media.

Furthermore, in both countries, the programs are designed for disposal on land, although there appears to be significant scientific support for disposal in the sea bed where the wastes would not recycle into the biosphere. The focus on land disposal seems to be based on the decisions of the London Dumping Convention where many nations agreed to a ban of dumping at sea, a common former practice in some countries. A careful reading of the report of the London Dumping Convention, however, shows that this ban does not apply to controlled disposals on the sea bed, if it is determined to be scientifically sound, technically feasible, environmentally safe and more economical than disposal on land.

It is therefore proposed that an earlier solution than the possible outcome of the present course may be found by determining whether disposal in the sea bed meets the above criteria, and, if so, redirecting the disposal efforts accordingly.

1. Objectives and Primer

1.1. Objectives

a) To review some beneficial uses of radioactive materials that cause the generation of radioactive wastes, to denote the classification of wastes and to present a model solution to waste management that is scientifically sound, environmentally safe and economically feasible.
b) To review the actual state of the management of radioactive wastes in Canada and the United States of America (USA), and account for any delays in finding a permanent solution.
c) To analyze the major gaps between the optimum process for radioactive waste management and the previously discussed state-of-the-art. Taking into consideration the political and social restraints, an attempt is made to put the current management program into a single management strategy, which allows for the utilization of appropriate processes/technologies.
d) To suggest corrections that may still be made to achieve an early solution to radioactive waste disposal in Canada and the USA, and to make critical projections of the state of the art with a view towards determining probable outcomes.

1.2. Primer on Radioactivity

Radioactive materials contain atoms with an imbalance of protons and neutrons in the nuclei, causing them to disintegrate spontaneously. These disintegrations result in the emissions of sub-atomic particles or gamma radiation, which are readily detected by several types of detectors, the most commonly known being the Geiger counter. Some radioactive materials occur naturally, such as uranium, radium and potassium-40. However, there are several artificially-produced radioactive materials such as cobalt-60, strontium-90 and cesium-137, generated by bombarding stable (non-radioactive) materials with nuclear particles from a reactor or accelerator. Specific radioactive materials can now be made to order, as needed for particular applications.

Naturally-occurring radioactive materials in the soil and buildings, as well as cosmic radiation from outer space, provide a continuous stream of background radiation in the environment. The annual exposure to a person in USA. or Canada from this background radiation may be approximately 0.9 to 1.7 millisieverts (mSv), depending on the location of the person (NCRP 1987). To put this level of background radiation in perspective, it is worth noting that the National Council for Radiation Protection and Measurements (NCRP) recommends standards of radiation exposure above background at 50 mSv to occupationally exposed individuals and 1.0 mSv to the general public (NCRP 1993). These levels should keep any potential risk from radiation well within the normal hazards of life. Exposure levels less than 0.01 mSv are classified as Negligible Individual Dose and may therefore be regarded as trivial.

The hazards of radioactive materials are mainly based on the radiation they emit. Hence it is necessary to explain a little about the hazards of radiation to put the issues related to the disposal of radioactive wastes in proper perspective. Radiation may originate from X-ray machines or from radioactive materials which were discovered in 1895 and 1896 respectively. It is important to know that there is no physical difference between X-rays from machines and gamma rays from radioactive materials. Because of their different sources, however, X-rays can be turned on and off with a switch, while radioactive materials emit radiation continuously, until they decay fully to stable (non-radioactive) conditions. Protection from radiation is obtained by limiting the time of exposure, shielding or keeping the source at a discreet distance. X-ray machines may cause radiation damage but not contamination. To illustrate this point, a person may receive a tan from ultraviolet radiation but cannot share that tan with anyone even by the most intimate relationship. On the other hand if contaminated liquid or dust falls on an object, the object becomes contaminated. Hence radioactive materials may contaminate people or objects. This difference between radiation damage and radioactive contamination is not fully appreciated by the average person.

When radiation impacts atoms, its energy may disturb the structure of the atom by knocking off one or more electrons, a process called ionization. This disruption of atomic structure may lead to damage of cells and also permits the detection of radiation via gases, liquids or solids. Here is a short answer to the dichotomy presented by radiation: On the one hand, radiation damage to normal cells may lead to cancer, while on the other hand radiation may destroy sensitive cancer cells to cure the disease. Additional details of applications of radioactive materials will be presented later.

Some biological effects of radiation were observed within a few years of its discovery, largely through the development of techniques for radiography, and the handling of radioactive materials like radium without adequate shielding and other safety measures that are common practice today. It is now known that single radiation doses of the equivalent of 3 Sv may cause reddening of light skin and doses of the next order of magnitude (ten times higher) can produce skin damage similar to third degree burns. While some genetic effects have been observed in animal studies, it is important to note that the bizarre effects suggested in comics such as Spiderman and the Incredible Hulk are merely fictitious. Genetic effects from radiation are no different from those due to other causes such as chemicals. The greatest legitimate concern of populations to long-term waste disposal is the possibility of the disposed wastes re-entering the biosphere and causing cancer: hence the need for long-term sustainability in disposal of these wastes.

It appears that people's fears of radiation are based largely on exaggerated perceptions of radiation hazards, based on childhood prejudices from misrepresentations through the comics and reinforced by distorted treatment of radiation through the media. Furthermore, part of the mystery of radiation may be attributed to the fact that it cannot be detected directly by any of the five human senses. The first widely publicized public incident associated with radiation was due to the use of two atomic bombs on Japan during the last world war. Although radiation was not responsible for the primary damage of these bombs, its effects lingered longest in the news, as the casualties are still being studied. These effects have supplied the scientific world with most of the human data for studying the long-term effects of radiation on people.

The valuable uses of radioactive materials are based largely on two significant properties of the radiation they emit: (1) Radiation is easily detected in very small quantities by extremely sensitive detectors that permit the accurate tracing of the behavior of chemical substances to which they belong; (2) Large quantities of radiation, as stated above, can do significant biological damage. A useful analogy to consider is fire, which in small quantities under controlled conditions can be very useful (e.g. heating and cooking), but in large quantities under uncontrolled conditions can be devastating. In many applications, the use of radioactive materials is the least expensive and easiest method of acquiring the desired result. In other applications, the use of radioactive materials supplies the only known method of conducting the investigation. Examples supplied in the next section will clarify these points.

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Bibliography

Cohen, B, "Catalog of Risks Extended and Updated," *Health Physics*, **61**(3): 317-335, 1991.

EPA. USEPA Mixed Waste Team Homepage—Mixed Waste Glossary. November 23, 1999. http://www.epa.gov/radiation/mixed-waste/mw_pg5.htm.

IAEA. "Managing Radioactive Waste." November 23, 1999.

http://www.iaea.org/worldatom/inforesource/factsheets/manradwa.html.

International Maritime Organization (1991). *The London Dumping Convention* 106-107. IMO.

McLean, V.A. The Health Physics Society's Newsletter, p. 12. *Health Physics Society*. November 1999.

Miller, K.L. (1985). *Derived Benefits which Lead to Radioactive Waste.* Management of Radioactive Materials and Wastes: Issues and Progress. (ed. S.K. Majundar and E. Willard Miller) 312-325. The Pennsylvania Academy of Science.

National Council on Radiation Protection and Measurements (1987) *Exposure of population in the United States and Canada from natural background radiation.* 142 Report #49. NCRP.

National Council on Radiation Protection and Measurements (1993) *Limitation of exposure to ionizing radiation.* 5. Report #116. NCRP.

Ray, D.L. with Guzzo, L. (1990). Nuclear Waste. *Trashing the Planet*. 142-156. Regnery Gateway

RCRA. "Resource Conservation and Recovery Act," *Environmental Law Handbook—Twelfth Edition*, Government Institutes, Inc., Rockville, MD. 1993.

Additional Recommended Reading

Beckmann, P. (1979). The Health Hazards of NOT going Nuclear. The Golem Press

League of Women Voters (1985). The Nuclear Waste Primer - A Handbook for Citizens. Nick Lyons Books.

Lenihan, J. (1993). The Good News about Radiation. Cogito Books.

National Council on Radiation Protection and Measurements (1993). Risk Estimates for Radiation Protection. Report #115. NCRP.

Biographical Sketches

Dr. E. Theodore Agard was born and reared in the Caribbean island of Barbados, where he graduated with advanced level school certificates in Pure and Applied Mathematics. He then attended the University College of the West Indies in Jamaica, graduating with First Class Honors in Pure Mathematics, Applied Mathematics and Physics. He was awarded a scholarship through which he graduated from The Middles Hospital Medical School, with an M.Sc. degree from the University of London in England.

After a break in his studies, while serving as a lecturer at the Trinidad campus of the University of the West Indies, he was awarded a fellowship by the Canadian International Development Agency, enabling him to graduate with a Ph.D. from the University of Toronto in Canada. He is also certified in Radiological Physics by the American Board of Radiology. Other positions he has held include: (1) Assistant Physicist at Massachusetts General Hospital (1959 to 1963); (2) Director of Medical Physics at Puerto Rico Nuclear Center, with a joint academic appointment at the University of Puerto Rico (1972 to 1976); (3) Radiation Physicist and Radiation Safety Officer at Kettering Medical Center in Dayton, Ohio, (1976 to 1984); (4) Consulting Radiation Safety Officer and Associate Clinical Professor at Wright State University, Dayton, Ohio; (5) Associate Clinical Professor in Radiotherapy at the Medical College of Ohio, Toledo, Ohio (1990 to 1992); (6) Director of Medical Physics at Flower Hospital in Toledo, Ohio (1993 to 1997). Dr. Agard is now officially retired, but continues to teach part-time as an Adjunct Professor at Florida Hospital College of Health Sciences, to consult, to speak to the public on various subjects including radiation safety, and also to write. He has published over thirty articles. His honors and awards include: (a) Elected Faculty Representative to the Senate of the University of the West Indies (1971 to 1972); (b) Elected Representative to the Board of Directors of the Health Physics Society (1994 to 1997), and (c) An Award of Honor from Radiology Centennial Inc. for contributing to the successful celebration of the Centennial Year of Radiology.

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Education

Ph.D., General Engineering, Oklahoma State University.
Master of Science, Radiation Physics, Vanderbilt University.
Bachelor of Arts, Physics, Emporia State University.

Professional Registrations

Comprehensive Practice-American Board of Health Physics.
Masters Level - Hazard Control Manager Certification Board.

Professional Highlights

Dr. Waite is an internationally recognized expert in radiological protection and waste management. He has 37 years of experience in the areas of health physics, environmental radioactivity, nuclear and mixed waste management, risk assessment, and program management. He is an expert in the development and implementation of Integrated Safety Management Systems (ISMS), and was a leader in the development of this comprehensive approach to managing the work at high-risk sites worldwide. He has more than 200 publications. He has been employed with CH2M HILL for 8 years. He has served on the National Academy of Science Committee on the Waste Isolation Pilot Project, and has been an editor of *Waste Management* and *Health Physics* journals and a member of Scientific Committee 64 (Environmental Radioactivity and Waste Management) of the National Council on Radiation Protection and Measurements. He is a recipient of the Elda E. Anderson Award given by the National Health Physics Society to the outstanding health physicist under the age of 40 in the United States; National President Emeritus of the Health Physics Society and an HPS Fellow. He has served on the World Health Organization Working Group on Health Implications of High-Level Radioactive Waste Disposal; OECD Nuclear Energy Agency Expert Group on radiation protection objectives of nuclear waste management; has taught worldwide, including regulatory compliance and quality assurance in Environment, Health and Safety Programs to Arab American Oil Company personnel in Saudi Arabia; and has been chairperson of the State of Ohio Radiation Protection Advisory Committee.