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REGULATION OF NATURALLY OCCURRING RADIOACTIVE MATERIALS IN NON- NUCLEAR INDUSTRIES

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Abstract

The volume and concentrations of naturally occurring radioactive material is large across a variety of industries commonly thought not to involve radioactive material. The regulation of naturally occurring radioactive material in the United States is in a state of flux. Inventory of naturally occurring radioactive materials is given, along with a range of concentrations. Current and proposed regulatory limits are presented.

1. INTRODUCTION

With the passage of the Atomic Energy Act of 1954 the regulation of most uses of radioactive materials was formalized. At the federal level the Atomic Energy Commission had the authority to regulate the use of most radioactive materials. With the exception of uranium and thorium of 0.05 or greater weight percent (source material), naturally occurring radioactive materials were excluded from these regulations. The regulation of naturally occurring radioactive materials remained within the purview of each of the individual states. Some activities of the World War II effort to build the atomic bomb resulted in naturally occurring radioactive material waste. Some of this waste continues to be the responsibility of the U.S. Department of Energy and some is the responsibility of the U.S. Nuclear Regulatory Commission (the regulatory arm of the old U.S. Atomic Energy Commission). Until the late 1970s, the only naturally occurring radioactive material that had received much attention was purified ^{226}Ra. The regulatory requirements for ^{226}Ra varied significantly from state to state. With the advent of more sensitive radiation detectors, it has become relatively easy to detect above natural background levels of naturally occurring radioactive materials. This advancement has created interest in the regulation of naturally occurring radioactive materials. The purpose of this presentation is to: 1) Present the magnitude of the problem of naturally occurring radioactive material as it exists in the United States and probably throughout the industrial world, 2) Relate some of the dichotomies of the regulations depending on where the regulatory authority lies, and 3) Suggest some policies that I would like to see enacted.

2. MAGNITUDE OF THE PROBLEM

Table I summarizes the inventory of materials and waste streams with above background levels of naturally occurring radioactive material. In my judgment these volumes are low. Also presented are the concentrations of the long-lived naturally occurring radionuclides. One of my major concerns regarding naturally occurring radioactive materials is that many plants have no inkling that in the routine operation of the plant, naturally occurring radionuclides are being concentrated. The first indication of a problem quite frequently occurs when waste is taken to some type of landfill. Most waste and scrap facilities, at least in the southern part of the United

States, have gate monitors for the detection of radioactive materials. Usually these monitors are set to alarm at an elevated level only slightly above ambient background. When this occurs, the waste or scrap facility rejects the load. It is common for these waste to include a chemical waste which make the disposal of a "mixed waste" very difficult. Even if the waste contains only radionuclides it is costly and difficult to dispose of such waste.

TABLE I. SOURCES, VOLUMES AND CONCENTRATIONS OF NATURALLY OCCURRING RADIOACTIVE MATERIALS *

Waste Stream	Production Rate per Yr.	Total U Bq/kg	Total Th Bq/kg	Total Ra Bq/kg
Phosphate	5.0×10^{10} kg	bkgd - 3000	bkgd - 1800	400 - 3700000
Phosphogypsum	4.8×10^{10} kg	bkgd - 500	bkgd - 500	900 - 1700
Slag	1.5×10^{9} kg	800 - 3000	700 - 1800	400 - 2100
Scale	4.5×10^{6} kg	**	**	1100 - 3700000
Coal Ash	6.1×10^{10} kg	100 - 600	30 - 300	100 - 1200
Fly Ash	4.4×10^{10} kg	**	**	**
Bottom Ash	1.7×10^{10} kg	**	**	**
Petroleum Production	2.6×10^{8} kg	**	**	bkgd - 3700000
Scale	2.5×10^{7} kg	**	**	bkgd - 3700000
Sludge	2.3×10^{8} kg	**	**	bkgd - 3700
Petroleum Processing	**	**	**	***
Refineries	**	**	**	> 4000
Petrochem Plnts	**	**	**	> 4000
Gas Plants	**	**	**	***
Water Treatment	3.0×10^{8} kg	**	**	100 - 1500000
Sludges	2.6×10^{8} kg	**	**	100 - 1200
Resins	4.0×10^{7} kg	**	**	300 - 1500000
Mineral Processing	1.0×10^{12} kg	6 - 129000	8 - 900000	< 200 - 129000
Rare Earths	2.1×10^{7} kg	26000 - 129000	9000 - 900000	13000 - 129000
Zr, Hf, Ti, Sn	4.7×10^{8} kg	6 - 3200	8 - 660000	300 - 18000
Alumina	2.8×10^{9} kg	400 - 600	500 - 1200	300 - 500
Cu and Fe	1.0×10^{12} kg	< 400	< 400	< 200
Geothermal Waste	5.4×10^{7} kg	**	**	400 - 16000
Paper Mills	**	**	**	> 3700

* Derived partially from US EPA, 1993 [1]

** Data not available

*** Lead-210 and Polonium-210

In the last year I have been involved in four instances where shipments of waste tripped gate monitors. In three of these cases there was no idea that the plant generated waste that contained radionuclides. I will describe two of the incidents to illustrate how far removed from the nuclear industry such incidents can occur. In the milling of rice the husk is removed leaving the white rice. In the steel industry rice husk is used as a thermal blanket. Gate monitors at a steel mill were tripped by a shipment of rice husk. I was not able to follow this situation to resolution; therefore, I do not know the radionuclide. In my opinion it was probably uptake of naturally occurring radioactive material in fertilizer or soil conditioner.

The second incident involved a municipal sewer plant. A shipment of sewer sludge tripped the gate monitor at a landfill. The radionuclide was ^{131}I. I realize that ^{131}I is not a naturally occurring radioactive material. I relate these two incidents to illustrate the problems caused by the lack of proper regulation of naturally occurring radioactive material. Had the landfill or the steel plant had guidelines and knowledge regarding appropriate alarm levels and acceptable levels of radioactive materials neither of these incidents would have occurred. The other two incidents are confidential and I am not at liberty to discuss them except to say that gate monitors were tripped.

3. REGULATORY ISSUES

At the federal level there are two agencies that have promulgated regulations regarding naturally occurring radioactive materials. The U.S. Environmental Protection Agency (EPA) [2] has regulations covering naturally occurring radioactive material in uranium mill tailings, thorium waste, and metal mining waste. The U.S. Nuclear Regulatory Commission (NRC) [3] has promulgated regulations covering licensed activities with uranium or thorium. Current regulations are for the most part concentration based. Tables II summarize current regulations. For comparison purposes guidelines used by the U.S. Department of Energy (DOE) [4] at its own facilities are also included. In 1994 EPA proposed a risk base limit for remediation of sites contaminated with radioactive materials. The proposed regulations did not exclude naturally occurring radioactive materials. As a result of objections raised by other federal agencies the proposed regulations have been withdrawn. However, I believe the EPA will propose similar regulations in the future. Recently the NRC proposed risk based regulations for the remediation of areas contaminated with radioactive material. The Conference of Radiation Control Program Directors (CRCPD) [5], an organization of individual state radiation control program directors, is developing a suggested state regulation for naturally occurring radioactive material. The proposed limits are also presented in Table III.

Thirteen states have promulgated or proposed regulations covering naturally occurring radioactive material. These are given in Tables IV and V. Among these 13 states there are seven different sets of limits. To illustrate differences between states, the following examples are given: In the state of Louisiana waste from bauxite ore processing is exempt and in Texas it is not. In the states of Texas and Mississippi the remediation of petroleum production sites is under the control of the agencies that regulate petroleum production rather than the radiation regulatory authority.

4. RISK OF EXPOSURE TO NATURALLY OCCURRING RADIOACTIVE MATERIALS

It is not my intent to present an indepth risk analysis; however, I would like to offer the following quotes from BEIR IV [10]:

- Below an average skeletal dose of about 0.8 Gy, the chance of developing bone cancer from radium-226 and radium-228 during a normal lifetime is extremely small — possibly zero.

- Risk estimates for thorium-232 induced liver cancer, bone cancer and leukemia — for thorium dioxide and its progeny. For liver cancer, a lifetime risk is estimated to be about 3×10^{-2} per person-Gy — to the liver. For bone sarcoma, the lifetime risk is estimated to be about $(0.55 - 1.2) \times 10^{-2}$ per person Gy. For leukemia, a lifetime risk of about $(0.5 - 0.6) \times 10^{-2}$ per person Gy.

- It is concluded, on the basis of present evidence, that the general population risk associated with natural uranium is very low and might be negligible.

TABLE II. FEDERAL REGULATIONS COVERING NATURALLY OCCURRING RADIOACTIVE MATERIAL

Agency	Category	Limit	Reference
EPA	Uranium Fuel Cycle	.25 mSv Whole Body .25 mSv Any Organ .75 mSv Thyroid	CFR 40.192.10
EPA	Thorium	.25 mSv Whole Body .25 mSv Any Organ .75 mSv Thyroid	CFR 40.192.41
EPA	Inactive Uranium Processing Cleanup	^{226}Ra 180 Bq/kg Top 15 cm Soil 550 Bq/kg subsequent 15 cm depth	CFR 40.192.12
EPA	Uranium Mill Tailings Disposal	Total Uranium 1 Bq/l Gross Alpha 0.6 Bq/l Total Radium 0.2 Bq/l	CFR 40.192.03
EPA	Uranium, Radium and Vanadium Mining	Effluent Dissolved ^{226}Ra 3mg/l	CFR 40.440.32
NRC	Disposal or On-Site Storage of Thorium or Uranium Wastes from Past Operations	Natural Thorium 370 Bq/kg Depleted Uranium 1300 Bq/kg Natural Uranium Ores 370 Bq/kg	Federal Register October 23, 1981
NRC	Disposal or On-Site Storage of Thorium or Uranium Wastes from Past Operations	Higher Concentrations Allowed if Buried or Under Institutional Control	Federal Register October 23, 1981
DOE	Formally Utilized Sites	^{226}Ra, ^{228}Ra, ^{232}Th, and ^{230}Th 180 Bq/kg top 15 cm, 550 Bq/kg subsequent 15 cm depth Basic Dose Limit 1 mSv/yr	ANL/ES-160 DOE/CH/8901

TABLE III. PROPOSED REGULATIONS COVERING NATURALLY OCCURRING RADIOACTIVE MATERIAL

Agency	Category	Limit	Reference
EPA	Remediation	0.15 mSv equivalent to 20 Bq/kg of uranium or 30 Bq/kg of thorium [6]	US EPA [7] Proposed
NRC	Remediation	0.25 mSv equivalent to 30 Bq/kg of uranium or 50 Bq/kg of thorium	US NRC [8] Proposed
CRCPD	Remediation	1 mSv/yr	Suggested State Regulations Draft 2/17/97

TABLE IV. STATE REGULATIONS FOR THE REMEDIATION OF SITES CONTAMINATED WITH NATURALLY OCCURRING RADIOACTIVE MATERIAL [9]

Radium Remediation Standard	Number of States
180 Bq/kg top 15 cm of soil 1100 Bq/kg subsequent 15 cm depth	2
180 Bq/kg	3
1100 Bq/kg	2
180 Bq/kg top 15 cm if radon greater than 740 Bq/m^3-sec or 1100 Bq/kg top 15 cm if radon less than 740 Bq/m^3-sec	3
180 Bq/kg top 15 cm 550 Bq/kg subsequent 15 cm depth or 1100 Bq/kg if dose does not exceed 1 mSv/Yr	1
Dose less than 0.15 mSv	1
180 Bq/kg top 15 cm if radon greater than 740 Bq/m^3-sec	1

TABLE V. STATE REGULATIONS COVERING EXEMPT QUANTITIES OF NATURALLY OCCURRING RADIOACTIVE MATERIAL

Radium Exemption Standard	Number of States
180 Bq/kg	4
180 Bq/kg top 15 cm if radon greater than 740 Bq/m^3-sec	4
180 Bq/kg above background	1
1100 Bq/kg	2
Dose less than 0.15 mSv	1
180 Bq/kg top 15 cm depth	1

5. UNREGULATED SOURCES OF NORM

Data is presented in Table VI on material that is routinely spread over soil without regulatory control. Note that these concentrations are above current remediation criteria and significantly above the proposed limits. We call this material fertilizer.

TABLE VI. SOURCE OF NATURALLY OCCURRING RADIOACTIVE MATERIAL ROUTINELY DILUTED

	Annual Rate	Total Uranium Bq/kg	Total Thorium Bq/kg	Total Radium Bq/kg	Total Potassium Bq/kg
Fertilizer	5.2×10^9 kg	1500 - 5000	700 - 2400	180 - 400	16000

5. SUGGESTIONS

Develop an informational and training program to alert industries of a potential problem.

If a radionuclide is a hazard at a given concentration, it is a hazard regardless of the regulatory environment. If an atom of uranium poses a hazard at a DOE facility or a NRC-licensed site, then the atom of uranium poses the same hazard at an alumina or rare earths production site. I suggest that radionuclides be regulated in a uniform and consistent manner.

The current situations of gate monitoring resulting in the refusal of shipments without an evaluation of the exposure potential is counter productive. I suggest that procedures or guidelines be established so that generators of naturally occurring radioactive waste are not unnecessarily refused entry to properly licensed land fills.

6. REFERENCES

[1] United State Environmental Protection Agency, Diffused NORM Waste — Waste Characterization and Preliminary Risk Assessment, April 1993, Draft RAE-9232/1, 1993.

[2] United States Code of Federal Regulations, Title 40.

[3] United States Federal Register, Disposal or Onsite Storage of Uranium Waste from Past Operations, Vol. 46, No. 205, p. 52061, October 23, 1981.

[4] Gilbert, T.L., Yu, C., Yuan, Y.C. Zielen, A.J. Jusko, and Wallo, A., A Manual for Implementing Residual Radioactive Material Guidelines. Argonne National Laboratory, ANL/ES-160, DOE/CH/8901, June 1991.

[5] Conference of Radiation Control Program Directors, Draft Regulation and Licensing of Technologically Enhanced Naturally Occurring Radioactive Materials, February 1997.

[6] Daily, M.C., "Working Draft Regulatory Guide on Release Criteria for Decommissioning NRC Staff's Draft for Comment," NUREG-1500, Table B-2, August 1994.

[7] United State Environmental Protection Agency, "Staff Working Draft of the Radiation Site Cleanup Regulation," May 17, 1994.

[8] United States Regulatory Commission, "Draft Radiological Criteria for License Termination," 7590-01-P1, to be published in the United States Federal Register, 1997.

[9] Gray, P., "Comparison of NORM Rules by State," The NORM Report, Summer 1996, p. 31, Peter Gray and Associates, Tulsa, Oklahoma.

[10] United States National Academy of Science, "Health Risk of Radon and Other Internally Deposited Alpha-Emitters BEIR-IV," National Academy Press, Washington, DC 1988.