

Radon History, Health Risk, and Ethics

1 CHAPTER ONE

Review

This chapter gives an introduction to the history of radon including research, case studies, and its effects on human health.

Chapter Outline

1. Chapter 1: Introduction to Radon & Health Risk
 1. History of Radon
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 2. Sources of Natural Radiation
 3. The Discovery of Radioactivity & How to Measure It
 4. The Discovery of Radium & Polonium
 2. Radon Research
 1. Miner Studies
 2. Animal Studies
 3. Residential Studies
 3. Health Effects of Radon
 1. Carcinogenic Health Effects
 2. Risk Estimates
 3. Radiation Exposure and Sources
 4. Radon Risk by Occupation
 5. The Tobacco Correlation
 6. EPA Citizens Guide
 4. Ethics
 1. Protecting Consumer Trust
 2. Communicating Responsibly
 3. Minimum Standards vs Best Practices

Chapter Learning Objectives

- ☐ Define the number of deaths per year attributed to radon-induced lung cancer.
- ☐ Explain the DNA effects of ionizing radiation.
- ☐ Identify three primary sources for the scientific basis of radon risk estimates.
- ☐ Cite the most definitive report of scientific data on indoor radon.
- ☐ Cite the percentage of radiation exposure caused by indoor radon to the general public in comparison with natural and manmade sources.
- ☐ Identify the EPA action level at which consumers are recommended to take corrective action to fix indoor radon levels.
- ☐ Identify the carcinogenic classification of radon.

Chemical symbol of Radon

- Rn

Facts & Characteristics of Radon

- Naturally occurring
- Radioactive Decay Products
- Produced by the decay of uranium and radium
- Found in soils, rock, and water throughout the U.S.
- Colorless
- Odorless
- Tasteless
- Considered Ionizing Radiation
- Largest source of exposure to naturally occurring radiation
- Class A Carcinogen
- Cannot be detected by the senses.

Rn	86 (222)
Density	9.73 g/L
Boiling point	-62°C
Melting point	-71°C
F.E. Dorn, 1900	
California Geological Survey Mineral Resources and Mineral Hazards Mapping Program	
(Xe) 4f ¹⁴ 5d ¹⁰ 6s ² 6p ⁶	
Radon	

Health Risk

- Exposure to high concentrations and can cause **lung cancer**.
- The EPA estimates **21,000 deaths** per year are attributed to radon-induced lung cancer.
- **DNA Effects of Ionizing Radiation:**
 - Inhaled radon decay products [RDP's] attach to **bronchial epithelium** or lung tissue.
 - Energy released by **ALPHA** particles can cause permanent damage to DNA molecules, either by **physical** or by **chemical** means.
 - In a very small portion of the irradiated cells, the **damaged DNA** will replicate in actively dividing cells, which may induce lung cancer.
 - DNA damage can occur at any level of radon exposure.

Annual Radiation Exposure Estimates

- Natural versus Man Made Radiation
 - 50% - Background or "natural" radiation
 - 50% - Medical or "man made" radiation
 - 37% - Indoor radon [outdated risk assessments indicate 55%]
- 4.0 pCi/L Annual Radon Exposure Equivalencies
 - 200 Chest x-rays
 - 8 Cigarettes/Day

Average Indoor Radon Concentration

- 1.3 pCi/L

Average Outdoor Radon Concentration

- 0.4 pCi/L [HINT: THINK OPPOSITE OF 4.0!]

Action Level

- EPA set 4.0 pCi/L as the Action Level
- Level at which citizens are recommended to take corrective measures to reduce radon levels indoors.
 - *Does not imply that any level below 4.0 pCi/L is considered acceptable*

Studies that Concluded Radon Risk

- Miner Studies
- Animal Studies
- Residential Studies
 - Case-Control
 - Ecological

Most Definitive Studies

- **BEIR - Biological Effects of Ionizing Radiation**
 - Health effects of radon exposure to Uranium miners
 - THE Definitive research indicating that radon causes lung cancer in humans.
- WHO Handbook on Indoor Radon, 2009, that *“the vast majority of radon induced lung cancers are thought to occur following exposure to low and moderate radon concentrations”*.
- Concludes that pooled residential studies [e.g. Iowa Radon Lung Cancer Study (IRLCS)] substantiate a direct method for determining risk without miner studies.

Other Important Health Risk Factors

- The World Health Organization (WHO) estimates that radon causes up to 15% of lung cancers worldwide.
- The primary risk of lung cancer from exposure to radon does not come from exposure to the gas itself, but from exposure to its decay products. When radon decays, a number of short half-life decay products are formed, primarily polonium-218, lead-214, bismuth-214, and polonium-214.
- Based on the EPA's risks calculations, the risk of lung cancer from radon exposure is almost **20 X** greater for a current smoker than for someone who has never smoked.
- 50% of the average dose of Ionizing Radiation to US citizens is due to **background radiation from natural sources such as:** soil and rocks (terrestrial), radon gas (37%), radiation from space (cosmic) and radiation sources that are found naturally within the human body (internal).

Source	Dose
Natural Radiation	
A 5 hour jet airplane ride	2.5 mrem/trip (0.5 millirem/hr at 39,000 feet) (Whole Body Dose)
Cosmic radiation from outer space	27 mrem/year (Whole Body Dose)
Terrestrial radiation	28 mrem/year (Whole Body Dose)
Natural radionuclides in the body	35 mrem/year (Whole Body Dose)
Radon gas	200 mrem/year (Lung Dose)
Diagnostic Medical Procedures	
Chest X-Ray	8 mrem (Whole Body Dose)
Dental X-Rays (Panoramic)	30 mrem (Skin Dose)
(2 Bite-Wings)	80 mrem (Skin Dose)
Mammogram	138 mrem per image
Barium Enema (X-Ray portion only)	406 mrem (Bone Marrow Dose)
Upper Gastrointestinal Tract	244 mrem (X-ray portion only) (Bone Marrow Dose)
Thallium Heart Scan	500 mrem (Whole Body Dose)
Consumer Products	
Building Materials	3.5 mrem/year (Whole Body Dose)
Luminous Watches (H-3 and Pm-147)	0.04-0.1 mrem/yr (Whole Body Dose)
Tobacco Products (To smokers @ 30 cigarettes per day)	16000 mrem/year (Bronchial Epithelial Dose),

Source: EPA

Figure 1-6. U.S. Radiation Exposure Sources by mrem Dosage

Radon Level	If 1,000 people who smoked were exposed to this level over a lifetime*...	The risk of cancer from radon exposure compares to**...	WHAT TO DO: Stop smoking and...
20 pCi/L	About 260 people could get lung cancer	250 times the risk of drowning	Fix your home
10 pCi/L	About 150 people could get lung cancer	200 times the risk of dying in a home fire	Fix your home
8 pCi/L	About 120 people could get lung cancer	30 times the risk of dying in a fall	Fix your home
4 pCi/L	About 62 people could get lung cancer	5 times the risk of dying in a car crash	Fix your home
2 pCi/L	About 32 people could get lung cancer	6 times the risk of dying from poison	Consider fixing between 2 and 4 pCi/L
1.3 pCi/L	About 20 people could get lung cancer	(Average indoor radon level)	(Reducing radon levels below 2 pCi/L is difficult.)
0.4 pCi/L	About 3 people could get lung cancer	(Average outdoor radon level)	

Source: EPA

Figure 1-7. Radon Risk for Smokers

Radon Level	If 1,000 people who never smoked were exposed to this level over a lifetime*...	The risk of cancer from radon exposure compares to**...	WHAT TO DO:
20 pCi/L	About 36 people could get lung cancer	35 times the risk of drowning	Fix your home
10 pCi/L	About 18 people could get lung cancer	20 times the risk of dying in a home fire	Fix your home
8 pCi/L	About 15 people could get lung cancer	4 times the risk of dying in a fall	Fix your home
4 pCi/L	About 7 people could get lung cancer	The risk of dying in a car crash	Fix your home
2 pCi/L	About 4 person could get lung cancer	The risk of dying from poison	Consider fixing between 2 and 4 pCi/L
1.3 pCi/L	About 2 people could get lung cancer	(Average indoor radon level)	(Reducing radon levels below 2 pCi/L is difficult.)
0.4 pCi/L		(Average outdoor radon level)	

Source: EPA

Figure 1-8. Radon Risk for Never Smokers

NRPP, NRSB & New Jersey Students must ALSO study the EPA Citizen's Guide to Radon.