

Radiological Environmental Monitoring & Surveillance HPHY6605, Spring 2012

Description: A thorough grounding in the sources and nature of the radiation environment and advanced considerations in the design of monitoring programs. Sampling and analytical measurement programs for specific radionuclides and sources with emphasis on quality assurance.

Day / Time: Wednesdays/ 7:00 - 9:30 PM

Location: Pocatello: Oboler Library B-3G; **Idaho Falls:** CHE 303

Texts: (1) “Environmental Radioactivity,” Fourth Edition, Merril Eisenbud and Thomas Gesell, Academic Press, San Diego, (1997) [bookstore]

(2) “Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance,” DOE report DOE/EH-0173T, US DOE, Washington, DC (1991) [will be provided for downloading]

Handouts: Copies of class materials and occasional supplements will be available before each class period at <http://www.physics.isu.edu/~gesell/PHYS605.html>

Instructor: Tom Gesell

Office: PS 105

gesethom@isu.edu (preferred method of contact)

282-3669 (office)

221-2108 (mobile phone - urgent items only please)

Office hours: Students may visit any time that my office door is open or by appointment.

Expectations: Students are expected to achieve an understanding of:

- Natural and man-made sources of radiation and radioactivity in the environment;
- Regulations and standards affecting environmental radioactivity;
- Monitoring of environmental effluents;
- Surveillance of the ambient environment;
- Selected topics in advanced surveillance techniques.

Grading: Grading is based on the following three elements with equal weight:

One midterm take-home exam

One term paper, presented orally and in writing

A take-home final exam

Ethics: The ISU policy on academic dishonesty applies. Students who are unfamiliar with this policy should review pages 9 and 10 of the ISU student handbook

<http://www.isu.edu/studenta/handbook.pdf> and the pertinent materials in the Faculty/Staff handbook http://www.isu.edu/policy/fs-handbook/part6/6_9/6_9a.html

Disabilities: Our program is committed to all students achieving their potential. If you have a disability (physical, learning disability, hearing, vision, psychiatric) which may need a reasonable accommodation, please contact ISU Disability Services located in the Rendezvous Building, Room 125, 282-3599 as early as possible.

<<http://www.isu.edu/ada4isu/students.shtml>>.

Information regarding ABET accreditation of the HP Programs

Our mission is educating students so they can achieve the highest standards of the health physics profession, and solving important problems for the people and industries of Idaho and the Nation through teaching, research, and service.

The educational objectives of the ISU Health Physics program are to produce Health Physicists with

- 1) broad, fundamental technical knowledge,
- 2) written and verbal communication skills
- 3) professional judgement and capability to think critically
- 4) practical experience in solving applied health-physics problems
- 5) the ability to work independently
- 6) a professional ethic of magnitude sufficient for them to productively and successfully work in a variety of health physics settings.

There are two additional objectives for the MS program.

7. An ability to conduct research and
8. Professional tools and experience above that expected for the baccalaureate program and the ability to work independently.

Expectations: The Idaho State University Health Physics Program participates in ABET Accreditation. This class serves to partially address the following curriculum areas under “Proposed Program Criteria” Section II, for Master’s Level Programs: (I) a minimum of one year of study beyond the basic-level, consisting of courses with increased depth and rigor; (iv) advanced qualitative and quantitative problem-solving skills, (v) other academic areas or specialities considered. This class will also in part address all 6 of the ISU educational objectives listed above.

Guide for writing and presenting the term paper:

Choose a topic in which **you** are interested.

You may focus on a particular source, a particular radionuclide or class of radionuclides, a monitoring methodology, an exposure situation, or other category.

Term papers should treat a topic mutually agreed upon by the instructor and the student. To facilitate selection of a mutually agreed upon topic, students are requested to submit a proposed topic and a proposed outline on the dates indicated in the course schedule. Narrow subjects generally make better term papers than broad subjects.

The title page should contain the paper title, the course title, year and semester, the student's name and the due date of the paper. The body of the paper should be 10-15 pages in length, double spaced and typed. An abstract is not necessary, but the paper should be divided into several appropriate sections that are clearly identified. Attention should be paid to grammar, syntax and spelling. Poorly written papers will be downgraded. Figures and tables should be used to illustrate technical points and should generally conform to the style required by the Health Physics Journal (see any January or July issue for instructions to authors).

A good paper will usually have a minimum of 10 references. Most of the references should be from technical literature such as scientific journals, books or reports. If appropriate for your topic, you may use a few citations from the popular press or even anti-nuclear literature, to illustrate the level of public concern for an issue, but information from the popular press or anti-nuclear literature should not be relied upon for basic factual information.

Use the author-year reference and citation system employed in recent issues of the Health Physics Journal, not the numerical system. All references cited from the body of the paper must be listed in the reference section. All references in the reference section should be cited at least once from the body of the paper. To cite files available for viewing/downloading from the internet, give the author's name (if known), the full title of the cited work in quotation marks, the title of the complete work, if applicable, in italics, the document date if known, the full http address, and the date of visit.

Oral presentations will be allocated approximately 25 minutes plus 5 minutes for questions. The preferred presentation method is PowerPoint, but other methods will be considered with advance notice. Use font sizes that will be legible to the audience and make sure pictures, charts, and tables are legible. If you have to say "I know you can't read this, but..." it means that you are cramming too much information on a slide. Use of a subtle background graphic on the slides is OK unless it distracts from the information you are presenting. Use your own judgement on animation, but it is certainly not required.

Papers substantially similar to those submitted to other ISU classes are not acceptable.

INITIAL SCHEDULE

Week	Date	Topic	Guest speaker
1	01/11/12	** Introduction of course; introduction of students; expectations; outline of course; references; hand-out materials; student papers; exams; schedule. <i>Reading: Chapter 1 of text.</i>	
		** Radiation fundamentals: terminology; dose concepts; dose equivalent; effective dose equivalent; external dose; internal dose. <i>Reading: consult any comprehensive health physics text.</i>	
2	1/18/2012	** Biological bases of radiation protection: demonstrated effects, both deterministic and stochastic, hypothetical effects at low doses. <i>Preparation chapter 2 of text; may supplement with any comprehensive health physics or radiobiology text.</i>	
		** Evolution of radiation protection standards; external dose limits; annual limits of intake; derived concentrations. <i>Preparation: chapter 3 of text; supplement with any comprehensive health physics text as needed.</i>	
3	1/25/2012	** Transport mechanisms - atmospheric. <i>Preparation: chapter 4 of text.</i>	
		** Transport mechanisms - terrestrial and aquatic. <i>Preparation: chapter 5 of text.</i>	
4	2/1/2012	** Radionuclides and radiation in the environment from natural sources - terrestrial. <i>Preparation: chapter 6 of text.</i>	
		** Radionuclides and radiation in the environment from natural sources cosmic. <i>Preparation: chapter 6 of text.</i>	
5	2/8/2012	** Radionuclides and radiation in the environment from nuclear fuel production: mining; milling; fabrication; uranium mill tailings. <i>Preparation: chapter 7 of text.</i>	
		** Radionuclides and radiation in the environment from reactors. <i>Preparation: chapter 8 of text.</i>	
6	2/15/2012	** Radionuclides and radiation in the environment from nuclear weapons. <i>Preparation: chapter 9 of text.</i>	
		** Radionuclides and radiation in the environment from waste management activities. <i>Preparation: chapter 10 of text.</i>	
7	2/22/2012	No Class	
8	2/29/2012	** Radionuclides and radiation in the environment from miscellaneous sources. <i>Preparation: chapter 11 of text.</i>	
	Distribute midterm exam	** Radionuclides and radiation in the environment from various accidents. <i>Preparation: chapter 12 of text.</i>	
9	3/7/2012	** Environmental tritium.	Paul Ritter
		** Concepts and strategy for environmental monitoring; regulatory requirements; public relations aspects; quality assurance; chain of custody. <i>Preparation: text, chapter 13; Environmental Regulatory Guide, Chapters 1 & 5.1-5.3.</i>	

Week	Date	Topic	Guest speaker
10	3/14/2012	** Effluent monitoring - water: grab sampling; proportional sampling; sample preservation. <i>Preparation: handouts; Environmental Regulatory Guide, Chap 2</i>	
		** Environmental surveillance - water: surface water; ground water. <i>Preparation: handouts; Environmental Regulatory Guide, Chap 5.10</i>	
11	3/21/2012	** Effluent monitoring - air: gases; particles. <i>Preparation: handouts; Environmental Regulatory Guide, Chapter 3.</i>	
	Collect midterm exam	** Environmental surveillance - air: gases; particles; radon and progeny as a special case. <i>Preparation: Environmental Regulatory Guide, Chapter 5.7</i>	
12	3/28/2012	Spring Break	
		Spring Break	
13	4/4/2012	** Environmental surveillance - soil, biota and foodstuffs. <i>Preparation: handouts; Environmental Regulatory Guide, Chapter 5.8, 5.9, 5.1**</i>	
	Distribute final exam	** Analysis of environmental samples: instrumental analysis; radiochemical analysis. <i>Preparation: handouts; Environmental Regulatory Guide, Chapter 6.</i>	Roy Dunker
14	4/11/2012	** Direct radiation measurements I: Active measurements; passive devices. <i>Preparation: handouts; Environmental Regulatory Guide, Chapter 5.4-5.6.</i>	
	Submit titles & outlines of papers	** Direct radiation measurements II: In situ gamma-ray spectroscopy; aerial gamma-ray spectroscopy. <i>Preparation: handouts; Environmental Regulatory Guide, Chapter 5.4-5.6; .</i>	
15	4/18/2012	** Radioecology: Potential dose to man from radioactivity in game animals	Doug Halford
		** Epidemiological studies related to environmental radiation and radionuclides	
16	4/25/2012	Student term paper presentations	
	Collect final exam and written papers	Student term paper presentations	

SELECTED REFERENCES

Web Sites

A good starting point for web-based radiation protection information, including environmental radiation, is The Radiation Information Network <http://www.physics.isu.edu/radinf> This site is maintained by ISU alumnus Bruce Busby who has also written articles on Web-based resources in the Health Physics Journal and the Health Physics Newsletter.

Books, Reports, Compendia

Environmental radioactivity, Fourth Edition, Merril Eisenbud and Thomas Gesell, Academic Press, San Diego, California (1997) [TEXT]

Environmental regulatory guide for radiological effluent monitoring and environmental surveillance, DOE report DOE/EH-0173T, US DOE, Washington, DC (1991) [TEXT - supplied]

Aerosol technology: properties, behavior and measurement of airborne particles, W. C. Hinds, Wiley, NY. (1982)

Air sampling instruments for evaluation of atmospheric contaminants, S. Hering, ed, ACGIH, Cincinnati (1989)

An aerial radiological survey of Pocatello and Soda Springs, Idaho, H. A. Berry, EPA-8613, Las Vegas (1987)

Assessment of techniques to determine previous radiation exposures, G. R. Eisele, ed., Published as Supplement One to Volume 60 of the journal Health Physics (1991)

ASTM, American Society for Testing and Materials Standards, Standard Practice for Sampling Surface Soil for Radionuclides, Standard C998-05, 2005.

Effluent and environmental surveillance, J. J. Kelly, ed., ASTM Special Technical Publication 698, American Society for Testing and Materials, Philadelphia (1980)

EML procedures manual, HASL-300, Current Edition, Environmental Measurements Laboratory, New York also available on line. It moves around so just google EML Procedures manual.

Environmental Impact of Radioactive Releases - Proceedings of a Symposium on Environmental Impact of Radioactive Releases organized by the IAEA and held in Vienna, 8-12 May, 1995, Symposium Series, IAEA, Vienna.

Environmental health physics - Proceedings of the twenty-sixth midyear topical meeting of the Health Physics Society, Research Enterprises Publishing Segment, Richland, Washington (1993).

Evaluation of Guidelines for Exposures to Technologically Enhanced Naturally Occurring Radioactive materials, Committee on Evaluation of Guidelines for Exposures to Technologically Enhanced Naturally Occurring Radioactive Materials, National Research Council. National Academy Press, Washington, DC. (1999)

Evaluation of environmental radiation exposures from nuclear testing in Nevada, T. F. Gesell and P. G. Voilleque, eds., Published as a special issue, number 5, Volume 59 of the journal Health Physics (1990)

Handbook of Radioactivity Analysis 2nd edition), Michael F. L'Annunziata, M.F. and Burkart, W., Academic Press, San Diego, California (2003)

Idaho radionuclide study, US Environmental Protection Agency, Report EPA/520/6-90/008, US EPA, Las Vegas (1990)

Idaho National Engineering Laboratory historical dose evaluation, US DOE Field Office Idaho, DOE/ID-12119 (1991)

Low-Level Measurements of Man-Made Radionuclides in the Environment, Garcia-Leon, M. & Madurga, G., World Scientific, 1991

Low-Level Environmental Radioactivity, Sources and Evaluation Richard Tykva, D.Sc., Josef Sabol, D.Sc., Technomic Publishing, Lancaster, PA, 1995

Meso-scale atmospheric circulations, B. W. Atkinson, Academic Press, New York (1981)

Meteorology and atomic energy, D. H. Slade, ed., report TID 24190, US Department of Commerce, Springfield, VA (1968)

Models and parameters for environmental radiological assessments, Charles W. Miller, ed, DOE/TIC-11468, Technical Information Center, Springfield, VA (1984)

Monitoring of radioactive effluents, Organization for Economic Co-operation and Economic Development, Paris (1974)

Natural radioactivity - Proceedings of the fourth international symposium on the natural radiation environment, A. O. De Bettencourt et al., eds., Radiation Protection Dosimetry 24(1-4) (1988).

Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors, Meinke, W. W. and Essig, T. H., Report NUREG-1301, U. S. Nuclear regulatory Commission, Washington D.C. (1991)

Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Boiling Water Reactors, Meinke, W. W. and Essig, T. H., Report NUREG-1302, U. S. Nuclear regulatory Commission, Washington D.C. (1991)

Principals of environmental sampling, Lawrence H. Keith, ed., American Chemical Society, Washington (1988)

Radiation in Our Environment, Walter Lee, Faun Publishing Company 09/01/1995

Radioactivity in the environment, Ronald L. Kathren, Harwood Academic Publishers, New York (1984)

Radioactivity in the marine environment, Panel on Radioactivity in the marine environment, National Academy of Sciences, Washington (1971)

Radioecological Techniques, Vincent Schultz and F. Ward Whicker, Perseus Publishing 2/01/1982

Radioecology, Vincent Schultz and : F. Ward Whicker Editors, Franklin Book Company, Incorporated, 05/01/1982

Radioecology, E. Holm, World Scientific Publishing Company, Incorporated 08/01/1994

Radioecology & the Restoration of Radioactive Contaminated Sites, F. Luykx and M. J. Frissel, Kluwer Academic Publishers, 07/01/1996

Radiological Assessment: Sources and Exposures, Faw, Richard E. & Shultis, Kenneth, Prentice Hall (Div. of Paramount Publishing), 1992

Radiological effluent technical specifications for BWR's, US NRC report NUREG-0473, US NRC, Washington, DC (1979)

Radiological effluent technical specifications for PWR's, US NRC report NUREG-0472, Rev 3, US NRC, Washington, DC (1983)

Radiological quality of the environment in the United States, US EPA, Report EPA 520/1-77-009, Washington, (1977)

Radiological assessment - a textbook on environmental dose analysis, J. E. Till and H. R. Meyer, eds., NRC Report NUREG/CR-3332, Superintendent of Documents, Washington, DC (1983)

Radiological Risk Assessment and Environmental Analysis, John E. Till and Helen A. Grogan (Eds), Oxford University Press, London (2008)

Radioactivity: Introduction and History, Michael F. L'Annunziata, Werner Burkart, Elsevier Science & Technology Books, September 2007

Radionuclides in the Environment, American Chemical Society Staff, Books on Demand, 01/01/1970

Radon and its decay products in indoor air, W. M. Nazaroff and A. V. Nero, eds., Wiley Interscience, New York (1988)

The natural radiation environment - Proceedings of the first international symposium on the natural radiation environment, J. A. S. Adams and W. M. Lowder, eds., University of Chicago Press, Chicago (1964)

The natural radiation environment II - Proceedings of the second international symposium on the natural radiation environment, J. A. S. Adams et al., eds., US Energy Research and Development Agency, Report CONF-720805-P1 and P2 (1972)

The natural radiation environment III - Proceedings of the third international symposium on the natural radiation environment, T. F. Gesell and W. M. Lowder, eds., US Department of Energy Report CONF-780422 vol. 1 and 2, (1980)

The natural radiation environment - Proceedings of the second special symposium on the natural radiation environment, K. G. Vohra et al., eds., Wiley Eastern, New Delhi (1982)

The Natural Radiation Environment VI, Proceedings of the Sixth International Symposium, P. Hopke, Ed., Environment International 22 (Suppl. 1) 1996.

The Natural Radiation Environment V, Proceedings of the Fifth International Symposium, A. Janssens, W. Lowder, M. Olast, J. Sinnaeve, and F. Steinhäusler, Eds., Radiation Protection Dosimetry 53(1-4) (1992)

The Natural Radiation Environment: Seventh International Symposium On The Natural Radiation Environment, McLaughlin, Jane P., Simopoulos, S. E., and Steinhäusler, F., eds. Elsevier (2005)

Transfer of radionuclides in natural and semi-natural environments, G. Desmet, et al., eds, Elsevier Applied Science, New York (1990)

Upgrading Environmental Data, a joint report of the Health Physics Society (HPSR-1) and the US Environmental Protection Agency (EPA 520/1-80-012) (1980)

Reports of the National Council on Radiation Protection and Measurement (NCRP), available from NCRP, 7910 Woodmont Avenue, Suite 400, Bethesda MD 20814, 800-229-2652, or online at <http://www.ncrppublications.org//>

- 44 Krypton-85 in the atmosphere (1975)
- 50 Environmental radiation measurements (1976)
- 52 ¹³⁷Cs Metabolism from environment to man: metabolism and dose (1977)
- 58 A handbook of radioactivity measurement procedures, 2nd ed, (1985)
- 62 Tritium in the environment (1979)
- 76 Radiological assessment: predicting the transport, bioaccumulation and uptake by man of radionuclides released to the environment (1984)
- 77 Exposures from the uranium series with emphasis on radon and its daughters (1984)
- 78 Evaluation of occupational and environmental exposures to radon and radon daughters in the United States (1984)
- 81 Carbon-14 in the environment (1985)
- 92 Public radiation exposure from nuclear power generation in the United States (1987)
- 93 Ionizing radiation exposure of the population of the United States (1987) [soon to be superceded]
- 94 Exposure of the population in the United States and Canada from natural background radiation (1987)
- 95 Radiation exposure of the U.S. population to commercial products and miscellaneous sources (1987)
- 97 Measurement of radon and radon daughters in air (1988)
- 103 Control of radon in houses (1989)
- 116 Limitation of exposure to ionizing radiation (1993)
- 118 Radiation Protection in the Mineral Extraction Industry (1993)
- 123 Screening Models for Releases of Radionuclides to Atmosphere, Surface Water and Ground (1996)
- 129 Recommended Screening Factors for Contaminated Surface Soil and Review of Factors Relevant to Site-Specific Studies (1999)
- 138 Management of Terrorist Events Involving Radioactive Material (2001)
- 141 Managing Potentially Radioactive Scrap Metal (2002)
- 146 Approaches to Risk Management in Remediation of Radioactively Contaminated Sites (2004).
- 152 Performance assessment of Near Surface Facilities for Disposal of Low-level Radioactive Waste (2005)
- 154 Cesium-137 in the Environment: Radioecology and Approaches to Assessment and Management (2006)
- 160 Ionizing Radiation Exposure of the Population of the United States (2009)
- 163 Radiation Dose Reconstruction: Principles and Practices (2010)
- 166 Population Monitoring and Radionuclide Decorporation Following a Radiological or Nuclear Incident (2010)

Reports of the International Commission on Radiation Units and Measurement (ICRU), <http://www.icru.org/>

- 51 Quantities and Units in Radiation Protection Dosimetry (1992)
- 53 Gamma-Ray Spectrometry in the Environment (1994)
- 60 Fundamental Quantities and Units for Ionizing Radiation (1998)
- 65 Quantities, Units and Terms in Radioecology, Journal of the ICRU, vol.1 no.2 (2001)
- 68 Retrospective Assessment of Exposure to Ionising Radiation, Journal of the ICRU, vol.2 no.2 (2002)
- 75 Sampling of Radionuclides in the Environment ICRU Report 75, Journal of the ICRU vol. 6, No 1, 2006
- 85a Fundamental Quantities and Units for Ionizing Radiation (Revised), Journal of the ICRU Vol. 11 No. 1 (2011)

Reports of the International Commission on Radiological Protection,
http://www.elsevier.com/wps/find/bookseriesdescription.cws_home/BS_ICRP/description

- 29 Radionuclide release into the environment - assessment of doses to man (1979)
- 39 Principles for limiting the exposure of the public to natural sources of radiation (1984)
- 43 Principles of monitoring for the radiation protection of the public (1984)
- 56 Age-Dependent Doses to Members of the Public from Intake of Radionuclides, Part 1
- 60 1990 Recommendations of the ICRP (1991)
- 65 Protection against Radon at Home and at Work. Annals of the ICRP (4) 1993.
- 66 Human Respiratory Tract Model for Radiological Protection. Annals of the ICRP 24 (1-3) 1994.
- 67 Age-Dependent Doses to Members of the Public from Intake of Radionuclides: Part 2, Annals of the ICRP 23 (2-3) 1993.
- 69 Age Dependent Doses to Members of the Public from Intake of Radionuclides: Part 3. Ingestion Dose Coefficients. Annals of the ICRP 25 (1) 1995.
- 70 Basic Anatomical and Physiological Data for Use in Radiological Protection. Part 1. Skeleton. Annals of the ICRP 25 (2) 1995.
- 71 Age Dependent Doses to Members of the Public from Intake of Radionuclides, Part 4, Inhalation Dose Coefficients. Annals of the ICRP 25 (3-4) 1995.
- 72 Age Dependent Doses to Members of the Public from Intake of Radionuclides, Part 5, Compilation of Dose Coefficients from Parts 1-4. Annals of the ICRP 26 (1) 1996.
- 77 Radiological Protection Policy for the Disposal of Radioactive Waste. Supplement to the Annals of the ICRP (Volume 27, 1997, although printed in 1998)
- 82 Protection of the Public in Situations of Prolonged Radiation Exposure. Annals of the ICRP 29 (1-2), 2000.
- 89 Basic Anatomical and Physiological Data for Use in Radiological Protection: Reference Values, 2003
- 91 A Framework for Assessing the Impact of Ionising Radiation on Non-Human Species, 2004
- 99 Low Dose Extrapolation of Radiation Related Cancer Risk, 2006
- 100 Human Alimentary Tract Model for Radiological Protection, 2007
- 103 Recommendations of the ICRP, 2008
- 108 Environmental Protection - the Concept and Use of Reference Animals and Plants, 2008

US Nuclear Regulatory Commission Regulatory Guides, <http://www.nrc.gov/reading-rm/doc-collections/reg-guides/>

- 1.21 Measuring, evaluating, and reporting radioactive material in liquid and gaseous effluents and solid waste (6/2009)
- 1.23 Meteorological monitoring programs for nuclear power plants (3/2007)
- 1.109 Calculation of annual dose to man from routine releases of reactor effluents for purpose of evaluating compliance with 10 CFR Part 50, Appendix I (10/1977)
- 1.145 Atmospheric dispersion models for potential accident consequence assessments at nuclear power plants (2/83)
- 3.8 Preparation of environmental reports for uranium mills (10/1982)
- 3.59 Methods for estimating radioactive and toxic airborne source terms for uranium milling operations (3/1987)
- 3.63 Onsite meteorological measurement program for uranium recovery facilities - data acquisition and reporting (3/1988)
- 3.64 Calculation of radon flux attenuation by earthen uranium mill tailings covers (6/1989)
- 4.1 Radiological Environmental Monitoring for Nuclear Power Plants (6/2009)
- 4.2 Preparation of environmental reports for nuclear power stations (7/1976)
- 4.2S1 Supplement 1 to Regulatory Guide 4.2, Preparation of Supplemental Environmental Reports for Applications To Renew Nuclear Power Plant Operating Licenses (09/2000)
- 4.11 Terrestrial environmental studies for nuclear power stations (8/1977)
- 4.13 Performance testing and procedural specifications for thermoluminescence dosimetry: environmental applications (7/77)
- 4.14 Radiological effluent and environmental monitoring at uranium mills (4/1980)
- 4.15 Quality assurance for radiological monitoring programs (inception through normal operations to license termination) -effluent streams and the environment (2/2006)
- 4.16 Monitoring and reporting radioactive materials In liquid and gaseous effluents from nuclear fuel cycle facilities (12/2010)
- 4.19 Guidance for selecting sites for near-surface disposal of low-level radioactive waste (8/1988)
- 4.20 Constraint on Releases of Airborne Radioactive Materials to the Environment for Licensees other than Power Reactors (12/1996)

International Atomic Energy Agency, IAEA, Vienna <http://www-pub.iaea.org/mtcd/publications/publications.asp>

IAEA Technical Report Series

- 179 Particle size analysis in estimating the significance of airborne contamination (1978)
- 207 Tritium in some typical ecosystems (1981)
- 250 The radiological impact of radionuclides dispersed on a regional and global scale: methods for assessment and their application (1985)
- 264 Environmental isotope data no. 8: world survey of isotope concentration in precipitation (1980-1983) (1986)
- 295 Measurement of radionuclides in food and the environment - a guidebook (1989)
- 323 Airborne gamma-ray spectrometer surveying (1991)
- 394 Health and Environmental Impacts of Electricity Generation Systems: Procedures for Comparative Assessment (1999)
- 419 Extent of Environmental Contamination by Naturally Occurring Radioactive Material (NORM) and Technological Options for Mitigation (2003)

IAEA Safety Series

- 46 Monitoring of airborne and liquid radioactive releases from nuclear facilities to the environment (1978)
- 115 International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources: A Safety Standard. (1996)

IAEA Safety Reports Series

- 33 Radiation Protection against Radon in Workplaces other than Mines (2004)

IAEA Safety Standards Series

- RS-G-1.8 Environmental and Source Monitoring for Purposes of Radiation Protection Safety (2005).

IAEA TECDOC Series

Soil sampling for environmental contaminants, IAEA-TECDOC-1415, 2004

Selected Federal Laws, Standards and Regulations <http://www.epa.gov/rpdweb00/laws/laws.html>

Clean Air Act

Clean Water Act

Safe Drinking Water

Indoor Radon Abatement Act

Nuclear Waste Policy Act

Standards for radioactivity in drinking water (40 CFR Part 141)

National emission standards for hazardous air pollutants (NESHAPS), US Environmental Protection Agency, 40 CFR 61 (current revision)

Standards for protection against radiation, US Nuclear Regulatory Commission, 10 CFR 20 (current revision)

EPA (U.S. Environmental Protection Agency), 1994a. "Proposed Federal Radiation Protection Guidance for Exposure of the General Public," *Federal Register* **59**, 66414.

EPA (U.S. Environmental Protection Agency) 40 CFR Parts 141,142—National Primary Drinking Water Regulations; Radionuclides

Journals

Health Physics Journal

Journal of Environmental Radioactivity

Radiation Protection Dosimetry