United Arab Emirates

الهيئة الاتحادية للرقابة النووية
FANR
Federal Authority for Nuclear Regulation

ICRP 2013

ICRP 2013
2nd International Symposium on the System of Radiological Protection

October 22 - 24, 2013 - Abu Dhabi, UAE

ICRP 2013: THE 2ND INTERNATIONAL SYMPOSIUM ON THE SYSTEM OF RADIOLOGICAL PROTECTION

Abu Dhabi, UAE • 2013 October 22-24

Programme Overview & Participating Organisations

Tissue reactions: The road from science to protection

International Commission on Radiological Protection – ICRP • Christie Hospital (UK) • Complutense University (Spain) • International Atomic Energy Agency – IAEA • International Radiation Protection Association – IRPA • Kinki University (Japan) • Medical University of Vienna (Austria) • Memorial Sloan-Kettering Cancer Center (USA) • OECD Nuclear Energy Agency – NEA • Pacific Northwest National Laboratory (USA) • Public Health England – PHE (UK) • University of Florida (USA) • University of Milan (Italy) • World Health Organisation – WHO • World Nuclear Association – WNA

Advances in recovery preparedness and response following Fukushima

International Commission on Radiological Protection – ICRP • French Nuclear Protection Evaluation Centre – CEPN • French Nuclear Safety Authority – ASN • Japanese Ministry of the Environment • Oita University of Nursing and Health Sciences (Japan) • Public Health England – PHE (UK) • The University of Tokyo (Japan)

NORM issues in the real world

International Commission on Radiological Protection – ICRP • UAE Federal Authority for Nuclear Regulation – FANR • Abu Dhabi National Oil Company – ADNOC (UAE) • French Institute for Radiological Protection and Nuclear Safety – IRSN • SENES Consultants (Canada) • US Nuclear Regulatory Commission – NRC

What do we need from ICRP in medicine?

International Commission on Radiological Protection – ICRP • Complutense University (Spain) • Dubai Health Authority (UAE) • European Society of Radiology – ESR • Prince Sultan Military Medical City (Saudi Arabia) • Public Health England – PHE (UK) • US National Council on Radiation Protection and Measurements – NCRP • World Health Organisation – WHO

The ICRP approach to environmental radiation protection: issues and application

International Commission on Radiological Protection – ICRP • Belgian Nuclear Research Centre • Environment Agency of Abu Dhabi (UAE) • French Institute for Radiological Protection and Nuclear Safety – IRSN • International Atomic Energy Agency – IAEA • Oregon State University (USA) • Plymouth Marine Laboratory (UK)

TABLE OF CONTENTS

WELCOME MESSAGES

Dr. Claire Cousins

Chair, International Commission on Radiological Protection

On behalf of the International Commission on Radiological Protection (ICRP), I would very much like to welcome everyone to our 2nd International Symposium on the System of Radiological Protection. It is particularly gratifying that the Symposium and ICRP Commission and Committee meetings are taking place in Abu Dhabi, in a region of the world where ICRP has not previously held a meeting. I would like to gratefully thank our local hosts, the UAE Federal Authority for Nuclear Regulation (FANR) for all their help and support in the organisation of the Symposium, the sponsors for their valuable contributions, and all participants and speakers for attending.

The Strategic Plan that ICRP developed for 2011-2017 included finding ways of establishing closer collaboration with the many people and organisations involved in radiological protection. Biennial symposia are the result of this effort and are also part of the strategy to both develop openness and continue the evolution of ICRP.

The 1st Symposium held in Bethesda, USA in 2011 was a new venture that was well-received by the radiological protection community as it stimulated lively discussion and debate. However, there is always room for improvement and some of the changes made for this Symposium are the result of feedback and comment from the first. A good deal of time and effort is required in preparation for such an event and it is not surprising that even before the 2nd Symposium has commenced, plans are well underway for the organisation of the 3rd Symposium in Seoul, Korea in 2015.

Finally, I hope this Symposium will allow many professionals to exchange views on some of the most challenging topics that radiological protection needs to address both today and in the future. By working together and sharing out thoughts and ideas, the System of Radiological Protection will continue to improve for the benefit of all.

In addition to the organisations supporting ICRP 2013, ICRP is grateful to the following organisations who have provided on-going support necessary to continue our work:

Australian Radiation Protection and Nuclear Safety Agency; Burnasyan Federal Medical Biophysical Center, Russia; Canadian Nuclear Safety Commission & Health Canada; Chinese Society of Radiation Protection; Danish National Board of Health; European Commission; Finnish Radiation and Nuclear Safety Authority; French Institute of Radiation Protection and Nuclear Safety; French Nuclear Safety Authority (ASN); German Ministry of the Environment; Icelandic Radiation Protection Institute; International Atomic Energy Agency; International Radiation Protection Association; International Society of Radiology; Japan NUS Co Ltd; Japanese Ministry of the Environment; Korean Nuclear International Cooperation Foundation; Norwegian Radiation Protection Authority; Organisation for Economic Co-operation and Development, Nuclear Energy Agency; Spanish Nuclear Safety Council; Swedish Ministry of the Environment; US Department of Energy; US Nuclear Regulatory Commission & Environmental Protection Agency

William D Travers

Director General, Federal Authority for Nuclear Regulation

On behalf of the Federal Authority for Nuclear Regulation (FANR), I am pleased to welcome everyone to the ICRP Symposium 2013 and to Abu Dhabi, the capital of the United Arab Emirates.

I know that the other UAE major sponsors of the event echo my sentiment, and I take this opportunity to thank: the Emirates Nuclear Energy Corporation; the UAE Armed Forces; and the Health Authority of Abu Dhabi for their support.

When the prospect of becoming the prime sponsor for this event was raised some time ago, the FANR staff and the FANR Board of Management, as well as other UAE agencies represented on the National Radiation Protection Committee reacted enthusiastically. We all saw this as an opportunity to reiterate the United Arab Emirates' commitment to a peaceful nuclear energy programme based upon the highest international standards for nuclear safety, radiation protection, nuclear security, and safeguards. This commitment extends throughout the nuclear sector, and includes all activities in which the UAE uses radiation.

The ICRP Symposium provides a platform for knowledge sharing and best practices which will help support national capacity building towards managing these activities safely for a sustainable future.

We look forward to engaging world class experts about radiation protection and for the opportunity to discuss current and emerging issues on the subject.

We also hope that the visitors to the UAE have an opportunity to experience the culture of this remarkable and hospitable country.

ICRP 2013: 2nd International Symposium on the System of Radiological Protection Programme Overview

Tuesday October 22

08:30-11:45 Opening session

Co-chairs:	Claire Cousins (ICRP Chair) Christopher Clement (ICRP Scientific Secretary)
08:30-08:45	Welcome remarks, Monira H. Al-Kuttab, Director, Government Communications Department, FANR
08:45-09:05	ICRP: Past, Present and Future, Claire Cousins (ICRP Chair)
09:05-09:25	Overview of ICRP Committee 1 Radiation Effects: Bill Morgan (ICRP C1 Chair)
09:25-09:45	Overview of ICRP Committee 2 Doses from Radiation Exposure: John Harrison (ICRP C2 Chair)
09:45-10:05	Overview of ICRP Committee 3 Protection in Medicine: Eliseo Vaño (ICRP C3 Chair)
10:05-10:35	**Break**
10:35-10:55	Overview of ICRP Committee 4 Application of the Commission's Recommendations: Jacques Lochard (ICRP C4 Chair)
10:55-11:15	Overview of ICRP Committee 5 Protection of the Environment: Kathryn Higley (ICRP C5 Vice-chair)
11:15-11:45	Q&A

11:45-12:45 Lunch

12:45-15:35 Tissue reactions: The road from science to protection

Co-chairs:	Bill Morgan (ICRP C1 Chair, Pacific Northwest National Laboratory, USA)
12:45-12:55	Introduction
12:55-13:05	Wolfgang Doerr (ICRP C1, Medical University of Vienna, Austria) *The biology of tissue reactions*
13:05-13:15	Jolyon Hendry (Christie Hospital, UK) *Threshold doses and circulatory disease risks*
13:15-13:25	Shinichiro Miyazaki (Kinki University, Japan) *General tissue reactions and implications for radiation protection*
13:25-13:35	Simon Bouffler (ICRP C1, Public Health England, UK) *The lens of the eye, exposures in the UK medical sector and mechanistic studies of radiation effects*
13:35-13:45	Wesley Bolch (ICRP C2, University of Florida, USA) *Dosimetric models of the eye and eye lens and their use in assessing dose coefficients for ocular exposures*
13:45-13:55	Miroslav Pinak (International Atomic Energy Agency) *Dose limits to the lens of the eyes: New limit for the lens of the eye - International Basic Safety Standards and related guidance*
13:55-14:05	Eliseo Vaño (ICRP C3 Chair, Complutense University, Spain) *Implications in medical imaging of the new ICRP thresholds for tissue reactions*
14:05-14:15	Ted Lazo (OECD Nuclear Energy Agency) *Non-cancer effects: Science and values aspects of protection decisions*
14:15-14:25	Marie-Claire Cantone (International Radiation Protection Association , University of Milan, Italy) *Implications of the implementation of the revised dose limit to the lens of the eye: The view of the IRPA professionals*
14:25-15:35	Panel Discussion

Wednesday October 23

09:00-12:40 Advances in recovery preparedness and response following Fukushima

Co-chairs:	Jacques Lochard (ICRP C4 Chair, Nuclear Protection Evaluation Centre, France) Ryugo Hayano (The University of Tokyo, Japan)
09:00-09:10	Introduction
09:10-09:40	Ryugo Hayano (The University of Tokyo, Japan) *Engaging with local stakeholders: Some lessons from Fukushima for recovery*
09:40-10:10	Tsutomu Sato (Ministry of the Environment, Japan) *Progress on off-site cleanup efforts in Japan*
10:10-10:40	Michiaki Kai (ICRP C4, Oita University of Nursing and Health Sciences, Japan) *Experience and current issues with recovery management from the Fukushima accident*
10:40-11:10	**Break**
11:10-11:40	Anne Nisbet (ICRP C4, Public Health England, UK) *Decision making for late phase recovery from nuclear or radiological incidents: New guidance from NCRP*
11:40-12:10	Jean-Christophe Niel (Nuclear Safety Authority, France) *The French policy for managing long term contaminated territories in the event of a nuclear accident*
12:10-12:40	Panel Discussion

12:40-13:40 Lunch

13:40-17:20 NORM issues in the real world

Co-chairs:	Donald Cool (ICRP C4 Vice-chair, Nuclear Regulatory Commission, USA) Bakheet Salem Al-Ameri (Abu Dhabi National Oil Company, UAE)
13:40-13:50	Introduction
13:50-14:20	Donald Cool (ICRP C4 Vice-chair, Nuclear Regulatory Commission, USA) *Review of the ICRP system, in particular the approach to existing exposure situations*
14:20-14:50	Jean-François Lecomte (ICRP C4 Secretary, Institute for Radiological Protection and Nuclear Safety, France) *Application of the Commission's recommendations to naturally occurring radioactive materials*
14:50-15:20	John Loy (Federal Authority for Nuclear Regulation, UAE) *What should a radiation regulator do about NORM?*
15:20-15:50	**Break**
15:50-16:20	Doug Chambers (ICRP C2, SENES, Canada) *Radiological protection in North American NORM industries*
16:20-16:50	Hazem Abuahmad (Abu Dhabi National Oil Company, UAE) *Construction of a NORM project in the BeAAT Hazardous Waste Facilities*
16:50-17:20	Panel Discussion

Thursday October 24

09:00-12:40 What do we need from ICRP in medicine?

Co-chairs:	Eliseo Vaño (ICRP C3 Chair, Complutense University, Spain) Jamila Salem Al Suwaidi (Dubai Health Authority, UAE)
09:00-09:10	Introduction
09:10-09:35	John Harrison (ICRP C2 Chair, Public Health England, UK) and Pedro Ortiz (ICRP C3, Austria) *The use of effective dose in medicine*
09:35-10:00	Madan Rehani (ICRP C3 Secretary, Austria) *Patient dose management in CT and CBCT*
10:00-10:25	John Boice (ICRP Main Commission, National Council on Radiation Protection and Measurements, USA) *Paediatric CT and recent epidemiological studies*
10:25-10:55	**Break**
10:55-11:25	Jamila Salem Al Suwaidi (Dubai Health Authority, UAE) *Digital and interventional radiology: Patient dose registries and diagnostic reference levels*
11:25-11:50	Ahmed M. Alenezi (Prince Sultan Military Medical City, Saudi Arabia) *Trends in radiation protection of PET/CT imaging*
11:50-12:10	Maria Perez (World Health Organisation) *Referral criteria and clinical decision support: Radiological protection aspects for justification*
12:10-12:40	Panel Discussion

12:40-13:40 Lunch

13:40-17:20 The ICRP approach to environmental radiation protection: issues and application

Co-chairs:	Kathryn Higley (ICRP C5 Vice-chair, Oregon State University, USA) Jacques Repussard (Institute for Radiological Protection and Nuclear Safety, France)
13:40-13:50	Introductions
13:50-14:15	David Copplestone (Stirling University, UK) *The ICRP's approach to protection of the living environment under different exposure situations*
14:15-14:40	Jacqueline Garnier-Laplace (ICRP C5, Institute for Radiological Protection and Nuclear Safety, France) *Establishing relationships between environmental exposures to radionuclides and their consequences for wildlife: inferences and weight of evidence*
14:40-15:05	Kathryn Higley (ICRP C5 Vice-chair, Oregon State University, USA) *The creation and application of voxelized dosimetric models, and a comparison with the current methodology as used for the ICRP RAPs*
15:05-15:35	**Break**
15:35-16:00	Himansu Sekhar Das (Environment Agency of Abu Dhabi, UAE) *Marine biodiversity in Abu Dhabi, UAE*
16:00-16:25	Diego Telleria (International Atomic Energy Agency) *Use of the ICRP system for the protection of marine ecosystems*
16:25-16:50	Jordi Vives i Batlle (ICRP C5, Belgian Nuclear Research Centre, Belgium) *Modelling Exposures and Effects in the Marine Environment after the Fukushima Accidents*
16:50-17:20	Panel Discussion

17:20-17:40 Concluding remarks

Claire Cousins (ICRP Chair, Addenbrookes Hospital, UK)
Jacques Lochard (ICRP Vice-chair, Nuclear Protection Evaluation Centre, France)

OPENING SESSION

ICRP: PAST, PRESENT AND FUTURE

C. Cousins

ICRP Chair
Consultant Vascular and Interventional Radiologist, Addenbrooke's Hospital, Cambridge, UK

Abstract–The International Commission on Radiological Protection (ICRP) is a premier international organisation for the protection of workers, patients and the public against ionising radiation. It was established in 1928 as the International X-ray and Radium Protection Committee to advance for the public benefit the science of radiological protection, with its work in the early years focussing mainly on occupational exposure in medicine. The name International Commission on Radiological Protection was adopted in 1950 to reflect the wider and more diverse areas of work that were being undertaken. ICRP has published extensively over the years with thirteen sets of general recommendations since 1928. These recommendations form the basis of radiation safety standards worldwide. ICRP is a registered charity in the UK and, hence, is an independent non-governmental organisation consisting of the Main Commission and five Standing Committees. All members work unpaid and voluntarily for ICRP, giving a considerable amount of time and expertise, and serving for four year terms. A new term began on 1st July 2013 with, for the first time, open nominations and elections for membership. Nearly half of the membership was newly elected resulting in 84 official members sitting on the Commission and Committees. However, there are more than 200 members who work with ICRP through its Task Groups and Working Parties. ICRP has evolved considerably since its creation both in its structure and operation. Like any organisation, new challenges have to be faced and these pertain to the institution itself and the nature of the work that has to be addressed. ICRP has developed a Strategic Plan for 2011-2017 and has already made progress with some of its initiatives. There are now many organisations working in the area of radiological protection and it is important for ICRP to establish close relevant liaisons to work effectively. This means ICRP has to be a modern interactive body that responds to the needs and concerns of the radiological protection community, as well as identifying areas of work that require scrutiny of science and practice to produce relevant recommendations. ICRP continues to have a leading role in the field of radiological protection and the work of the new Commission and Committees will ensure this position is maintained and further strengthened in the coming years.

OVERVIEW OF ICRP COMMITTEE 1 RADIATION EFFECTS

W.F. Morgan

ICRP Main Commission and Committee 1 Chair
Pacific Northwest National Laboratory, Richland, WA, USA

Abstract–The ICRP mission is to advance, for the public benefit, the science of radiological protection, specifically by providing recommendations and guidance on all aspects of protection against ionizing radiation. ICRP Committee 1 (C1) contributes to this mission by considering the risk of induction of cancer and heritable disease (stochastic effects) together with the underlying mechanisms of radiation action. In addition, C1 also considers the risks, severity, and mechanisms of induction of tissue/organ damage and developmental defects (deterministic effects). C1 recently completed ICRP Report 118: "ICRP Statement on Tissue Reactions / Early and Late Effects of Radiation in Normal Tissues and Organs – Threshold Doses for Tissue Reactions in a Radiation Protection Context" and this will be the focus of the C1 session at the ICRP Symposium. In addition C1 also completed ICRP Report 115 "Lung Cancer Risk from Radon and Progeny and Statement on Radon". Task Group (TG) 64 plans to extend this study to include other alpha emitters. TG 75 is in the process of finalizing the "Stem Cell Radiobiology" report and the overview will include a discussion on the progress and current status of this report. Two new TG's have been initiated. TG 91 will address "Radiation Risk Inference at Low-Dose and Low-dose Rate Exposure for Radiological Protection Purposes"; and C1 will oversee TG 92 to review the "Terms and Definitions" used by ICRP in the past, evaluate them for accuracy, and where there are inconsistencies resolve them. TG 92 involves representatives of all five ICRP committees and will have its first face-to-face meeting in Abu Dhabi. The overall goal of this presentation will be to update the membership, current activities, and future programs of ICRP C1.

OVERVIEW OF ICRP COMMITTEE 2 DOSES FROM RADIATION EXPOSURE

J. Harrison

ICRP Main Commission and Committee 2 Chair
Public Health England, UK

Abstract–Over many years, ICRP Committee 2 has provided sets of dose coefficients to allow users to evaluate equivalent and effective doses for intakes of radionuclides or exposure to external radiation for comparison with dose limits, constraints and reference levels as recommended by ICRP. Following from the 2007 Recommendations, Committee 2 and its Task Groups are engaged in a substantial programme of work to provide new dose coefficients for various conditions of radiation exposure. The methodology being applied in the calculation of doses can be regarded as state-of-the-art, in terms of the biokinetic models used to describe the behaviour of inhaled and ingested radionuclides and the dosimetric models used to model radiation transport for external and internal exposures. The level of sophistication of these models is greater than required for the calculation of the protection quantities with their inherent simplifications and approximations, introduced necessarily for example by the use of radiation and tissue weighting factors. However, ICRP is at the forefront of developments in this area and its models are used for scientific as well as protection purposes. This overview will provide an outline of recent work and future plans, including publications on dose coefficients for adults, children and *in utero* exposures, with new dosimetric phantoms in each case. The committee has also recently finished a report on radiation exposures of astronauts in space and is working with members of the other committees on the development of advice on the use of effective dose.

OVERVIEW OF ICRP COMMITTEE 3 PROTECTION IN MEDICINE

E. Vaño[a], D. L. Miller[b], M. Rehani[c]

[a] *ICRP Main Commission and Committee 3 Chair*
[b] *ICRP Committee 3 Vice-chair*
[c] *ICRP Committee 3 Secretary*

Abstract–Committee 3 of ICRP is concerned with protection of persons and unborn children when ionising radiation is used for medical diagnosis, therapy, or biomedical research. According to the 2011-2017 Strategic Plan, Committee 3 develops recommendations and guidance for protection of patients, staff, and the public against radiation exposure in medicine. This paper presents an overview of the work of the Committee in recent years and current work in progress. The ICRP reports dealing with radiological protection (RP) in medicine in the last 10 years cover topics on: education and training in RP; preventing accidental exposures in radiation therapy; doses to patients from radiopharmaceuticals; radiation safety aspects of brachytherapy; release of patients after therapy with unsealed radionuclides; and managing radiation dose in interventional radiology, digital radiology, computed tomography, paediatrics, cardiology and other medical specialties. Work in progress deals with RP in Ion Beam Therapy, Occupational Protection in Brachytherapy, Justification in Imaging, RP in Cone Beam CT, Doses to Patients and Staff from Radiopharmaceuticals (update), Occupational Protection in Interventional Radiology, and Diagnostic Reference Levels for Diagnostic and Interventional Imaging. The Committee is also involved in preparation of a document on effective dose (and its use medicine).

OVERVIEW OF ICRP COMMITTEE 4 APPLICATION OF THE COMMISSION'S RECOMMENDATIONS

J. Lochard

ICRP Vice-chair and Committee 4 Chair
Director of the Centre d'étude sur l'Evaluation de la Protection dans le domaine Nucléaire-CEPN, France

Abstract–ICRP Committee 4 has the responsibility to develop principles, recommendations and guidance on the protection of man and the environment against radiation exposure in all exposure situations. The Committee also acts as major point of contact between the ICRP structure and other international organisations and professional bodies concerned with protection against ionizing radiation. Currently the committee completes a series of Task Groups on the application of the Commission's Recommendations to existing exposure situations: naturally occurring radioactive material, radon in dwellings and at workplaces, and the protection of aircraft crew against cosmic radiation exposure. The programme of work for the forthcoming 2013-2017 period includes the update of Publications 109 on protection of people in emergency exposure situations and Publication 111 on protection of people living in long term contaminated areas after a nuclear accident, to take into account the lessons from Fukushima and recent international developments in the domain. It also includes the preparation of future Publications on radiological protection in surface and near surface disposal of radioactive waste to complement Publication 122 on geological disposal just published, and in contaminated sites from past activities. Finally an important task will be to develop a Publication on the Ethics of radiological protection.

OVERVIEW OF ICRP COMMITTEE 5 PROTECTION OF THE ENVIRONMENT

C-M. Larsson

ICRP Main Commission and Committee 5 Chair
Australian Radiation Protection and Nuclear Safety Agency, Miranda, Australia

Abstract–ICRP established Committee 5 in 2005 in response to the need to provide direct demonstration of environmental protection from radiation in accordance with national law and international agreements. The development of the ICRP system for environmental protection was facilitated by research over the previous decades, as well as by ICRP's evaluation of the ethical and philosophical basis for environmental protection as laid out in Publication 91. The 2007 Recommendations (Publication 103) incorporated environmental protection as one of the integral elements of the radiation protection system. Over a relatively short time, the system has evolved to incorporate a set of 12 *reference animals and plants*, or RAPs, which is a small enough number to develop comprehensive databases for each RAP, but wide-ranging enough to provide some insight into radiation impact, and protection against such impact as appropriate, in terrestrial, freshwater and marine ecosystems. As necessary, the databases can be used to derive supplementary databases for *reference organisms* typical for a particular exposure situation of concern or under study. The system so far details biology of the RAPs (Publication 108), outlines transfer factors for estimation of internal concentrations of radionuclides of environmental significance under different situations (Publication 114), provides further information (in Publication 108) on dosimetry, biological effects and *derived consideration reference levels*, or DCRLs (bands of environmental dose rates where potential detrimental effects may deserve attention), and provides information on application of the system in planned, emergency and existing exposure situations (Publication 124). Currently, a review of experimental determinations of RBE, to guide derivation of specific weighting factors for use in environmental radiation protection if possible and necessary, is being concluded, as is work on improved dosimetry. Further work in this area involves consolidation of databases, recommendations for derivation of specific databases for reference organisms on the basis of the RAPs data, and recommendations for application of the system to environmental protection in relation to certain human activities of potential environmental concern. Consideration needs to be made for the wider range of ecosystem effects that may be covered in ecological risk assessments, which incorporate the complete suite of stressors that result from human activity, and their effects, to understand the role of radiation effects in this context.

THE BIOLOGY OF TISSUE REACTIONS

W. Dörr

ICRP Committee 1
Dept. of Radiation Oncology & Christian Doppler Laboratory for Medical Radiation Research for Radiooncology, Medical University of Vienna, Austria

Abstract–Effects of radiation exposure are observed in virtually all normal tissues, with interactions if several organs are involved. Early reactions occur in turnover tissues, where proliferative impairment results in hypoplasia; late reactions, based on combined parenchymal, vascular and connective tissue changes, result in loss of function within the exposed volume; consequential late effects develop through interactions between early and late effects in the same organ; very late effects are dominated by vascular sequelae. Invariably, involvement of the immune system is observed. Importantly, latent times are inversely dependent on the biologically equivalent dose. Each tissue component, and - importantly - each individual symptom, displays a specific dose-effect relationship. Isoeffective doses are modulated by exposure conditions: dose-rate reduction - down to chronic levels - and dose fractionation particularly impact on late responding tissues, while overall exposure time affects predominantly early (and consequential late) reactions. Consequences of partial organ exposure are related to tissue architecture: In “tubular” organs (gastrointestinal tract, but also vasculature), punctual exposure affects function in downstream compartments. In “parallel” organs, like liver or lungs, only exposure of a significant (organ-dependent) fraction of the total volume results in clinical consequences. Forthcoming studies must address biomarkers of the individual risk for tissue reactions and strategies to prevent/mitigate tissue effects after exposure.

THRESHOLD DOSES AND CIRCULATORY DISEASE RISKS

J. Hendry

Christie Hospital, Manchester, UK

Abstract–Tissue reactions (deterministic effects) become manifest either early or late after doses above a threshold dose, which is the basis to recommended dose limits for avoiding such effects. Threshold doses have been defined for comparative purposes at 1% incidence of an effect, although the choice of incidence level may be scenario-dependent in practice. Latency time before manifestation is related to cell turnover rates and tissue complexity. In general, threshold doses become lower for longer follow-up times because of the slow progression of injury before manifestation, in particular after lower doses. Radiosensitive individuals may contribute to low threshold doses, which would provide a safety margin for the majority of a population. A threshold dose of 0.5 Gy has been suggested by ICRP report 118 for radiation-induced circulatory disease, after acute or chronic exposures. There is a long latency and a smaller threshold dose when follow-up times are increased from 20 to 58 years as exemplified by the atomic-bomb survivors. Epidemiological studies of those individuals and workers suggest that if a linear dose-incidence is assumed, the risk of some types of circulatory disease per Gy or Sv is about the same as for induced cancer. Animal studies show that doses >2 Gy induce the expression of inflammatory and thrombotic molecules in endothelial cells. This causes progressive loss of capillaries in the heart and leads to reduced perfusion, myocardial cell death and fibrosis. However, doses <1 Gy inhibit both inflammatory cell adhesion to endothelial cells and the development of atherosclerosis in mice. Different mechanisms of injury at low and high doses preclude the simple extrapolation of risk on a linear-quadratic basis from acute to chronic exposures.

GENERAL TISSUE REACTIONS AND IMPLICATIONS FOR RADIATION PROTECTION

S. Miyazaki

Atomic Energy Research Institute, Kinki University, Osaka, Japan

Abstract–Non-cancer effects and risks at low doses from ionizing radiation are controversial topics within the field of radiation protection. These issues are discussed in ICRP Publication 118, "ICRP Statement on Tissue Reactions." Both non-cancer effects and risks are expected to become increasingly important to the system of radiation protection. Before this can happen, several factors must be considered: thorough characterization of the relationship between dose and risk; verification of the biological mechanisms for any noted excess risk; and adjustment of noted excess risks through the use of a detriment factor. It is difficult to differentiate the relatively small risks associated with radiation from other risk factors in the low-dose region of the dose response curve. Several recent papers also indicate the possibility of a non-linear dose response relationship for non-cancer effects. In addition, there are still many uncertainties associated with the biological mechanisms for non-cancer effects. Finally, it is essential to consider the incorporation of detriment into a well-defined system of radiological protection. Given the recent interest in non-cancer effects, it is essential to facilitate discussions in order to more clearly define dose limits within the existing system of radiation protection for both cancer and non-cancer effects.

THE LENS OF THE EYE, EXPOSURES IN THE UK MEDICAL SECTOR AND MECHANISTIC STUDIES OF RADIATION EFFECTS

S. Bouffler[ab], E. Ainsbury[b], S. Peters[b], P. Gilvin[b], K. Slack[b], E. Markiewicz[c], R. Quinlan[c]

[a] *ICRP Committee 1*

[b] *Centre for Radiation, Chemical and Environmental Hazards (CRCE), Public Health England, UK*

[c] *Biophysical Sciences Institute, Durham University, UK*

Abstract–Recent reviews of cateract and lens opacities in radiation-exposed populations indicate risk at doses below the previous threshold value of 2 Gy. Consequently ICRP now recognise a threshold of 0.5 Gy and recommend a dose limit of 20 mSv year^{-1} (5 year average, no single year exceeding 50 mSv). A small targeted survey of eye lens doses in medical staff undertaking cardiology / radiology procedures in 3 major UK hospitals was undertaken for 4 weeks in January 2013. Information on job role, number of procedures and use of personal protective equipment was obtained; PHE Personal Dosimetry Services lens dosimeters on a headband were used to assess lens doses. 13 of 61 staff received recorded doses > 0.15 mSv, the minimal detectable dose, and in two cases projected annual doses could be close to 20 mSv. PPE use was good but lead glasses were rarely worn. To characterise better the dose-response (20-2000 mGy x-ray) for lens opacities, a study of early and late changes in the mouse lens eye is being undertaken. Such studies should help to determine the mechanisms that contribute to radiation cateractogenesis and to identify thresholds and/or discontinuities in dose-response.

DOSIMETRIC MODELS OF THE EYE AND EYE LENS AND THEIR USE IN ASSESSING DOSE COEFFICIENTS FOR OCULAR EXPOSURES

W.E. Bolch

ICRP Committee 2 Secretary
Advanced Laboratory for Radiation Dosimetry Studies, J. Crayton Pruitt Family Department of Biomedical Engineering, University of Florida, USA

Abstract–Based upon recent epidemiological studies of ocular exposure, the Main Commission in its Publication 118 states that the threshold dose for radiation-induced cataracts is now considered to be approximately 0.5 Gy for both acute and fractionated exposures. Consequently, a reduction was also recommended for the occupational annual equivalent dose to the eye lens from 150 mSv to 20 mSv, averaged over defined periods of 5 years. To support ocular dose assessment and optimization, Committee 2 included Annex F within ICRP Publication 116 – *Conversion Coefficients for Radiological Protection Quantities for External Radiation Exposure*. Annex F provides dose coefficients – absorbed dose per particle fluence – for photon, electron, and neutron irradiation of the eye and eye lens using two dosimetric models. The first are the reference adult male and female voxel phantoms of ICRP Publication 110. The second is the stylized eye model of Behrens et al. [PMB 54 4069-4087 (2009)] which itself is based on ocular dimensional data given in Charles and Brown [PMB 20 202-218 (1975)]. In this presentation, we will review the data and models of Annex F with particular emphasis on how these models treat tissue regions thought to be associated with stem cells at risk.

DOSE LIMITS TO THE LENS OF THE EYES: NEW LIMIT FOR THE LENS OF THE EYE - INTERNATIONAL BASIC SAFETY STANDARDS AND RELATED GUIDANCE

M. Pinak, T. Boal

International Atomic Energy Agency

Abstract–The IAEA, recognizing the new approach of the ICRP on the protection of the lens of the eyes as it is expressed in its Publication 118 (ICRP Statement on Tissue Reactions / Early and Late Effects of Radiation in Normal Tissues and Organs – Threshold Doses for Tissue Reactions in a Radiation Protection Context) from 2011, included recommended dose limits in the revised BSS [Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards INTERIM EDITION, General Safety Requirements Part 3- (GSR Part 3)]. The paper to be presented, reports on the development of related guidance aiming to assist its Member States in the implementation of this new dose limit for the lens of the eye. The ICRP Statement reports on results of a review of the recent epidemiological evidence which suggests that there are some deterministic effects of radiation exposure, particularly those with very late manifestation, where threshold doses are, or might be, lower than previously considered. For the lens of the eye, the threshold of absorbed dose is now considered to be 0.5 Gy and on that basis ICRP has revised downwards its recommended dose limit for the lens of the eye. The presented paper also introduces the intended mechanism for providing international guidance on how to utilize the newly recommended limit in practice, particularly in industrial radiography and interventional radiology, where occupational doses received to the lens of the eyes would require most attention, after the limit is introduced into the regulatory framework of individual states.

IMPLICATIONS IN MEDICAL IMAGING OF THE NEW ICRP THRESHOLDS FOR TISSUE REACTIONS

E. Vaño[a,b], D.L. Miller[a,c], L. Dauer[a,d]

[a] *ICRP Committee 3*
[b] *Radiology Department, Medicine School and San Carlos Hospital, Complutense University, Madrid, Spain*
[c] *Center for Devices and Radiological Health, Food and Drug Administration, MD, USA*
[d] *Department of Medical Physics, Department of Radiology, Memorial Sloan-Kettering Cancer Center, NY, USA*

Abstract–The ICRP Statement on Tissue Reactions issued by the Commission in April 2013 reviewed epidemiological evidence and suggested that there are some tissue reactions where threshold doses are or might be lower than those previously considered. For the lens of the eye, the threshold is now considered to be 0.5 Gy. The absorbed dose threshold for circulatory disease in the heart and brain may be as low as 0.5 Gy. These values could be reached in some patients during interventional cardiology or neuroradiology procedures. The new thresholds should be considered during the justification process and in optimization strategies for clinical procedures, especially in patients likely to require repeated interventions. The new dose thresholds also influence occupational protection for operators and staff. Some operators do not protect their eyes or their brain adequately. After several years of work without proper protection, the absorbed doses to the lens and to the brains of staff could exceed 0.5 Gy. These new thresholds, and the need for specific occupational dosimetry related to lens doses, must be considered in radiation protection programs and should be included in the education and training of professionals involved in fluoroscopy-guided procedures.

IMPLICATIONS FOR RADIOTHERAPY OF THE NEW ICRP THRESHOLDS FOR TISSUE REACTIONS

L. Dauer [a,b], E. Vaño[a,c], D.L. Miller[a,d]

[a] *ICRP Committee 3*

[b] *Department of Medical Physics, Department of Radiology, Memorial Sloan-Kettering Cancer Center, NY, USA*

[c] *Radiology Department, Medicine School and San Carlos Hospital, Complutense University, Madrid, Spain*

[d] *Center for Devices and Radiological Health, Food and Drug Administration, MD, USA*

Abstract–ICRP Publication 118, Part 1 *Statement on Tissue Reactions*, and Part 2 *Early and Late Effects of Radiation in Normal Tissues and Organs – Threshold Doses for Tissue Reactions in a Radiation Protection Context*, reviews epidemiological evidence and provides updated estimates of 'practical' threshold doses for tissue injury, defined at the level of 1% incidence. Particular attention is paid to circulatory disease and cataracts. Current evidence indicates that the absorbed dose threshold for these outcomes may be as low as 0.5 Gy. Threshold doses for tissue reactions can be reached in some patients during radiotherapy procedures. Tissue reactions are typically managed through a "tolerance dose" concept. The new thresholds should be considered during the justification process and in optimization strategies for clinical procedures, especially during treatment planning. These new dose thresholds also influence occupational protection for operators and staff. They must be considered in radiation protection programs and should be included in the education and training of professionals involved in radiotherapy. This is especially true for brachytherapy and for procedures requiring fluoroscopy guidance.

NON-CANCER EFFECTS: SCIENCE AND VALUES ASPECTS OF PROTECTION DECISIONS

T. Lazo

OECD Nuclear Energy Agency

Abstract–The NEA organized its third workshop on Science and Values in Radiological Protection in November 2012, in Tokyo. One of the issues addressed, non-cancer effects, had also been addressed in the first two Science and Values workshops (Helsinki, Finland, 2008; Vaux-de-Cernay, France, 2009), but presented several new elements of relevance to ICRP discussions of the evolution of the system of radiological protection. Radiological protection science, both epidemiological and biological, now suggests that stroke and heart disease may well be caused by radiation exposure at doses of the order of 0.5 Gy or less. Further, it is possible that such detriments may be caused by either chronic or acute exposures. While significant uncertainties remain, the need to consider non-cancer detriment in risk assessment and in the development of protection strategies is now a significant scientific and ethical question. This paper will present the results of the NEA Science and Values workshop discussion of non-cancer risks, and of the questions and possible future directions raised during the workshop.

IMPLICATIONS OF THE IMPLEMENTATION OF THE REVISED DOSE LIMIT TO THE LENS OF THE EYE: THE VIEW OF THE IRPA PROFESSIONALS

M-C. Cantone

University of Milan, Italy (on behalf of the IRPA Task Group)

Abstract–IRPA established a Task Group (TG) to provide an assessment of the impact of the implementation of the ICRP revised dose limit for the lens of the eye for occupational exposure, since there is, at this time, significant interest and some concern of radiation protection professionals at both national and international level. Associated Societies (ASs) of IRPA were asked to provide views and comments on the basis of a questionnaire, as a tool to structure the answers, by addressing, within the different areas of practice, three principal topics: i) Implications for Dosimetry; ii) Implications for Methods of Protection; iii) Wider Implications of Implementing the Revised Limits. The responses received to the questionnaire indicate various methods of approach and express different points of view, reflecting the nuances of the particular ASs or specific professional groups. Topical experts volunteering and nominated by ASs were selected to assist with the collation of the responses and a report was produced by the TG. Specific conclusions have been drawn on the three topical issues, which include the potential cost implications. A number of recommendations were drawn from the received responses, considered as the voice of radiation protection professionals, including: the request for more understanding about the relationship between radiation exposure of the lens of eye and cataract formation and for further guidance to assist implementation; the importance of economic and social considerations when introducing the limits into the regulations of each country; the need to propose or more clearly-define procedures related to the employment of people with existing or pre-cataract conditions and also the practical aspects related to dosimetry and protective equipment.

ENGAGING WITH LOCAL STAKEHOLDERS: SOME LESSONS FROM FUKUSHIMA FOR RECOVERY

R.S. Hayano

Department of Physics, The University of Tokyo, Japan

Abstract–The Fukushima Dai-ichi NPP accident contaminated the soil of densely-populated regions in Fukushima Prefecture with radioactive cesium, which poses significant risks of internal and external exposure to the residents. If we apply the knowledge of post-Chernobyl accident studies, internal exposures in excess of a few mSv/y would be expected to be frequent in Fukushima. Our extensive whole-body-counter surveys however showed that the internal exposure levels of residents are much lower than estimated (Hayano RS, Tsubokura M, Miyazaki M, Satou H, Sato K, Masaki S, Sakuma Y., Proc Jpn Acad Ser B 2013;89:157-63.); in 2012-2013, the ^{137}Cs detection percentages (the detection limit being ~300 Bq/body) are about 1% for adults, and practically 0% for children. These results are consistent with those of many other measurements/studies conducted so far in Fukushima, e.g., rice inspection, foodstuff screening and duplicate-portion studies. As such, the risk of external exposure is in general higher for the majority of residents in Fukushima. We have therefore started to deploy a new type of personal dosimeters, which can record integrated dose every hour with timestamps, in order to evaluate the risks of residents who wish to return to the 20-km evacuation zone. In these efforts, the most crucial and time consuming is to re-establish communication at all levels; between residents and local medical staff, between experts and local staff, between the central government and municipalities, and so on.

PROGRESS ON OFF-SITE CLEANUP EFFORTS IN JAPAN

T. Sato

Ministry of the Environment, Japan

Abstract–Japanese government established the Act on Special Measures Concerning the Handling of Radioactive Pollution in August, 2011 in order to remediate the radioactive pollution caused by the accident at the TEPCO's Fukushima Dai-ichi Nuclear Power Station (NPS). This Act came fully into force on January, 2012. Based on this Act, Ministry of the Environment (MOE) have carried out decontamination work as well as contaminated-waste management. The contamination areas in which decontamination work is implemented are designated into two categories under the Act. One is the 'Special Decontamination Area', in which the location is within 20km from NPS or annual cumulative air dose is more than 20mSv, where decontamination is implemented by the national government. Another is the 'Intensive Contamination Survey Area', in which over 0.23µSv/hour of air dose rate is monitored (equivalent to over 1mSv/year), where decontamination is implemented by each municipality with financial and technical supports by the national government. Japanese government utilized the ICRP standards as reference to establish the remediation policy. For example, under the current policy for the Special Decontamination Area, three kinds of targets have been established. The area less than 20mSv/year: to reduce additional exposure dose less than 1mSv/year as a long-term goal, the area between 20-50mSv/year: to reduce additional exposure dose less than 20mSv/year, the area more than 50mSv/year: demonstration projects of decontamination will be implemented in order to obtain lessons learned for considering future decontamination policy. In regard with the storage for removal soils, etc., MOE announced the Basic Principles for Interim Storage Facility in October, 2011 and is making efforts to establish it, while securing temporary storage sites at each municipality.

EXPERIENCE AND CURRENT ISSUES WITH RECOVERY MANAGEMENT FROM THE FUKUSHIMA ACCIDENT

M. Kai

ICRP Committee 4
Oita University of Nursing and Health Sciences, Oita, Japan

Abstract–The Fukushima accident has brought about a large impact not only on the local affected area but also on a broad national area in Japan. It is essentially socio-economic consequences with inevitable changes of daily live as well as psychological effects. Although the latest international reports say it would be not possible to detect an excess of cancer deaths from the radiation exposure, the concern about the risk at low doses is very much present and amplified among the population. It is expected that the radiation doses in contaminated areas will vary considerably over time depending on the various protective actions implemented in the recovery phase of the post-accident situation. After the accident, the nuclear disaster headquarter of Japanese Government adopted the criteria of 0.23μSv/hr ambient dose rate with the objective to reduce exposure in the range of 1 mSv/y. The evacuated areas have been zoned according to the annual dose based on 20 mSv/y or more. However, these decisions have significantly impacted the daily lives of residents in the affected areas and led to the breakup of many communities. Experience has shown that the direct involvement of the affected population and local professionals was a decisive factor for the management of the recovery phase.

DECISION MAKING FOR LATE-PHASE RECOVERY FROM NUCLEAR OR RADIOLOGICAL INCIDENTS: NEW GUIDANCE FROM NCRP

A.F. Nisbet[a], S.Y. Chen[b]

[a] *ICRP Committee 4*
Public Health England, Chilton, Didcot, UK
[b]*Chair, NCRP Scientific Committee SC5-1*
Illinois Institute of Technology, Chicago, USA

Abstract–In 2010 the U.S. National Council on Radiation Protection and Measurement (NCRP) established a scientific committee (SC5-1) to prepare a comprehensive report that defines the framework and approach for optimising decision making in late-phase recovery from nuclear or radiological incidents that lead to wide-area contamination. The NCRP report builds on recommendations from ICRP Publication 111 (2009) which specifically addresses the protection of people living in long-term contaminated areas. Based on the approach, the report addresses all relevant dimensions: health, environment, economic, psychological, cultural, ethical and political. NCRP, like ICRP, considers optimisation to be the best approach to decision making for balancing these multiple risk factors in situations involving wide-area contamination where the conventional clean-up approach may encounter some serious constraints. The report describes optimisation as an iterative process that can be broken down into a series of steps, all of which involve deliberations with stakeholders as a necessary element for a community-focused recovery effort. The steps, which are elaborated on in the report, range from defining the situation, to a series of actions involving assessing impacts, evaluating options, developing a strategy, and demonstrating its successful implementation. In conclusion, the report makes a series of recommendations aimed at enhancing and strengthening late phase recovery following a major nuclear or radiological incident.

THE FRENCH POLICY FOR MANAGING LONG TERM CONTAMINATED TERRITORIES IN THE EVENT OF A NUCLEAR ACCIDENT

J-C. Niel

Director general, Autorité de Sûreté Nucléaire (ASN), France

Abstract–In 2005, at the request of the Government, ASN established a Steering committee for managing the post-accident phase of a nuclear accident or radiological emergency situation (CODIRPA) for "establishing the framework, for defining, preparing and implementing the steps necessary to deal with the post-accident situation". Under the supervision of ASN, CODIRPA set up a number of policy elements from 2005 to 2012, involving several experts from different backgrounds (relevant Ministerial offices, local information commissions, associations, elected officials, health agencies, expertise agencies, licensees, international experts, etc.). The first policy elements for post-accident management in the event of nuclear accident have been published in November 2012. These elements were drafted in regard to cover the immediate post-emergency situations, transitional and long-term periods with nuclear accidents of medium scale causing short-term radioactive release (under 24 hours) that might occur at French nuclear facilities equipped with a special intervention plan. They also apply to actions to be carried out in the event of accidents during the transport of radioactive materials. This publication is a first important step forward in the preparedness of management of the Post-Accident Phase in the event of a nuclear accident which has to be pursued and intensified in order to be applied by the stakeholders, in particular at the local level.

REVIEW OF THE ICRP SYSTEM, IN PARTICULAR THE APPROACH TO EXISTING EXPOSURE SITUATIONS

D.A. Cool

ICRP Committee 4 Vice-chair
U.S. Nuclear Regulatory Commission, Washington, D.C., USA

Abstract–The ICRP System of Protection consists of Planned, Emergency, and Existing Exposure Situations. With the Recommendations in ICRP Publication 103, a coherent approach has been established that emphasizes the optimization of protection with appropriate constraints or reference levels in each exposure situation. Existing Exposure Situations pose unique challenges because the source of exposure already exists and it may not always be possible to directly control the source. This is the case for natural occurring sources, which are ubiquitous in the environment, and vary widely in the magnitude of exposures that may be received by individuals. Decisions on protection strategies must consider a graded, pragmatic, and flexible approach for dealing with exposure of members of the public, and those that may be occupationally exposed while working with naturally occurring sources. Although limits are not applicable, aspects of the management approach for Planned Exposure Situations may be appropriate, depending upon the magnitude of exposures.

APPLICATION OF THE COMMISSION'S RECOMMENDATIONS TO NATURALLY OCCURRING RADIOACTIVE MATERIALS

J-F. Lecomte

ICRP Committee 4 Secretary
Institute for Radiological Protection and Nuclear Safety, France

Abstract–After the publication of its general recommendations in 2007 (Publication 103), the Commission is preparing a series of publications dedicated to different types of existing exposure situations such as radon exposure, cosmic exposure in aviation and NORM exposure. The publication related to NORM will present the main types of corresponding activities and describe the characteristics of NORM exposure. It will also develop a conceptual framework for the practical application of the Commission's system to NORM exposure. In particular, the publication will explain why NORM activities are a priori existing exposure situations and when some of them should be managed as planned exposure situations. It will indicate when the workers should be considered as occupationally exposed. It will also provide recommendations on the application of the three principles of radiological protection. The need to carefully consider the justification of the reuse or recycling of residues will be pointed out. Guidance will be provided for the selection of the reference level and for the implementation of the optimisation process through a graded approach including both prevention and mitigation of exposures. Flexibility will be recommended for the application of dose limits, notably when the situation is managed as a planned exposure situation.

WHAT SHOULD A RADIATION REGULATOR DO ABOUT NORM?

J. Loy

Federal Authority for Nuclear Regulation, Abu Dhabi, UAE

Abstract–The standard regulatory framework of authorisation, review and assessment, inspection and enforcement and regulation-making is principally directed towards ensuring the regulatory control of planned exposure situations. Some mining and industrial activities involving exposures to NORM, such as uranium mining or the treatment and conditioning of NORM residues, may readily fit within this standard framework. In other cases, such as oil and gas exploration and production, the standard regulatory framework needs to be adjusted. For example, it is not sensible to require that an oil company seek a licence from the radiation regulator before drilling a well. The paper discusses other approaches that a regulator might take to assure protection and safety in such activities involving exposures to NORM, including the use of conditional exemptions from regulatory controls. It also suggests some areas where further guidance from ICRP on application of the system of radiological protection to NORM would assist both regulators and operators.

RADIOLOGICAL PROTECTION IN NORTH AMERICAN NORM INDUSTRIES

D.B. Chambers

ICRP Committee 2
Director of Risk and Radioactivity, SENES Consultants (an ARCADIS Company), Ontario, Canada

Abstract–All soils and rock contain naturally occurring radioactive materials (NORM). Many ores and raw materials contain relatively elevated levels of natural radionuclides. Examples of such NORM materials include uranium ores, monazite (a source of rare earth minerals), and phosphate rock used to produce phosphate fertilizer. Wastes containing elevated levels of NORM can also be generated, as has been seen in the oil and gas industries. Such activities can result in above background radiation exposures to workers and the public. The objective of this paper is to review the sources and exposure from NORM in North American industries and to provide perspective on the potential radiological hazards to workers and the environment. Proper consideration of NORM issues is important and needs to be integrated in the assessment of these projects. Concerns over radioactivity and radiation amongst NGOs and the local public have resulted in the cancellation of NORM projects. The paper describes the current regulatory framework for NORM in Canada and the role of the US Environmental Protection Agency. In addition, potential implications of the recent activities of the International Atomic Energy Agency (IAEA) and the International Commission on Radiological Protection (ICRP) on NORM industries will be discussed.

CONSTRUCTION OF A NORM PROJECT IN THE BEAAT HAZARDOUS WASTE FACILITIES

P.E. Hazem Abuahmad

Abu Dhabi National Oil Company (ADNOC), HSE Division, Abu Dhabi, UAE

Abstract–During exploration and production operations of ADNOC's subsidiaries in United Arab Emirates, Naturally Occurring Radioactive Material (NORM) is produced and accumulated into drilling tubulars, plant equipment and components. These NORM hazardous wastes shall be managed in such a way that they do not damage human health and environment. The primary radionuclides of concern in oil and gas industry, are typically Radium-226 and Radium-228. These radioisotopes are the decay products of uranium and thorium isotopes that are present in subsurface formations from which hydrocarbons are produced. While uranium and thorium are largely immobile, radium is slightly more soluble and may become mobilized in the fluid phases of the formation. In order to safely treat and dispose of NORM waste products, ADNOC's subsidiary "TAKREER" is developing a new Facility within the existing Central Environmental Protection Facilities (BeAAT) in Ruwais city. The NORM Plant is envisaged to treat, handle and dispose of ADNOC's subsidiaries NORM waste in the forms of scale, sludge, and contaminated equipment. The NORM treatment facility will cover activities such as decontamination, volume reduction, NORM handling and concrete immobilization of NORM waste into packages for designated landfilling.

THE USE OF EFFECTIVE DOSE IN MEDICINE

J. Harrison[a] , P.O. López[b]

[a] *ICRP Main Commission and Committee 2 Chair*
Public Health England, UK
[b] *ICRP Committee 3*

Abstract–The quantity 'effective dose' was developed by ICRP for the radiological protection of workers and the public. In this context, it is used as a risk-adjusted dosimetric quantity to optimize protection by comparing doses, received or planned, with constraints, reference levels and limits expressed in the same quantity. Effective dose was not intended for estimating health detriment in populations or to individuals. ICRP recommends that risk assessment for medical diagnosis and treatment is best evaluated using appropriate risk values for the individual tissues at risk and for the age and sex distribution of the individuals. ICRP also suggests that effective dose can be of practical value for comparing relative doses related to stochastic effects from different diagnostic examinations and interventional procedures; the use of similar technologies and procedures and the use of different technologies for the same medical examination; provided that the representative patients or patient populations for which the effective doses are derived are of similar age and sex distribution. The applicability of effective dose to patient exposure was explored in a quantitative study by Balanov and Shrimpton, with the outcome that that effective dose can provide a measure of risks associated with medical exposures, but adjustments to the nominal risk per unit effective dose are needed to account for age and sex differences. An ICRP Task Group is working on a document to help with the correct application of effective dose to patient diagnostic exposures.

PATIENT DOSE MANAGEMENT IN CT AND CBCT

M. Rehani

ICRP Committee 3 Secretary
European Society of Radiology and IAEA, Vienna, Austria

Abstract–The ICRP through its publication 87 and 102 has provided recommendations and guidance for patient dose management in CT and currently a Task Group is working on cone beam CT (CBCT). With increasing number of CT examinations that many patients undergo and increasing information available from a CT examination, dose to an individual patient is a matter of concern despite technological advances. Implementation of ICRP framework of justification to an individual patient (level 3) requires newer approaches besides increasing awareness. Realising the need to target medical professionals, ICRP publications 87 and 102 have been primarily targeted at medical professionals and professional bodies with further focus on national and international bodies and industry. They have provided guidance on applying ICRP's principles of justification and optimization in different clinical applications of CT. While collective dose from CT is also an issue, the emphasis has been directed to individual patient dose and protection. Patient dose management in newer applications of CBCT is being covered by the current TG. Apparently ICRP's actions have contributed to raising concern well in time; motivated professionals, organizations and industry to take steps that lead to enhanced level of patient dose management.

PAEDIATRIC CT AND RECENT EPIDEMIOLOGICAL STUDIES

J.D. Boice, Jr.

ICRP Main Commission
Division of Epidemiology, Department of Medicine and Vanderbilt-Ingram Cancer Center, Vanderbilt University School of Medicine, Vanderbilt University, Nashville, Tennessee, USA
National Council on Radiation Protection and Measurements, Bethesda, Maryland, USA

Abstract–Recent investigations on the association between CT procedures among children and adolescents under age 20 and possible increased risk of cancer have been reported that heighten the awareness of these relatively high-dose diagnostic CT procedures and the need for reducing unnecessary examinations and lowering the dose per exam for appropriate clinical benefit (Pearce Lancet 2012; Mathews BMJ 2013). Uncertainties in the epidemiologic methods, however, add caution to concluding that the associations are causal. The reasons why the examinations were performed was not known, and the dosimetric approaches did not include individual dose reconstructions *per se* or account for the possibility for missed examinations (NCRP Rept 171, 2012, pp. 88-91; The Boice Report #14, 2013; http://www.ncrponline.org/PDFs/BOICE-HPnews/14_UNSCEAR_Vienna_July2013.pdf). The associations appear to reflect reverse causality (confounding by indication) in that the reasons why the children received frequent CT exams were the likely reasons why the cancers developed, i.e. the symptoms or prodromal stages of cancer caused the x-rays and not vice versa! Examples of reverse causation in epidemiologic investigations of radiation administered in the clinical setting will be presented. Ongoing epidemiologic studies of paediatric CT (hopefully with improved methodologies) may help resolve current uncertainties (Einstein Lancet 2012).

DIGITAL AND INTERVENTIONAL RADIOLOGY: PATIENT DOSE REGISTRIES AND DIAGNOSTIC REFERENCE LEVELS

J.S. Al Suwaidi[a], N.K. Al Mazrouei[b], S. Pottybindu[c], M. Siraj[d], D. Mathew[d], A.A. Al Blooshi[d], V.P. Kuriakose[c]

[a] *Dubai Health Authority, Medical Education Department, Dubai Hospital, Dubai, UAE*
[b] *Dubai Health Authority, Medical Physics Section, Radiation Protection Unit, Dubai, UAE*
[c] *Dubai Health Authority, Latifa Hospital, Radiology Department, Dubai, UAE*
[d] *Dubai Health Authority, Primary Health Care, Radiology Department, Dubai, UAE*

Abstract–Digital Radiology introduced benefits to the medical imaging practices and enhanced the quality of services provided to patients. This paper discusses the major differences between Digital Radiology and Conventional Radiology with emphasis on methodologies followed to estimate patient radiation doses. It presents the current details on the trends in diagnostic patient dose registries and dose guidance levels applied in the digital diagnostic and interventional radiology practices. The practical impact of the new recommendations of the International Commission on Radiological Protection (ICRP) is highlighted to specify the current challenging points in the practice of radiation protection in medicine. Considering the latest ICRP recommendations and the advances in digital radiology, the importance of patient dose recording and the establishment of Diagnostic Reference Levels (DRLs) for digital radiology are indicated. Dubai Health Authority (DHA) experience in establishing local DRLs are presented along with dose guidance values published internationally. The DHA participated in national and regional projects under the umbrella of the International Atomic Energy Agency (IAEA). The necessity for local radiation protection educational programs and patient dosimetry monitoring and recording were emerged from our patient radiation dosimetry projects. These are considered as essential requirements to prompt radiation safety culture within the various healthcare communities.

TRENDS IN RADIATION PROTECTION OF PET/CT IMAGING

A.M. Alenezi, K. Soliman

Prince Sultan Medical Military City, Department of Medical Physics, Riyadh, Saudi Arabia

Abstract–Over the past decade, the use of hybrid PET/CT imaging has increased substantially. This would lead to an increase in radiation doses to staff and patients. Major efforts have been made to reduce radiation dose in PET/CT facilities. This paper briefly reviews the methods suggested to reduce patient and staff dose in clinical PET/CT imaging. A brief review of some published information on staff and patient doses will be analyzed and presented. Generally, the diagnostic CT dose component is often higher in magnitude than the dose from PET alone; focusing on CT dose reduction will decrease the overall patient dose in PET/CT imaging studies. On the other hand, the PET dose component can be reduced by administering lower activity to patient, optimize the workflow and appropriate utilization of protective devices. There is a wide variation in work practices of staff dose among PET institutions. The current trends are such that, the annual ICRP staff dose limits are unlikely to be exceeded. To reduce patient's dose from CT alone, the following factors are to be considered: proper justification for ordering contrast enhanced CT (CECT), utilization of automatic exposure control (AEC) features, optimization of scan parameters, and utilization of iterative reconstruction algorithms.

REFERRAL CRITERIA AND CLINICAL DECISION SUPPORT. RADIOLOGICAL PROTECTION ASPECTS FOR JUSTIFICATION

M.R. Pérez

World Health Organization

Abstract–Advanced imaging technology has opened new horizons to medical diagnostics and improved patient care. However, a substantial fraction of procedures are unjustified and do not provide a net benefit. An area of special concern is the unnecessary use of radiation when clinical evaluation or other imaging modalities could provide an accurate diagnosis. Referral criteria for medical imaging are consensus statements based on the best available evidence, to assist decision making process when choosing the best imaging procedure for a given patient. Although they are advisory rather than compulsory, there should have good reasons to deviate from them. Voluntary use of referral criteria has shown limited success compared with integration into clinical decision support systems. These systems support good medical practice, can improve health service delivery, and foster safer, more efficient, fair, and cost-effective care, thus contributing to health systems strengthening. Justification of procedures and optimization of protection, the two pillars of radiological protection in health care, are implicit in the notion of good medical practice. However, health professionals are not familiar with them, and have a low awareness of radiological protection aspects of justification. A stronger collaboration between radiation protection and health care communities could contribute to improve radiation protection culture in the medical practice.

THE ICRP APPROACH TO ENVIRONMENTAL RADIATION PROTECTION: ISSUES AND APPLICATION

THE ICRP'S APPROACH TO PROTECTION OF THE LIVING ENVIRONMENT UNDER DIFFERENT EXPOSURE SITUATIONS

R.J. Pentreath[c], C-M. Larsson[a,d], D. Copplestone[b,e]

[a] *ICRP Main Commission and Committee 5 Chair*
[b] *ICRP Committee 5*
[c] *Plymouth Marine Laboratory, UK*
[d] *Australian Radiation Protection and Nuclear Safety Agency, Miranda, Australia*
[e] *School of Natural Sciences, University of Stirling, Stirling, UK*

Abstract–The ICRP system to protect the living components of the environment is designed to provide a broad and practical framework across all exposure situations. The objectives of the ICRP are therefore also set in fairly broad terms, recognising that national and local environmental protection requirements may need to be set within it. The framework recognises the need to be able to demonstrate an adequate level of protection in relation to planned exposure situations, whilst also providing an ability to manage existing and accident and emergency situations in a rational way. The objects of protection are always real biota, in real exposure situations, and the scientific basis for their protection similarly needs to be based on data originating from studies on the relationships between exposure and dose, and dose and effects, and effects and consequences in real animals and plants. The former, of course, are not always the same as the latter. The framework that has been developed has therefore had to take such realities into account, and to make the optimum use of the data currently available, whilst being sufficiently flexible to accommodate knew scientific information as it arises without having to alter the framework as a whole.

ESTABLISHING RELATIONSHIP BETWEEN ENVIRONMENTAL EXPOSURES TO RADIONUCLIDES AND THEIR CONSEQUENCES FOR WILDLIFE: INFERENCES AND WEIGHT OF EVIDENCE

J. Garnier-Laplace[a], F. Alonzo[b], C. Adam-Guillermin[b]

[a] *ICRP Committee 5*
Institut de Radioprotection et de Sûreté Nucléaire, PRP-ENV, Service de recherche et d'expertise sur les risques environnementaux, France
[b] *Institut de Radioprotection et de Sûreté Nucléaire, PRP-ENV/SERIS, Laboratoire d'écotoxicologie des radionucléides, France*

Abstract–Ecological risk assessments (ERA) for radioactive substances are based on a number of inference rules to face knowledge gaps and generally require the implementation of a weight of evidence approach. Until recently, dose (rate) – response relationships used to derive benchmarks to support the demonstration of wildlife protection have mainly relied on laboratory studies from a limited number of test species as a representation of biodiversity. This is recognized that understanding of underlying biological mechanisms, combined with advanced conceptual and mathematical approaches, is needed to develop general rules and increase our confidence when extrapolating from test species to complex biological/ecological systems. Moreover field data sets based on robust sampling strategies are still needed to validate benchmark values derived from controlled laboratory tests and highlight potential indirect ecological effects if any. The talk will illustrate through several examples the added value of combining laboratory- and field-based approaches to obtain science-ground benchmark dose (rates) with enhanced robustness (*e.g.*, screening benchmarks for ERA, ICRP Derived Consideration Reference Levels) based on meta-analysis of dose-effect relationships covering ecologically relevant exposure times, spatial scales, species and endpoints.

THE ICRP APPROACH TO ENVIRONMENTAL RADIATION PROTECTION: ISSUES AND APPLICATION

THE CREATION AND APPLICATION OF VOXELIZED DOSIMETRIC MODELS, AND A COMPARISON WITH THE CURRENT METHODOLOGY AS USED FOR THE ICRP RAPS

K. Higley[ab], M. Gomez-Fernandez[b], E. Ruedig[c], J. Jia[b], E. Caffrey[b], M. Comolli[b], C. Hess[b]

[a] *ICRP Committee 5 Vice-chair*

[b] *Department of Nuclear Engineering and Radiation Health Physics, Oregon State University, USA*

[c] *Environmental and Radiological Health Sciences, Colorado State University, USA*

Abstract–Over the past decade the International Commission on Radiological Protection has developed a comprehensive approach to environmental protection that includes the use of Reference Animals and Plants (RAPs) to assess radiological impacts on the environment. For the purposes of calculating radiation dose the RAPs are approximated as simple shapes that contain homogeneous distributions of radionuclides. Since uncertainties in environmental dose effects are larger than uncertainties in radiation dose calculation, some have argued against more realistic dose calculation methodologies. However, due to the complexity of organism morphology, internal structure and density, dose rates calculated via a homogenous model may be too simplistic. The purpose of this study is to examine the benefits of a voxelized phantom versus simple shapes for organism modeling. Both methods typically use Monte Carlo methods to calculate absorbed dose, but voxelized modeling uses an exact 3D replica of an organism, with accurate tissue composition and radionuclide source distribution. It is a multi-stage procedure that couples imaging modalities and processing software with Monte Carlo N-Particle (MCNP). These features increase dosimetric accuracy and may in fact reduce uncertainty in Non-Human Biota (NHB) dose-effects studies by providing mechanistic answers regarding where and how population-level dose effects arise.

MARINE BIODIVERSITY IN ABU DHABI, UAE

A.A. Cibahy, H. Das

Environment Agency, Abu Dhabi, UAE

Abstract–Abu Dhabi has diverse terrestrial and marine habitats that support high biological diversity of plant and animal species. The marine and coastal environment in Abu Dhabi is under threat due to pressures from urban and industrial encroachment; the increasing demand for food, energy, transportation and water from a growing population; and from climate change. EAD identified eight marine and coastal habitats and six terrestrial habitats for management and conservation activities. The marine habitats are: coral reefs; sea grasses / seaweeds; mangroves; sandy beaches; rocky shores; lagoons and creeks; intertidal flats; and Sabkhas. The terrestrial habitats are: sand sheets; dunes and mega dunes; plains (alluvial and interdunal plains); mountains, rocky terrain and wadis; and inland Sabkha. The establishment and management of Marine Protected Areas (MPAs) have shown positive results for a number of habitats and species. For example, the population of dugongs has been stable primarily due to the establishment of MPAs. Similarly, owners of private islands have an active role in ensuring biodiversity conservation. As of 2012, 13.2% of Abu Dhabi's area was considered as MPAs or Terrestrial Protected Areas (TPAs). The protection status of these sites varies and they are not representative of all Abu Dhabi significant habitats.

THE ICRP APPROACH TO ENVIRONMENTAL RADIATION PROTECTION: ISSUES AND APPLICATION

USE OF THE ICRP SYSTEM FOR THE PROTECTION OF MARINE ECOSYSTEMS

D. Telleria[a], T. Cabianca[b], G. Proehl[c], V. Kliaus[d], J. Brown[e], C. Bossio[f], J. Van der Wolf[g], I. Bonchuk[h], M. Nilsen[i]

[a] *IAEA-Assessment and Management of Environmental Releases Unit*
[b] *Public Health England - Planned Exposure Group, UK*
[c] *IAEA-Assessment and Management of Environmental Releases Unit*
[d] *Laboratory of Radiation Safety, Republican Scientific-Practical Centre of Hygiene, Republic of Belarus*
[e] *Norwegian Radiation Protection Authority, Norway*
[f] *Nuclear Regulatory Authority, Radiological Safety Assessments Division, Argentina*
[g] *Delft University of Technology, Netherland*
[h] *Ukrainian Radiation Protection Institute, Ukraine*
[i] *Norwegian Radiation Protection Authority, Norway*

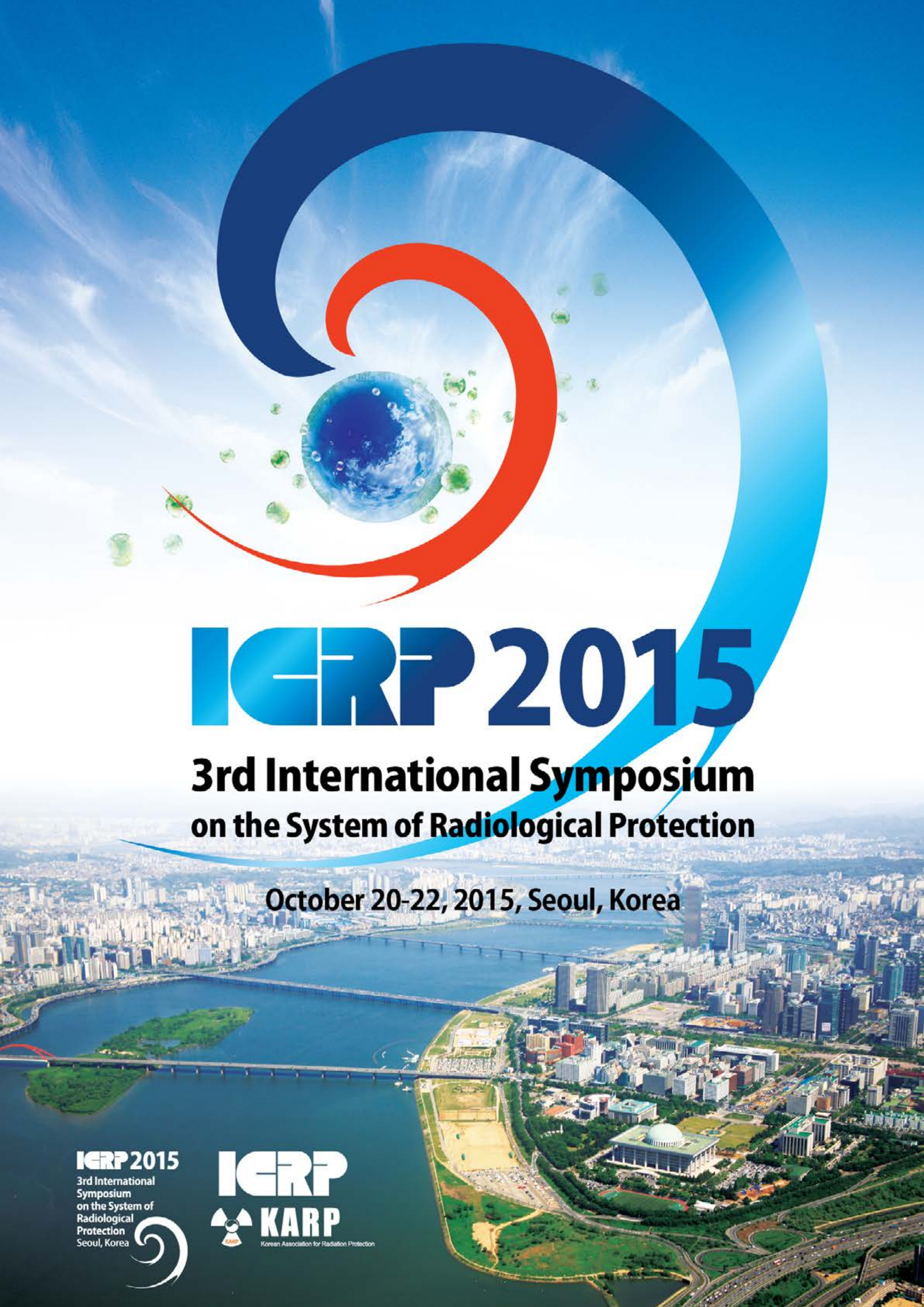
Abstract–The International Commission on Radiological Protection (ICRP) recently reinforced the international system of radiological protection, initially focused on humans, by identifying principles of environmental protection and proposing a framework for assessing impacts of ionising radiation on nonhuman species, based on a reference flora and fauna approach. For this purpose, ICRP developed dosimetric models for a set of reference animals and plants, which are representative of flora and fauna in different environments (terrestrial, freshwater, marine), and produced numerical criteria based on information on radiation effects, with the aim to evaluate the level of potential or actual radiological impacts and as an input for decision making. The International Atomic Energy Agency (IAEA) includes considerations on the protection of the environment in its safety standards, and is currently developing guidelines to assess radiological impacts based on the aforementioned ICRP approach. This paper presents methods developed by the IAEA to enable assessment of the radiological impact to the marine environment in connection with the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972, the corresponding 1996 Protocol and the Convention for the Protection of the marine Environment of the North-East Atlantic 1992. These methods, based on IAEA standards and ICRP recommendations, were presented in 2013 for technical discussions to representatives of the contracting parties of these conventions mentioned above, and are being assessed for the inclusion in their procedures.

MODELLING EXPOSURES AND EFFECTS IN THE MARINE ENVIRONMENT AFTER THE FUKUSHIMA ACCIDENT

J. Vives i Batlle

ICRP Committee 5
Belgian Nuclear Research Centre (SCK•CEN), Belgium

Abstract–Quantifying the radiological impact on wildlife under emergency exposure situations requires an assessment of exposures and subsequent prediction of the likely effects using established dose/response relationships, with both aspects posing challenges of their own. The main challenge in exposure assessment is establishing radionuclide concentrations in the media (seawater and sediments) and their transfer to biota. There is usually a complex mixture of radioisotopes, from the short-lived prevailing in the early phase to the longer-lived persisting over longer periods. The problem needs to be approached dynamically, because organisms are likely at disequilibrium with fluctuating media activity concentrations. For the assessment of effects, one must also distinguish between the early (dynamic) and the later (equilibrium) phases, where relevant acute and chronic benchmarks must be applied. A dynamic model was applied to simulate the uptake and turnover of marine biota at the Fukushima Dai-ichi NPP. The relative importance of the internal and external dose component (mainly from exposure to sediment) in the first two months post-accident was estimated. We found that earlier assessments using equilibrium transfer models over-estimated the exposures by 2 – 3 orders of magnitude, whereas the dynamic model brings dose estimates reasonably in line with monitoring studies. On that basis, marine biota populations would seem to be at relatively low risk. However, some organisms are experiencing protracted exposures at local hotspots, and little is known about how long radionuclides will persist in the local environment, or what are the long-term effects on populations. Moreover, knowledge gaps remain on the effects of chronic exposures to marine biota in field situations. Furthermore, a dose-based approach has certain limitations when addressing the general issue of protecting an environment comprising both biotic and abiotic compartments. Therefore, it is too early to conclude that the marine environment off Fukushima is of no radiological concern, signalling the direction for future investigations.


ICRP 2015
3rd International Symposium
on the System of Radiological Protection
October 20-22, 2015, Seoul, Korea
ICRP 2015
3rd International Symposium on the System of Radiological Protection Seoul, Korea
ICRP
KARP
Korean Association for Radiation Protection

The International Commission on Radiological Protection thanks
the following organisations for providing the
financial support necessary to make ICRP 2013 possible:

United Arab Emirates

FANR
الهيئة الاتحادية للرقابة النووية
Federal Authority for Nuclear Regulation

مؤسسة الإمارات للطاقة النووية
Emirates Nuclear Energy Corporation

UAE Armed Forces

هيئة الصحة - أبوظبي
HEALTH AUTHORITY - ABU DHABI

Federal Ministry for the
Environment, Nature Conservation
and Nuclear Safety

Canadian Nuclear
Safety Commission

Cameco

LANDAUER
EUROPE

JRIA
Japan
Radioisotope
Association