SUMMARIES

Summaries of articles in this issue

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General Summaries

Summaries of articles in this issue

REVIEW

Experience and the results of emergency management of the 1957 accident at the Mayak Production Association
G Sh Batorshin and Yu G Mokrov (R1)
The paper provides a summary of information on large-scale radiation accident (the 'Kyshtym Accident') that took place in 1957 at the production site of the Mayak Production Association located in the Southern Urals of Russia.

The main problems discussed in the paper are:

- causes and scales of the accident,
- radiation environment,
- efficiency, outcomes and final present-day status of the accident site and the contaminated territories.

Safety relevant guidelines are also presented.

PAPERS

Long-term monitoring of water treatment technology designed for radium removal-removal efficiencies and NORM formation
Liie Hill, Siiri Suursoo, Madis Kiisk, Alar Jantsikene, Nele Nilb, Rein Munter, Enn Realo, Rein Koch, Kaisa Putk, Maria Leier, Taavi Vaasma and Kadri Isakar (1–24)

- Observed mechanisms for radium removal were co-precipitation and adsorption.
- NORM waste formation in the treatment plant was quantified.
- Accumulation of Ra-226 and Ra-228 was observed in filter materials.

A national survey on radon remediation in Switzerland
Liie Hill, Siiri Suursoo, Madis Kiisk, Alar Jantsikene, Nele Nilb, Rein Munter, Enn Realo, Rein Koch, Kaisa Putk, Maria Leier, Taavi Vaasma and Kadri Isakar (25–33)

- The rate of radon remediation in Switzerland is 46%.
- The most important reason for not taking action are the costs.
- The most often applied remediation method is the aeration of the cellar.
- The importance of a control measurement after remediation has to be emphasized.

Monte Carlo simulation of beta particle-induced bremsstrahlung doses
D Mrdja, K Bikit, I Bikit, J Slivka, S Forkapic and J Knezevic (34–47)

- The bremsstrahlung spectra produced in various materials by the following beta emitters: Sr-90 (Y-90), P-32, and Bi-210, including corresponding dose rates, were investigated by Monte-Carlo simulations.
- In these simulations, it is supposed that the point radioactive sources are surrounded by cylindrically shaped capsules made from different materials: Pb, Cu, Al, glass, and plastic.
- The bremsstrahlung dose rate and bremsstrahlung spectrum from the Y-90(Sr-90) point source encapsulated in an Al capsule, were also measured experimentally and compared with the corresponding simulation results.
- In addition, the bremsstrahlung radiation risk for medical staff in therapies using Y-90 was considered in simulations.

Dose estimation to eye lens of industrial gamma radiography workers using the Monte Carlo method
I A M Al-Affan, S C Evans, M Qutub and R P Augusto Hugtenburg (48–60)

- Simulations with the FLUKA Monte Carlo code were used to establish the possibility of using lead to cover the existing concrete walls of a linear accelerator treatment room maze, to reduce the dose of the scattered photons at the maze entrance.
- The results showed that adding lead of 1–4 mm thickness to the walls/floor of the maze reduced the dose at the maze entrance by up to 80%.
- Dose rate measurements performed at the maze entrance of a treatment room with 1.3 mm thickness of lead sheets added to the maze walls and floor supported the results from the simulations.

A Monte Carlo study of organ and effective doses of cone beam computed tomography (CBCT) scans in radiotherapy
Abdullah Abuhaimed, Colin J Martin and Marimuthu Sankaralingam (61–80)

- Organ and effective doses for two software versions V2.5 and V1.6 used in an OBI system were compared using Monte Carlo simulations.
- Organ doses resulting from the V2.5 protocols were higher than those of V1.6 for organs that were partially or fully inside the scans fields.
- Organ doses rose by up to 77% in the new version, which led to increase effective doses by up to 18%.
- The main reason for the dose increase in the new version was extension of the field size in the lateral and axial directions.
- Several recommendations have been made for optimization of the patient dose involved for IGRT.

Integration of risks from multiple hazards into a holistic ALARA/ALARP demonstration
P A Bryant, J Croft and P Cole (81–91)

- An overview is provided on the origins of ALARA, its development over time and importance as part of a healthy radiation safety culture.
- The integration of the ALARA principle into the UK Regulatory Regime is discussed with its particular application to not only to radiological hazards, but all hazards.

- A framework is proposed for the integrated assessment of risks from multiple hazards as part of a holistic ALARA argument.
- Some of the key challenges associated with the assessment of multiple hazards are discussed such as balancing of risks or management of materials with multiple hazards.

Low radon exposure and mortality among Jouac uranium miners: an update of the French cohort
Estelle Rage, Syvaine Caër-Lorho, Dominique Laurier (92–108)

- The French cohort of uranium miners was extended by the inclusion of the Jouac miners. This epidemiological study, set up to investigate the effect of radon exposure on the mortality risks, followed-up the miners from 1946 to 2007.
- There was no evidence of a significant excess risk of overall mortality, but a significant excess of mortality from cancer, and more specifically from lung cancer and kidney cancer was observed compared to the general population.
- The exposure-risk relations showed a significant increase of the risk for death from lung cancer and from cerebrovascular diseases associated with cumulative radon exposure.

Main problems and suggested solutions for improving radiation protection in medicine in Ibero-American countries. Summary of an International Conference held in Madrid, 2016
Eliseo Vano, Pablo Jimenez, Raul Ramirez, Javier Zarzuela, Ana Maria Larcher, Eduardo Gallego, Santiago Gonzalez and Maria del Rosario Perez (109–120)

- The Ibero-American Conference on Radiation Protection in Medicine (CIPRaM) held in Madrid, 2016, assessed the status of implementation of the Call for Action derived from the IAEA-WHO Bonn Conference.
- CIPRaM objectives were a) to identify and prioritize the five most relevant problems in RP in Medicine for eight thematic areas b) to suggest solutions for these problems and c) to develop indicators to assess progress with the proposed solutions.
- The Conclusions of the Conference may be considered representative of a population of 642 million of inhabitants (430 million from Spanish-speaking countries and 212 million from Portuguese-speaking countries).

Patient doses from medical examinations in Russia: 2009–2015
M Balonov, V Golikov, I Zvonova, L Chipiga, S Kalnitksy, S Sarycheva and A Vodovatov (121–139)

- First publication of current levels of medical exposure of adult patients in Russia from different modalities of x-ray and nuclear medicine diagnostics.
- The annual number of examinations is gradually increasing, reaching 203 million in 2015 that corresponds to 1.4 examinations per capita with domination of radiography and fluorography (96% in total) and fast growing number of CT examinations.
- Mean effective doses of adult patients increase by an order of magnitude with each x-ray modality from dental x-ray examinations (0.01–0.1 mSv) to radiography (0.1–1 mSv), CT and fluoroscopy (1–10 mSv) and to interventional examinations (usually above 10 mSv).

- Mean effective doses from PET/CT examinations constitute 15–25 mSv, with contribution of x-ray exposure being equal to or higher than internal exposure from radiopharmaceutical.
- Significant variations in doses between hospitals indicate the potential for optimization with the focus on interventional examinations, CT and nuclear medicine examinations combined with CT.

Education and training in radioecology during the EU-COMET project-successes and suggestions for the future
Clare Bradshaw, Lindis Skipperud, Nicholas A Beresford, Catherine L Barnett and Miquel Vidal (140–151)
Competence and skills in radioecology, the science that studies radioactivity in the environment, are needed in research and by industry and radiation protection authorities. However, it is a small and multidisciplinary science; maintaining this competence at a European, or even worldwide, level is a challenge. A recent European project, COMET, made progress in meeting education and training (E&T) needs, through the development of a web platform, field courses, training courses, PhD and MSc courses and workshops. However, the current lack of sustainable funding must be urgently addressed if radioecological competence is to be maintained in Europe in the future.

- Competence and skills in radioecology are needed in research and by industry and radiation protection authorities.
- The EU COMET project has made progress in meeting education and training needs through the development of a web platform and a number of advanced courses and workshops.
- Future initiatives must address the current lack of sustainable dedicated funding if radioecological competence is to be maintained in the future.

Sustainability and integration of radioecology-position paper
M Muikku, N A Beresford, J Garnier-Laplace, A Real, L Sirkka, M Thorne, H Vandenhove and C Willrodt (152–163)

- The position paper gives an overview of how the EC funded COMET project contributed to the integration and sustainability of radioecology in Europe via its support to and interaction with the European Radioecology ALLIANCE.
- COMET developed innovative mechanisms for joint programming and implementation of radioecological research.
- COMET maintained and developed strong mechanisms for knowledge exchange, dissemination and training to enhance and maintain European capacity, competence and skills in radioecology.

COMET strongly supported the development and implementation of medium-term topical research roadmaps consistent with the ALLIANCE Strategic Research Agenda
J Garnier-Laplace, H Vandenhove, N Beresford, M Muikku and A Real (164–174)

- The bremsstrahlung spectra, produced by Sr-90+Y-90, P-32 and Bi-210 were simulated.
- The bremsstrahlung dose rates from different source encapsulations were analyzed.
- Bremsstrahlung radiation risk for medical staff in therapies with Y-90 is considered.

Radiation protection for surgeons and anesthetists: practices and knowledge before and after training

A Brun, R Alcaraz Mor, M Bourrelly, G Dalivoust, G Gazazian, R Boufercha, M P Lehucher-Michel and I Sari-Minodier (175–188)

- Objective is to evaluate knowledge and practices in radiation protection before and one-month after training among French surgeons and anesthetists with a questionnaire.
- Results show a lack of knowledge and good practices when using ionizing radiation in operating room, a non-systematic use of protective equipment (50.0% of the participants wear a thyroid-shield, 53.3% a passive and 17.8% an electronic dosimeter) and the evaluation after training highlights a significant improvement in knowledge ($p<0.001$) but not in good practices ($p=0.666$).
- In conclusion, it needs to modify training strategies to improve awareness and practices in radiation protection among these professionals.

Evaluation of coefficients to derive organ and effective doses from cone-beam CT (CBCT) scans: a Monte Carlo study

Abdullah Abuhaimed and Colin J Martin (189–206)

- Dose-width product (DWP) was proposed for CBCT scans instated of DLP, which is used for CT scans.
- The link between DWP and effective doses of CBCT scans (called CCE) was studied under different conditions.
- The link between organ doses and CTDIIEC of CBCT scans (called CCT) was studied under different conditions.
- Influence of the beam width of CBCT scans on CCT values and CCE values was investigated and compared to those derived for CT scans.

Calculation of the exposure buildup factors for x-ray photons with continuous energy spectrum using Monte Carlo code

Mustafa Mohammad Rafiei and Hossein Tavakoli-Anbaran (207–217)

This paper shows that:

- We calculated the exposure buildup factor (for continues energy gamma source) via MCNPX code.
- We observed that there is a significant difference between the exposure buildup factor due to the continuous and monoenergetic gamma source.
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Paediatric interventional cardiology in Costa Rica: diagnostic reference levels and estimation of population dose

C Ubeda, E Vano, L Salazar, Retana V, F Santos, R Gutierrez and C Manterola (218–228)

- The study was carried out as part of International Atomic Energy Agency regional.
- The study was made in 100% of the paediatric cardiac laboratories in Costa Rica.
- The national diagnostic reference levels for the procedures by age range were from 1.79 Gy·cm2 (<1 yr) to 23.0 Gy·cm2 (10 to <16 yrs).

- The national diagnostic reference levels by weight range for the procedures were from 1.0 Gy·cm2 (<10 kg) to 49.6 Gy·cm2 (50-<80 kg).
- The contribution to collective dose to population in Costa Rica amounted to 0.78 person.Sv.

Spectral windows analysis method for monitoring anthropogenic radionuclides in real-time environmental gamma-ray scintillation spectrometry
E Prieto, R Casanovas and M Salvadó (229–246)

- A novel analysis methodology based on the spectral windows technique for environmental real-time gamma-ray spectra is proposed for early-warning alarm procedures.
- This algorithm has been designed for its application to spectra registered in short integration times and low-dose rate environmental measurements.
- The developed method automatically resolves peak overlapping and also compensates natural radioactivity oscillations related to meteorological variations removing the Compton scattering.
- The method has been tested in laboratory conditions using a $LaBr_3(Ce)$ detector to obtain activity concentrations for natural radionuclides, ^{222}Rn daughters (^{214}Bi or ^{214}Pb) and also for anthropogenic radionuclides (^{137}Cs and ^{131}I).

An analysis of radon levels in the basements of UK workplaces and review of when employers should test
Tracy D Gooding (247–261)

- The distribution of radon levels in more than 3500 workplace basements can be described in most cases as lognormal over a large range.
- The data are more likely to conform to the lognormal distribution if results are separated by workplace type (retail, industrial, etc), radon potential (Affected or non-Affected Area), seasonally corrected and with a 4 Bq m^{-3} adjustment made for outdoor air.
- To be proportionate with monitoring radon levels in ground floor workplaces, the minimum occupancy threshold for basements, which is currently 50 hours per year (one hour per week), could be increased for non-Affected Areas.

Evaluation of skin absorbed doses during manipulation of radioactive sources: a comparison between the VARSKIN code and Monte Carlo simulations
Ernesto Amato and Antonio Italiano (262–272)

- Evaluation of skin absorbed doses during manipulation of radioactive sources in nuclear laboratories is presented in view of the computing tools currently used in literature.
- A comparison between an analytical approach (VARSKIN) and Monte Carlo calculations (GAMOS) is carried out, for twenty radionuclides, highlighting the different features of the two approaches.
- Use of Monte Carlo codes, coupled to the method provided by the present work, enables the user to get – in short time – skin dose estimate for the customized geometrical layout in a wide range of research areas where radionuclides are used.

Comparison of external doses between radio-contaminated areas and areas with high natural terrestrial background using the individual dosimeter 'D-shuttle' 75 months after the Fukushima Daiichi nuclear power plant accident
Masaharu Tsubokura, Shuhei Nomura, Izumi Yoshida, Toyoaki Sawano, Makoto Miyazaki, Satoru Tomita, Oikawa Tomoyoshi and Masami Watanabe (273–285)

- This paper presents study results of comparison of external doses of the public residing in the radio-contaminated areas due to Fukushima Daiichi nuclear accident with the areas with high natural terrestrial background.
- Measurements of personal doses by means of the individual electronic dosimeters 'D-shuttle' were conducted 75 months after the Fukushima Daiichi nuclear accident in Minamisoma city and three other municipalities not contaminated with radionuclides released after the accident.
- The external dose of individuals living in Minamisoma city six years after the Fukushima Daiichi nuclear accident was comparable to that of individuals living in municipalities with a high natural radiation background in Japan.
- Time spent at home and in the workplace contributed to majority of the total dose from external exposure.

A semiparametric approach to evaluate the harm of low-dose exposures
Kyoji Furukawa and Munechika Misumi (286–298)

- While exposure to moderate-high level of radiation exposure is known to cause adverse health effects, what is the lowest dose that could be harmful remains controversial.
- The conventional dose-response estimation based on simple parametric models could be unexpectedly inefficient, biased and/or inaccurate in uncertainty evaluations at low doses.
- The conventional dose-response estimation based on simple parametric models could be unexpectedly inefficient, biased and/or inaccurate in uncertainty evaluations at low doses.

A Monte Carlo simulation study for the gamma-ray/neutron dual-particle imager using rotational modulation collimator (RMC)
Hyun Suk Kim, Hong Yeop Choi, Gyemin Lee, Sung-Joon Ye, Martin B Smith and Geehyun Kim (299–309)

- Development of a gamma-ray/neutron dual-particle imaging system will be necessary for many applications in homeland security and radiation safety.
- A Monte Carlo simulation study was performed to develop a gamma-ray/neutron dual-particle imager, based on rotating modulation collimators (RMC).
- Modulation patterns were obtained for gamma-ray and neutron sources on various configurations using MCNP code.
- An image reconstruction algorithm utilizing the maximum-likelihood expectation maximization (MLEM) method based on the analytical modeling of source-detector configurations was applied to the Monte Carlo simulation results.
- The results show promises for developing an RMC-based gamma-ray/neutron dual-particle imager using PSD-capable scintillators.

Comparison of the UNSCEAR isodose maps for annual external exposure in Fukushima with those obtained based on airborne monitoring surveys
Ryugo Hayano and Makoto Miyazaki (310–317)

- The temporal trend of annual effective doses of the people living in the areas affected by the FDNPP accident is analysed from the periodical air-borne monitoring data of ambient dose equivalent rates.
- Annual additional 1 mSv effective dose isodose lines for three and five years after the accident show relatively good agreement with those obtained by UNSCEAR based on the soil deposition data of radionuclides.
- However, closer examination reveals that the annual effective doses predicted by UNSCEAR are less than those of the present work at later times. The reason of the underestimation is discussed.

Pharmacological approach to increasing the retention of radiation-induced γ-H2AX foci using phosphatase inhibitors: significance in radiation biodosimetry
Akshaykumar A Nayak, Kamalesh Dattaram Mumbrekar and B S Satish Rao (318–328)

- Microscopic method is more sensitive compared to flow cytometry for γ-H2AX analysis.
- Calyculin A can inhibit the dephosphorylation and increased retention of γ-H2AX foci signals.
- Our observations using dephosphorylation inhibitors for γ-H2AX foci persistence gives further scope for biodosimetric implications.

Development and validation of a high-resolution mapping platform to aid in the public awareness of radiological hazards
Peter G Martin, Dean Connor, Oliver D Payton, Macarena Leal-Olloqui, Anya C Keatley and Thomas B Scott (329–342)

- Portable mobile phone-compatible radiological mapping platform developed.
- Sub-meter spatial resolution attainable.
- Multiple units deployed to investigate distribution of naturally-occurring radiation.
- Live transmission, presentation and reporting of survey data.
- Applications for emergency response to radiological incidents.

^{18}F-choline PET/CT for parathyroid scintigraphy: significantly lower radiation exposure of patients in comparison to conventional nuclear medicine imaging approaches
Sebastijan Rep, Marko Hocevar, Janja Vaupotic, Urban Zdesar, Katja Zaletel and Luka Lezaic (343–356)

- ^{18}F-flurocholine PET/CT imaging for localization of hyperfunctioning parathyroid glands combines superior diagnostic performance and lower radiation exposure to patients in comparison to conventional scintigraphic diagnostic methods.
- For conventional scintigraphic diagnostic methods, the radiation exposure is higher for the reference method, dual-tracer (^{99}mTc-MIBI/^{99}mTc-pertechnetate) subtraction scintigraphy than for the hybrid, ^{99}mTc-MIBI SPECT/CT imaging, whose diagnostic performance is superior to the reference method.

- Hybrid imaging approaches (^{18}F-fluorocholine PET/CT and ^{99}mTc-MIBI SPECT/CT) combine anatomical (low-dose CT) and functional information for superior diagnostic performance without adding significant radiation exposure to patients.

Direct adjustment for confounding by smoking reduces radiation-related cancer risk estimates of mortality among male nuclear workers in Japan, 1999–2010
Shin'ichi Kudo, Jun'ichi Ishida, Keiko Yoshimoto, Shoichi Mizuno, Sumio Ohshima, Hiroshige Furuta and Fumiyoshi Kasagi (357–371)

- We examined radiation-related cancer risk by directly assessing the possible confounding effect of smoking, using data from two questionnaire surveys performed among Japanese nuclear workers in 1997 and 2003.
- Mortality follow-up was carried out for 71733 male respondents whose the mean cumulative dose was 25.5 mSv.
- Statistically significant ERRs/Sv were found for all causes, all diseases, etc. without adjustment for smoking, but they were no longer statistically significant after adjustment for smoking.
- The present study demonstrated that smoking heavily distorts radiation risk estimates when a correlation between smoking and radiation dose is suggested.

Klein-Nishina electronic cross-section, Compton cross sections, and buildup factor of wax for radiation shielding and protection
Manar Alenezi, Kayla Stinson, Muhammad Maqbool and Norman Bolus (372–381)

- Investigation of paraffin wax (Carbon = 85.14%, Hydrogen = 14.86%) for radiation shielding and protection.
- Calculation of Klein-Nishina electronic cross section and Compton cross sections of wax.
- Calculation of linear attenuation coefficient of wax.
- Investigation of buildup factor of wax.

^{18}F-FDG production procedures as a source of eye lens exposure to radiation
Małgorzata Wrzesień (382–393)

- The paper focuses on the eye lenses of employees during the 18F-FDG production process.
- The working system two different radiopharmaceuticals production centres was analysed.
- The maximum daily dose of Hp(3) exceeds 200 μSv during quality control procedure.
- Estimated annual exposure of eye lenses may exceed the new dose limit.
- The quality control of radiopharmaceuticals and injection the ^{18}F-FDG need for optimization.

Ion chambers compliance results of Brazilian radiation therapy facilities
G Joana, C Salata, P Leal, R Vasconcelos, N do Couto, F C Teixeira, A D Soares, E S Santini and M Gonçalves (394–406)

- The ionization chambers calibration profile in Brazil strongly depends on the nuclear regulatory body.
- The acquisition of new technologies for radiation treatment is a challenge for the ionization radiation metrology field.

- The public radiotherapy facilities in Brazil usually have more difficulties to suit the calibration regulatory guidelines.

Monte Carlo simulation investigation on the minitype reference radiation employed for the calibration of gamma ray dose or dose rate meters
Wenjie Li, Yixin Liu, Biao Wei, Peng Feng, Yang Xu and Benjiang Mao (407–421)

- Simulate the distribution of the scattering spectra and dose rate in MRR.
- Simulate the components of the scattering gamma spectra in MRR.
- Extract the metrological feature the gamma scattering spectra in MRR.

Prediction of dose to the relatives of patients treated with radioiodine-131 using neural networks
Marzieh Ebrahimi, Mohammad Reza Kardan, Vahid Changizi, Seyed Mahdi Hosseini Pooya and Parham Geramifar (422–433)

- The effective dose to family members and caregivers of 52 thyroid cancer patients who had been treated with radioiodine I-131 was measured.
- Neural network was used for prediction of dose to the relatives of patients.
- The inputs of neural network were 13 different parameters that potentially could affect the dose and the output was dose to the family members.
- The mean square error of predicted doses by the neural network and measured doses by TLD (Mean Squared Error) for 99 individuals was 0.142.
- The optimum neural network was able to predict all relatives who receive doses more than 1 mSv.

MEMORANDUM

Conclusions and recommendations from the 17th Workshop of the European ALARA Network 'ALARA in emergency exposure situations'
Sylvain Andresz, Julie Morgan, Pascal Croüail and Fernand Vermeersch (434–439)

- The most recent European ALARA Network workshop questioned the application of the optimisation principle (ALARA) in emergency exposure situations, with lessons learnt from Chernobyl and Fukushima accidents.
- The method for optimisation should evolve over the course of an accident, from robust 'reasonably foreseeable worst-case scenario' to appropriate adaptation to the very local conditions.
- Emergency plans should not only consider the urgent phase of an accident and be flexible enough to be able to adapt to the circumstances. Non-radiological criteria (economical, societal etc.) should be better considered. At some point in time, these criteria will be regarded more important than radiological ones.
- To this regard, public and stakeholders should be given more consideration in decision-making so their needs and concerns are incorporated as effectively as possible. This applies to all phases of an accident, and notably in preparedness.

RPA Consultation: is the system of protection 'fit for purpose' and can it be readily communicated? Views of the radiation protection professionals
Roger Coates and Renate Czarwinski (440–455)

- The memorandum presents the outcome of a consultation by the International Radiation Protection Association (IRPA) to determine the views of the worldwide radiation protection professionals regarding the current key challenges within the system of protection.
- It makes suggestions on how the system could be improved so that it is more suited for practical application and is better able to be communicated to wider stakeholders.
- Key issues include uncertainty at low dose, limitation and the role of dose limits, 'reasonableness' and communication.
- The suggestions identified are a contribution to the ongoing longer term gradual evolution of the system of protection.

NOTE

Contribution of interventional cardiology to the collective dose in Spain
Roberto M Sánchez Casanueva, Eliseo Vañó Carruana, José Miguel Fernández Soto, Antonio Fernández-Ortiz, Fernando Alfonso Manterola and Javier Goicolea Ruigómez (N1–N7)

- The fraction of the collective dose per million inhabitants derived from IC was 34 man-Sv.
- The contribution of the IC derived from the medical use of x-rays in Spain resulted 4%.
- The contribution of the IC derived from the medical use of x-rays in Spain resulted 4%.

OPINION ARTICLE
Integrating radiation protection criteria for radioactive waste management into remediation procedures in existing exposure situations after a nuclear accident
Daisuke Sugiyama, Hideo Kimura, Hirokazu Tachikawa, Takeshi Iimoto, Yosuke Kawata, Haruyuki Ogino and Minoru Okoshi (456–462)

- A guideline of radiation protection system with dose criteria for the public on waste management is proposed for the remediation of existing exposure situations after a nuclear accident.
- Stepwise approach makes the waste management reasonably practical in the context of remediation.
- Intermediate reference levels for waste management should be selected in the range of annual effective dose of 1 to 10 mSv.
- A target reference level for waste disposal should be set at 1 mSv/y.
- The applicability of the stepwise approach is illustrated with case studies in typical situations after the Fukushima nuclear accident.

NEWS AND INFORMATION

News from the IAEA-Management of disused sources
Anthony D Wrixon (466–469)

- This note provides a short history of the IAEA's work on the safe and secure management of radioactive sources since 1998.
- One early output was the development of the Code of Conduct on the Safety and Security of Radioactive Sources.

- This Code has since been supplemented by Guidance on the Import and Export of Radioactive Sources and, most recently, by Guidance on the Management of Disused Radioactive Sources.
- All of these documents have been endorsed by the IAEA's General Conference, thereby giving them political significance.