THE eBulletin
Radiological Protection Bulletin

# Contents

No. 2 (December 2002)

The *eBulletin* is published in full and free of charge on this website.

It may be possible to obtain back issues: please e-mail bulletin@hpa-rp.org.uk for prices or if you have any queries. Extracts from hard copy back issues are also available from the archive.

If you have any feedback or questions for the editor, please contact us at:

National Radiological Protection Board
Chilton
Didcot
Oxon
OX11 0RQ
E-mail: publications@hpa-rp.org.uk

---

**Editor:** Michael Clark (e-mail: michael.clark@hpa-rp.org.uk)

**Correspondence:** Letters for publication on this issue are invited. They should have no more than 500 words. The Editor's decision is final.

THE eBulletin

Radiological Protection Bulletin

# Editorial

**No. 2**
**(December 2002)**

## Power lines and health



**On 5 December 2002, NRPB organised an open meeting to air public concerns about possible health effects caused by electricity supply and usage. Lord Winston chaired the meeting and about 150 people attended at the National Exhibition Centre in Birmingham. An expert panel listened to concerns raised by members of the audience and answered questions. The issues raised and questions asked were primarily from pressure groups and activists.**

It can be argued that the power lines and health debate is a smokescreen for a typical planning conundrum. The vast majority of people, businesses, organisations and corporations need to use electricity, and it is part of the essential fabric of modern life. A power line delivering electric power to our doorsteps and workplaces is therefore a necessity, but we do not necessarily want to live near large power stations, substations or overhead transmission cables. This is no different from other aspects of modern life where costs and benefits are not equally distributed. A healthy economy demands good communications and transport, but we would prefer not to live near telecommunications facilities, major roads, railways or airports. So a cynic might conclude that the debate about power lines and health is just a diversion to mask a 'not in my backyard' attitude.

However this is too dismissive of some people's concerns. There is some evidence for a small increase in the risk of childhood leukaemia in homes with relatively high magnetic fields over an extended time period. The NRPB Advisory Group on Non-ionising Radiation (AGNIR) highlighted this possibility in 1992 and 2001, and there are international epidemiological studies that have come to similar conclusions. Also, while there has been a focus of research on possible links with very serious health effects such as cancer, there is the possibility that health could be affected in other ways. For example, there are claims that exposure to elevated electromagnetic fields can cause miscarriage, anxiety, depression, and sleep disorders. In the extreme, some people claim to be hypersensitive to electromagnetic fields and others claim to have been made suicidal.

The meeting provided an opportunity for people to air their concerns to an expert panel, the members of which were there to listen and answer questions rather than to lecture. It also provided an opportunity for pressure groups to hold their own meeting following the NRPB one. Here, some more formal presentations were made and there was discussion of various ideas, findings and hypotheses. The second meeting was open to the public and observers, and some NRPB staff attended.

Questions and hypotheses from activists and pressure groups dominated the two meetings, which is entirely understandable. However, it does prompt the question of how representative are the concerns raised? Can they really be labelled as 'public concerns'? Surveys of people's health concerns place electromagnetic fields very low on any list when the surveys are carried out on randomly selected groups. For example, there is far more concern about air pollution and what might be in foodstuffs. The radiological risks of most concern to the public are currently the possible consequences of a terrorist attack and from the disposal of radioactive waste. Concerns about electromagnetic fields are important issues for NRPB to address but they need to be seen in a broad perspective, as emphasised by Lord Winston in response to questions raised during the NRPB meeting.

**Michael Clark**

# Internal links

- Advisory Group on Non-ionising Radiation

THE eBulletin

Radiological Protection Bulletin

# News & Affairs

**No. 2**
**(December 2002)**

## Recent announcements about the Health Protection Agency



On 15 November 2002, the Public Health Minister, Hazel Blears, wrote to the Chairman of NRPB, Sir Walter Bodmer, explaining Government plans to establish the Health Protection Agency (HPA). Initially, it is proposed to establish HPA as a Special Health Authority from 1 April 2003 under the provisions of the National Health Service Act 1977. Subsequently, the Government aims to make changes to primary legislation to establish the HPA as an executive non-departmental body by 1 April 2004, if legislative time allows.

The original plan to use the Regulatory Reform Act 2001 to change the provisions of the Radiological Protection Act 1970 has been shelved and NRPB will not be part of the Special Health Authority from 1 April 2003. Nevertheless HPA and NRPB will work closely together to develop a co-ordinated plan to deal with emergencies and to identify areas for collaborative research. The radiological protection functions of HPA will be incorporated into the new legislation for the proposed non-departmental public body by 1 April 2004.

The Public Health Minister wrote at the same time to the chairs of the Public Health Laboratory Service (PHLS) and the Centre for Applied Microbiology and Research (CAMR). In her letter she says,

'Responses to the consultation paper on the Health Protection Agency showed widespread support for establishing the agency. It will improve specialist support for health protection and health emergency planning - both vital functions, particularly given the threat of terrorism. Our original proposal was to establish the agency by means of a Regulatory Reform Order, but the timetable for doing so by 1 April 2003 was always very tight. We believe that this alternative approach - of setting up first a special health authority from April 2003 and then an executive non-departmental public body - offers more certainty and security both for the agency's staff and for the users of its services.'

She adds, 'I am grateful to the boards of the three bodies for the contribution you have made so far to the development of thinking on the agency, and I know we will continue to work together on this. In particular, I would like to emphasise that it is important that the Health Protection Agency and the National Radiological Protection Board should work closely and effectively together from April 2003 to help achieve improvements in services to users.'

### Shadow Chairman of HPA

Sir William Stewart, FRS, FRSE has been identified as the Shadow Chairman of HPA; other non-executive members of the board will be appointed shortly. Sir William was previously Chairman of CAMR and is well-known at NRPB following his chairmanship of the Independent Expert Group on Mobile Phones during 1999/2000. Until very recently, he has also been chairman of the Mobile Telecommunications Health Research programme.
Sir William said, 'I am very pleased that we can look forward to the Agency's coming into being on 1 April 2003. This is a bold and progressive step which will serve the public well in the rapidly changing world of the twenty-first century.'

**Michael Clark**

## Internal links

- NRPB response to the original proposals to set up HPA

## External links

- Announcements regarding the Health Protection Agency

THE eBulletin

Radiological Protection Bulletin

# News & Affairs

**No. 2**
**(December 2002)**

## Study of car phone accidents



The Harvard Center for Risk Analysis (HCRA) has published a study which concludes that increased mobile phone use in cars has led to more fatalities and injuries in road accidents. HCRA estimates that the use of cell phones by drivers in the USA may result in approximately 2,600 deaths, 330,000 moderate to critical injuries, 240,000 minor injuries, and 1.5 million instances of property damage per year. This represents about 6% of all road traffic accidents in the USA, but because the data on cell phone use by motorists are still limited, the range of uncertainty is wide. The estimate of fatalities ranges from between 800 and 8,000, and the estimate of injuries is between 100,000 and 1 million.

**Michael Clark**

# External links

- Harvard Center for Risk Analysis - news page

THE eBulletin

Radiological Protection Bulletin

# News & Affairs

**No. 2**
**(December 2002)**

## Dose reconstruction at Chernobyl



Immediately following the Chernobyl accident in 1986, there were very few measurements of radionuclide concentrations in air within 30 km of the reactor site. This makes it very difficult to estimate reliable inhalation doses to the local population at the time. Some recent collaborative work, funded by the European Union, by scientists in Austria, Germany, the Ukraine and Russia has attempted to give some reliable dose estimates by establishing a radionuclide 'vector' using ground deposition measurements of caesium-137 (K Muck *et al* (2002) *Health Physics*, **82**(2), 141-56 and 157-72). They show that the ratio of iodine-131 to caesium-137 changes with distance because of the higher dry deposition velocity of iodine. The ratios of less volatile radionuclides such as strontium-90, zirconium-95, barium-140, and cerium-144 to caesium-137 decreased even more rapidly with distance because they were attached to larger particles sizes (average of 8 μm). Using this model, the reconstructed effective doses from inhalation in the 30 km zone range between 3 mSv and 150 mSv, depending on distance and evacuation time. For infants the effective doses were higher, in the range 10-700 mSv. Thyroid doses due to inhalation ranged from 0.02 to 1 Sv for adults and from 0.02 to 6 Sv for infants. In general, inhalation doses were significantly higher than external doses, the ratio decreasing with evacuation time. A further paper (G Prohl *et al* (2002) *Health Physics*, **82**(2),173-82) gives reconstructed ingestion doses using the same vector assumptions. Depending on evacuation time, effective doses from ingestion ranged from 0.003 to 0.18 Sv for adults and from 0.02 to 1.3 Sv for infants. Again, the dominant isotope giving the dose is iodine-131.

Given that the authorities did not instigate early countermeasures in 1986, and the observation of a subsequent elevated incidence of thyroid tumours in the local population who were children at the time, the high thyroid doses shown in the reconstruction is not surprising. These papers provide strong scientific support for the early imposition of countermeasures in the event of serious nuclear accidents, especially the use of thyroid-blocking iodine tablets.

**Michael Clark**

THE eBulletin

Radiological Protection Bulletin

# News & Affairs

**No. 2**
**(December 2002)**

## Residential radon and lung cancer - a new study from China



A recent paper by Wang *et al* (*American Journal of Epidemiology*,**155**, 554-64, 2002) describes an important new case control study of residential radon exposure and lung cancer. The study is set in Pingliang and Qingyang prefectures, Gansu province, China, which have low residential mobility and high mean radon levels. The latter are, at least in part, a consequence of the fact that many dwellings are below ground.

Both potential cases and controls were interviewed to obtain information on demographic characteristics, smoking, diet, cooking practices and on residential, occupational and medical histories. One point of note was that surrogates provided information for 54% of cases but only 4% of controls. Attempts were made to measure radon levels in all dwellings occupied for more than 2 years in the 30 years before entry to the study. Measurements were made with two one-year alpha track detectors. The mean radon concentrations were 230 Bq $m^{-3}$ for cases and 222 Bq $m^{-3}$ for controls. These are approximately ten times higher than average UK values.

The study team succeeded in enrolling 768 cases of lung cancer and 1659 controls for whom adequate data were available. The criterion applied was that at least one radon measurement must be available in the window of interest (5-30 years before diagnosis for cases) as must data on the primary adjustment factors. The mean coverage of the exposure window was 72% for cases and 79% for controls. There was complete coverage of the exposure window for 366 cases and 1045 controls.

Odds ratios (essentially equivalent to relative risks) for lung cancer increased significantly with increasing radon concentration ($p<0.001$). The estimated excess odds ratio at 100 Bq m-3 was 0.19 (95% confidence interval 0.05-0.47). The excess odds ratio increased steadily as attention was concentrated successively on those for whom radon measurements covered more of the exposure window, reaching 0.31 (0.10-0.81) for those with complete measurement histories.

It is expected that errors in the estimates of radon exposures will cause odds ratios to fall below their true values. The authors report that adjustment for their best estimate of exposure uncertainty increased the excess odds ratio by about 50%.

While the general picture was of a clear association between domestic radon exposure and lung cancer, one observation was striking. The association seemed stronger in those living in below ground dwellings (439 cases), rather than above ground houses and apartments (329 cases). Indeed when all cases were included the excess odds ratio for the latter was -0.01. However, when attention was concentrated on those with more complete measurement histories in above ground dwellings, the odds ratio increased steadily, reaching 0.17 for those with complete exposure histories. Reassuringly, the high proportion of proxy respondents amongst the cases did not seem to have generated any artefacts, indeed, the odds ratio was slightly higher when the analysis was restricted to subject respondents.

The unadjusted excess odds ratio from this study, at 0.19, is rather above that estimated from the miner data and from, for example, the study set in South-West England. The authors note, however, that other recent studies have also yielded higher estimates of radon risks. They conclude that their study suggests 'that effects of residential radon

may equal or exceed miner-based estimates, which are currently used to evaluate risk'.

**Gerald Kendall**

THE eBulletin

Radiological Protection Bulletin

# News & Affairs

No. 2
(December 2002)

## Mobile phones and cancer



The Swedish Radiation Protection Authority (Statens stralskyddsinstitut) has engaged two internationally well-known epidemiologists to review published epidemiological studies on the relationship between the use of cellular telephones and cancer risk. They are Dr John D Boice, Jr and Dr Joseph K McLaughlin from the International Epidemiology Institute, USA.

In their review, Boice and McLaughlin concluded that there was no consistent evidence for increased risk of brain cancer, meningioma, acoustic neurinoma, ocular melanoma, or salivary gland cancer, examined over a wide range of exposure measures, including type of phone, duration of use, frequency of use, total cumulative hours of use, tumour location and laterality (concurrence of tumour location with hand normally used during phone conversations).

Boice and McLaughlin have also reviewed the Swedish studies by Lennart Hardell *et al*, which demonstrated an association between the use of cellular phones and cancer. These, and a few studies that addressed this concern in the USA, are uninformative, either because the follow-up was too short and numbers of cancers too small (USA) or because of serious methodological limitations (Sweden).

In contrast, five well-designed epidemiological studies have been conducted in three countries and using different designs: three hospital-based case-control studies in the USA, a registry-based case-control study in Finland, and a registry-based cohort study of over 400,000 cellular phone users in Denmark. Boice and McLaughlin find a consistent picture from these studies that appears to rule out, with a reasonable degree of certainty, a causal association between cellular telephones and cancer to date. There is a caveat here, because the widespread use of mobile phones is a comparatively recent phenomenon, and it may be too early to detect any association. This point was emphasised in the Stewart Report of the Independent Expert Group on Mobile Phones (IEGMP) published in 2000.

Complementing the human data are the emerging results of experimental studies, which have failed to confirm earlier reports of possible adverse outcomes from radiofrequency exposure. Moreover, there is no biologically plausible mechanism to support a carcinogenic effect of non-ionising radiofrequency waves.

Many people today worry about the possible risks associated with the use of cellular phones. While the current state of the science is reassuring, ongoing case-control studies being conducted in 13 countries using a shared protocol, and continued follow-up of cohorts of cellular phone users, should provide further evidence regarding any possible carcinogenic effect associated with long-term cellular telephone use.

**Michael Clark**

# External links

- The full report is available from the Swedish Radiation Protection Authority website.
- Independent Expert Group on Mobile Phones

THE eBulletin

Radiological Protection Bulletin

# News & Affairs

**No. 2**
**(December 2002)**

## Molten nuclear fuel test



It may only be a small risk at 1 in 10,000 years of reactor operation, but a reactor meltdown has potentially such serious consequences that considerable resources are put into minimising the risk. Recently the Organisation for Economic Co-operation and Development Nuclear Energy Agency (NEA) announced the result of a successful international experiment on limiting the consequences of severe nuclear reactor accidents. This involved melting material representative of a light water reactor core to 2000 °C under controlled conditions and then introducing reactor steel into the melt. Complex physical and chemical phenomena occur at these temperatures and following the test, the properties of the solidified material (called 'corium') are being extensively studied. The aim of this research to refine strategies for maintaining the integrity of reactor containment materials during reactor core meltdown. The experiment was carried out at the Kurchatov Institute in Moscow under the auspices of NEA. The project brings together 16 NEA member countries and Russia.

Every project has to have an acronym and the one chosen for this is MASCA. However a perusal on OECD and related websites does not give any hints on what MASCA stands for. Perhaps it is a Russian acronym?

**Michael Clark**

# External links

- The MASCA Project on the Kurchatov Institute website
- The MASCA Project on the NEA website

- Emergency Response
- Business Activities
- Local & Regional Services


THE eBulletin

Radiological Protection Bulletin

# News & Affairs

**No. 2**
**(December 2002)**

## Cancer and the clock

eBulletin > No. 2 >

Some recent work reported by Fu *et al* indicates that mutations in mouse genes known to cause defects in circadian rhythms also seem to make the mice unusually cancer prone (*Nature* (2002) **420,** 373-74). About 30% of the mice died before they reached 16 months, half of these deaths being due to spontaneous lymphomas. In normal mice such lymphomas are usually first seen at 20 months.

The mice had both copies of the *mPer2* gene mutated, a genotype previously shown to cause a strong defect in mouse circadian rhythms. Normal mice have endogenous clocks that control physiology and behaviour with roughly 24-hour periodicity. Physiological rhythms were disrupted in the *mPer2* mutated mice and the mice also appeared to be more sensitive to gamma radiation. Irradiation led to an increased rate of tumour formation and also premature hair loss and greying.

In addition to the increase in spontaneous tumours, the relationship between gamma radiation and clock genes implies that disruption of circadian transcriptional regulation can cause defects in cell proliferation and death. There appears to be a transcriptional cascade from clock genes to downstream growth control and growth effector genes.

**Michael Clark**

- Emergency Response
- Business Activities
- Local & Regional Services


THE eBulletin

Radiological Protection Bulletin

# News & Affairs

**No. 2**
**(December 2002)**

## Sir Michael Clapham KBE

eBulletin > No. 2 >

Sir Michael Clapham died aged 90 on 11 November 2002. He was a Cambridge-educated classicist, printer, scientist and industrialist who became chairman of Imperial Chemical Industries (ICI) in the 1960s and Chairman of the Confederation of British Industry in the turbulent years 1972-74. He was a remarkable man because, while engaged in the printing industry during World War II, he serendipitously discovered the diffusion technique for isotope separation. He had been employed by the Kynoch Press (the in-house printing arm of ICI) and was trying to improve the metal photo-engraving process that produced the minute dots of ink used to print newspapers. The fine mesh required for photo engraving was fabricated traditionally by mechanical means but, in collaboration with John Humphries, Michael Clapham perfected a photo-reduction and electrolytic method to produce metal plates with thousands of invisibly small holes. Soon afterwards the application of the technique to isotope diffusion separation was realised and Clapham found himself seconded to the 'Tube Alloys Project'. He spent time in America on the Manhattan project and the rest is history. This exceptional classicist, turned printer, turned physicist and chemist, made significant contributions to science and industry (*The Times*, 2 December 2002).

**Michael Clark**

THE eBulletin

Radiological Protection Bulletin

# News & Affairs

**No. 2**
**(December 2002)**

## Measuring depleted uranium



Following the 1999 conflict in the Balkans, some public concern has been raised about the use of depleted uranium (DU) munitions in Kosovo. Various health effects from exposure have been claimed, including a 'Balkan syndrome' in some troops stationed there, both during the conflict and afterwards. A systematic study of DU concentrations in soil has recently been published (J Uyttenhove, M Lemmens and M Zizi (2002) *Health Physics*, **83**(4) 543-48) following a collaboration between the Belgian Ministry of Defence and the Physics Department of the University of Ghent. Using a high-resolution gamma spectrometer, 150 soil samples from 50 selected sites all over Kosovo were analysed in the laboratory. Of the 50 chosen sites, 14 were close to areas where military information had revealed the use of DU munitions. After careful analysis, the authors conclude that there is no indication of DU contamination at any of the 50 sites, with a minimum detectable activity of 15 Bq. However, the authors make it clear that their conclusion relates to hypotheses about widespread DU contamination in Kosovo. For safety reasons they did not sample areas in the immediate vicinity of known DU munitions usage. The risk posed by unexploded munitions and toxic chemicals in targeted areas was deemed too high.

The authors had to devise a sensitive method to distinguish DU from natural uranium because uranium is present naturally in all soils and because Kosovo is an area of relatively high uranium concentrations. The progeny isotopes of uranium are removed in the enrichment process and DU is in equilibrium with protactinium-234 and thorium-234 isotopes after a few months. The long half-life of uranium-234 (240,000 years) is then an effective barrier to equilibrium with any other isotopes. In practice, the 1001 keV line in the decay of protactinium-234m can be used to discriminate between DU and natural uranium. For typical natural concentrations of uranium (25 Bq $kg^{-1}$) the 1001 keV line is in the background noise of observed spectra using the Ghent spectrometer. The authors demonstrated that only if DU is present can the 1001 keV line be seen above background, and this was confirmed by comparing with DU spiked samples.

This study indicates that while some sensitive hand-held scintillation counters might be able to detect intact or fragmented DU munitions in post-battlefield conditions, such instruments could not be used as indicators of more widespread contamination. Only careful sampling and very sensitive laboratory equipment can do this unambiguously at present.

**Michael Clark**

THE eBulletin

Radiological Protection Bulletin

# News & Affairs

**No. 2**
**(December 2002)**

## Therapeutic spice



Cancer researchers at the University of Rochester Medical Center have found that curcumin, a substance in curry long believed to have health benefits, seems to protect skin during radiation therapy. Doctors say that, while further study is needed, cancer patients could consider eating foods with curry during their radiation treatment. Curcumin, the substance that gives turmeric its yellow colour, is a natural anti-inflammatory compound and scientists have already shown that it can suppress tumor blood vessel growth. This process, called anti-angiogenesis, can strangle tumors. Now reserachers from the James . Wilmot Cancer Center have discovered through a study of mice that curcumin may protect skin from the burns and blisters that often occur during radiation treatment.

Scientists presented results of the pilot study at the 44th annual meeting of the American Society for Therapeutic Radiology and Oncology, held in New Orleans in October 2002. The team of researchers, led by Ivan Ding, assistant professor of radiation oncology, studied the impact of various doses of curcumin on skin protection in mice given radiation therapy. The difference in skin damage was dramatic. This could be significant because skin damage is a perennial problem for patients undergoing radiation to treat their tumours. If a non-toxic, natural substance can help prevent this damage and also enhance the effectiveness of radiation therapy, there are potential benefits to patients and physicians.

**Michael Clark**

# External link

- University of Rochester Medical Center, news page

THE eBulletin

Radiological Protection Bulletin

# News & Affairs

**No. 2**
**(December 2002)**

## Don't kiss me!



A letter in the *New England Journal of Medicine* (**346**, 1833, 6 June 2002) alerts readers to yet another hazard in this ever more dangerous world. The authors had conducted a study of about 400 people with food allergies involving nuts or seeds. Although there was no direct query on the topic, twenty of those questioned reported that they had experienced an allergy as a result of being kissed. Four patients reacted even though their partner had cleaned his or her teeth.

Perhaps the most striking case was a patient who had been kissed by his mother immediately after she had tasted pea soup on the stove. Within a minute, a large weal had developed at the site. This was followed within minutes by flushing, urticaria, angioedema and severe wheezing which required the administration of epinephrine in the emergency department. The puzzling feature is that the patient was known to be allergic to peanuts but not to peas. The authors speculate that the soup contained both or that the child was also sensitive to peas. However, the latter seems implausible; it is hard to believe that such an extreme allergy could have gone undetected.

In most instances reactions were mild, but the authors suggest that patients of dating age who have severe food allergies may need to tell their friends.

**Gerald Kendall**

THE eBulletin

Radiological Protection Bulletin

# News & Affairs

**No. 2**
**(December 2002)**

## Professor Challis is Chairman of MTHR



Professor Lawrie Challis OBE, Emeritus Professor of Physics at Nottingham University, has succeeded Sir William Stewart FRS, as Chairman of the Link Mobile Telecommunications Health Research (MTHR) Programme Management Committee. Professor Challis was previously Vice-chairman of the Programme Management Committee and was formerly Vice-chairman of the Independent Expert Group on Mobile Phones (IEGMP) from 1999 to 2000. The announcement was made at the MTHR seminar at the Royal Society, London on 11 November 2002.

Professor Challis said of his new role,'This is an important and exciting research programme and we are all extremely grateful to Bill Stewart for getting the programme established so effectively. It is a great honour and privilege to follow in his footsteps.'

Sir William Stewart, the outgoing Chairman, commented, 'I was recently appointed Shadow Chairman of the proposed Health Protection Agency and I must devote a major part of my time and effort into the setting up of this hugely important new agency. I shall be sorry to step down because the MTHR is a good committee. However I have worked well with Lawrie Challis for many years and am very pleased that the MTHR will be in his safe and independent hands.'

Following the publication of the report by IEGMP in May 2000, the Link MTHR programme was set up in 2001 to look into the possible health impact of mobile telecommunications. The research programme is funded jointly by industry and Government on a 50:50 basis, and funds of around £7M have been allocated to the programme so far.

**Michael Clark**

# External links

- Link Mobile Telecommunications Health Research (MTHR) Programme
- Independent Expert Group on Mobile Phones (IEGMP)

THE eBulletin

Radiological Protection Bulletin

# Article

**No. 2**
**(December 2002)**

## Occupational exposure to electromagnetic fields in the context of the ICNIRP guidelines



**The International Commission on Non-Ionizing Radiation Protection (ICNIRP) published guidelines for limiting exposure to electromagnetic fields (EMFs) in 1998. The guidelines are intended to protect people against the known adverse health effects arising from exposure to EMFs. There is a great deal of interest within certain sectors of industry over whether occupational exposures to EMFs comply with the ICNIRP guidelines. NRPB has conducted assessments of occupational exposure to EMFs produced by a wide range of devices used in a variety of industrial and commercial applications. A review has been published that summarises measured data obtained through the assessments and considers the exposures in the context of the ICNIRP guidelines. The Health and Safety Executive provided funding to support the review.**

The ICNIRP guidelines advise *basic restrictions* that are based directly on established health effects and it is stated that protection against adverse health effects requires that these basic restrictions are not exceeded. The physical quantities used to specify the basic restrictions are as follows where the frequency range over which each restriction applies is given in brackets: induced current density (up to 10 MHz), specific energy absorption rate (SAR) (100 kHz to 10 GHz) and power density (10 to 300 GHz). Current density and SAR cannot be readily measured in tissues within living people, therefore ICNIRP has introduced *reference levels* for practical exposure assessment purposes to determine whether the basic restrictions are likely to be exceeded. The reference levels are expressed in terms of electric field strength, magnetic field strength (and magnetic flux density), power density, limb current, contact current and specific energy absorption.

Compliance with the reference levels ensures compliance with the relevant basic restrictions.The reference levels are not, however, limits and if they are exceeded by measured or calculated values, it does not necessarily follow that the basic restrictions will also be exceeded. The guidelines state that whenever a reference level is exceeded it is necessary to test compliance with the relevant basic restriction and to determine whether additional protective measures are necessary.

A review of occupational exposures to electric and magnetic fields at sub-optical frequencies has recently been published (Cooper, 2002). Measurements of electric and magnetic field strength, magnetic flux density, power density and contact current are reported that have been obtained in assessments of exposure to EMFs undertaken by NRPB in recent years. The data are necessarily selective since the exposure assessments were carried out at the request of customers of NRPB, therefore it cannot be assumed that all potential occupational exposure conditions are addressed. Nevertheless, the review covers a number of devices and applications including electricity generation, resistance welders, induction heaters, plasma discharge equipment, security systems and access control equipment. Compliance with the ICNIRP guidelines was assessed by comparing the measured data with the reference levels advised by ICNIRP for occupational exposure. Data published in a previous report (Allen *et al*, 1994) were also compared with the reference levels to investigate compliance.

The measurements of electric field strength and magnetic flux density reported in the review are summarised in Figures 1 and 2. Many of the measurements complied with the relevant reference levels; however, a number of devices and applications can be identified where the reference levels may be approached or exceeded under certain circumstances.

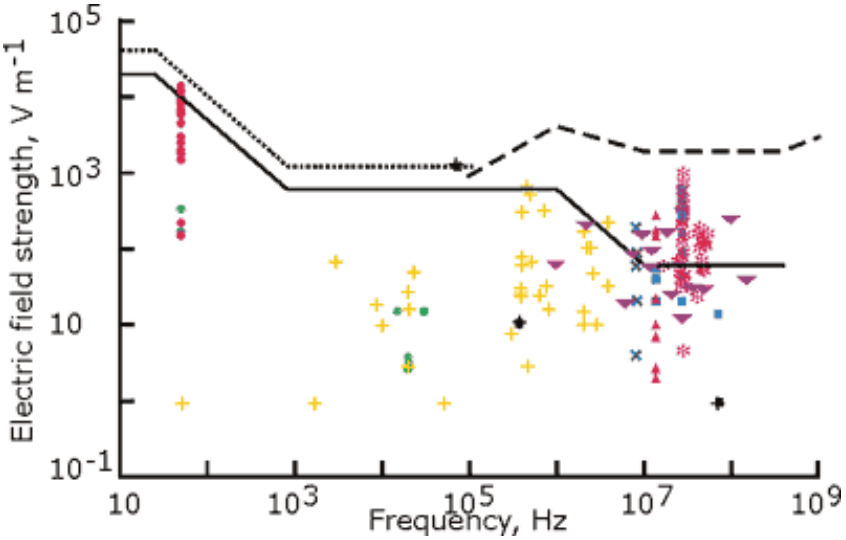



**FIGURE 1 Occupational electric field exposures shown with the ICNIRP reference levels for root mean square (rms) electric field strength (solid line) and peak electric field strength (broken line). The dotted line extending to frequencies below 100 kHz indicates the rms reference level that applies under conditions in which adverse indirect effects from contact with electrically charged conductors can be excluded**

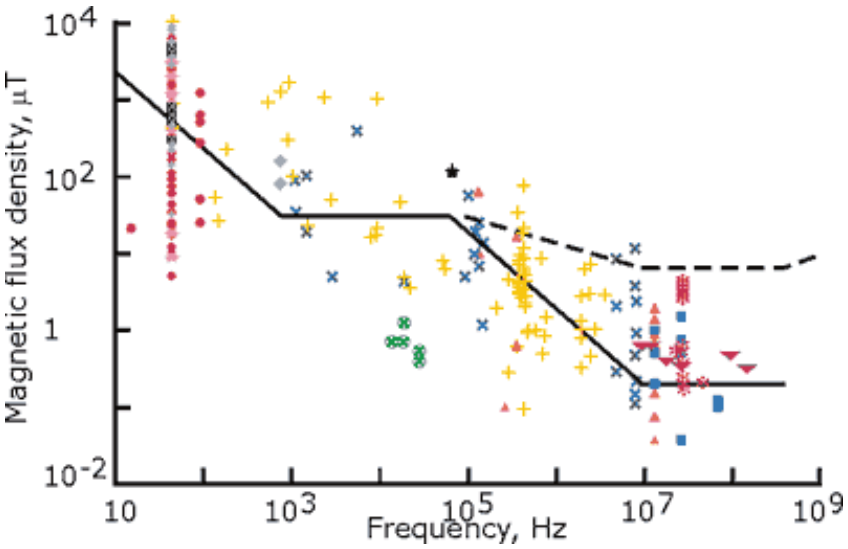
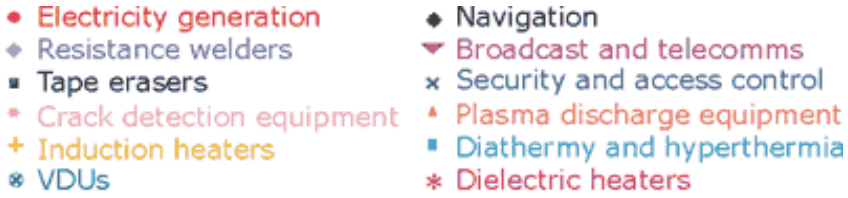



**FIGURE 2 Occupational magnetic field exposures shown with the ICNIRP reference levels for rms magnetic flux density (solid line) and peak magnetic flux density (broken line)**




**Key for figures**

Exposures at frequencies below 100 kHz that exceeded the reference levels were found close to electricity generating equipment, resistance welders, tape erasers, crack detection equipment, induction heaters and metal detectors. Many of these devices employed high currents, therefore the magnetic fields tended to be more critical than the electric fields when the measurements were compared with the respective reference levels. In fact, the reference level of electric field strength was not found to be exceeded anywhere under conditions where contact

with electrically charged conductors could be avoided. In many cases, the magnetic flux density reduced rapidly with increasing distance from the source and the reference level was exceeded at locations where the limbs and extremities might be exposed but where other parts of the body would not normally be situated. In these cases it is likely that the guidelines would not be exceeded since the basic restriction on induced current density applies only to tissues of the central nervous system in the head and trunk of the body.

In situations where the head and trunk might be exposed and where the reference levels were exceeded, the potential for the basic restriction to be exceeded may depend on the position occupied by the operator and the spatial distribution of the magnetic field. The ICNIRP reference levels of electric field strength and magnetic flux density are intended to be spatially averaged values over the entire body of the exposed individual, providing the basic restrictions on localised exposure are not exceeded. Many of the fields produced by the devices considered above were found to exhibit considerable spatial variation. Consequently, the current density induced in the body under realistic conditions may be less than that which would be induced assuming the whole body is exposed uniformly to the maximum field strength measured at a point in space.

Exposures at frequencies above 100 kHz may be averaged over time before comparing them with the reference levels, although the basic restriction on induced current density should still be complied with at frequencies below 10 MHz. Details on how time averaging is to be applied are specified in the ICNIRP guidelines. As a consequence of time averaging, brief exposures that exceed the reference levels may not result in the basic restrictions being exceeded if the duty factor is low. This is often the case with dielectric heaters and some security and access control systems such as radiofrequency identification (RFID) systems and anti-theft equipment. A simple numerical dosimetric analysis based on the spatial distribution of magnetic field strength (Chadwick, 1998) has been used to calculate the current density induced in a loop of human tissue, and the concomitant SAR, for many of the RFID and anti-theft devices investigated. The results indicated that the occupational basic restrictions on induced current density and SAR would not be exceeded, even under pessimistic conditions of exposure to the magnetic fields produced by the devices.

The basic restrictions that apply at frequencies between 10 MHz and 10 GHz are expressed in terms of whole-body average and partial-body SAR. The corresponding reference levels may be exceeded under certain conditions on exposure to the EMFs produced by plasma discharge equipment such as plasma etchers and radiofrequency sputtering equipment; however, time-averaging can often be applied. A broad range of exposures under diverse conditions have been found for workers involved in broadcasting, telecommunications and diathermy, hence it is difficult to draw general conclusions from the measurements reported for these applications. The potential to exceed the basic restrictions may depend on the spatial distribution of the EMFs at the position occupied by the worker and whether time averaging may be applied.

Further work is required in some areas to determine whether occupational exposures exceeding the reference levels are likely to result in non-compliance with the basic restrictions under typical working conditions. Analyses of the spatial distributions of magnetic fields produced by resistance welders, RFID devices, anti-theft equipment and other security systems would provide valuable information on exposures and would allow compliance with the basic restrictions to be investigated in greater detail. Product standards for some of these devices have been developed by the European Committee for Electrotechnical Standardization (CENELEC); the standards incorporate protocols for assessing compliance with reference levels and basic restrictions.

## References

Allen, SG, Blackwell, RP, Chadwick, PJ, *et al* (1994) Review of occupational exposure to optical radiation and electric and magnetic fields with regard to the proposed CEC Physical Agents Directive. Chilton, NRPB-R265.

Chadwick, PJ (1998) Occupational exposure to electromagnetic fields: practical application of NRPB guidance. Chilton, NRPB-R301.
http://www.hpa.org.uk/radiation/publications/archive/reports/1998/nrpb_r301.htm

Cooper, TG (2002) Occupational exposure to electromagnetic fields in the context of the ICNIRP guidelines. Chilton, NRPB-W24.
http://www.hpa.org.uk/radiation/publications/w_series_reports/2002/nrpb_w24.htm

International Commission on Non-Ionizing Radiation Protection (1998) Guidelines for limiting exposure to time-

varying electric, magnetic and electromagnetic fields (up to 300 GHz). *Health Physics*, **74**, 494-522. www.icnirp.org/documents/emfgdl.pdf

**Tim Cooper**

# External links

- International Commission on Non-Ionizing Radiation Protection
  www.icnirp.de

THE eBulletin

Radiological Protection Bulletin

# Article

**No. 2**
**(December 2002)**

## Assessment of the radiological impact of routine discharges from EU nuclear sites



**In many member states of the European Union (EU) nuclear power makes an important contribution to the production of electricity. This industry makes controlled discharges of very low level radioactive waste to the environment. Nevertheless, the population of the EU will receive additional exposures as a result of these discharges. These exposures will vary from year to year as old reactors and plant are decommissioned, new ones introduced and discharge practices change. A study has recently been completed (Smith, Bexon, Boyer *et al*, 2002) which assesses the impact of radioactive effluents discharged during routine operations from EU sites. The assessment was performed using the methodology implemented in the computer program PC CREAM. Calculations of collective doses truncated at 500 years and individual doses indicative of those received by members of the critical group were carried out for discharges occurring in the period from 1987 to 1996.**

### Introduction

NRPB, in collaboration with the Nuclear Research and Consultancy Group of KEMA ECN (NRG) in the Netherlands and Gesellschaft für Anlagen-und-Reaktorsicherheit (GRS) in Germany, has undertaken a radiological impact assessment of routine discharges from EU nuclear sites. The assessment was carried out using PC CREAM (Mayall *et al*, 1997) and the discharge database Bilcom97 compiled by the European Commission.

The study includes all nuclear power stations of capacity greater than 50 MW(e) and fuel reprocessing plants operational in EU member states between 1987 and 1996. A wide range of nuclear power stations exist in the EU including advanced gas-cooled reactors (AGRs), boiling water reactors (BWRs), fast breeder reactors (FBRs), gas cooled reactors (GCRs), high temperature gas reactors (HTGRs), pressurised water reactors (PWRs) and a steam generating heavy water reactor (SGHWR).

Bilcom97 is written in MS Access and includes data from Schnepf, R, *et al*, Radioactive effluents from nuclear power stations and nuclear fuel reprocessing plants in the European Community 1987-1991 (Radiation Protection 84, European Commission Report EUR 16901 EN) and Willemenot, JM, *et al*, Radioactive effluents from nuclear power stations and nuclear fuel reprocessing plants in the European Community 1991-1995 (Radiation Protection 104, European Commission (1999)).

### Data

The quantities of radionuclides discharged in airborne and liquid effluents from each site were taken from the Bilcom97 database. The database is based mainly on discharge data derived from reports produced by national authorities but also on discharge reports produced by site operators. Methods of reporting vary from site to site and as a result some inconsistencies occur within the database. Consequently, careful interpretation of the data was needed. In particular, assumptions had to be made regarding the radionuclide composition of aggregated discharges where breakdowns were missing or incomplete.

In addition to discharge data, an extensive set of site-specific data was needed as input to the dose calculations.

These data included details about the nuclear facility, meteorological conditions around the site and information about the habits and lifestyles typical of members of the critical group who live nearby.

## Method

The doses calculated in this study were estimated using the EC radiological impact assessment software PC CREAM (Mayall, 1997). Collective doses truncated at 500 years were calculated for the EU population and adult individual annual doses, typical of those received by members of the critical group, were calculated in the 50th year assuming a continuous and constant discharge over 50 years.

The dispersion of radionuclides discharged to atmosphere was modelled using a Gaussian plume model, taking into account the range of meteorological conditions that might prevail during the discharge. Representative meteorological data were obtained for each site, and an effective release height of 30 m, 60 m or 100 m was allocated based on the value nearest to the release height quoted for each site.

To calculate doses arising from liquid discharges the sites were grouped into two categories; 'coastal' sites which are located along the coast and discharge directly into the marine environment and 'inland' sites which are located inland and discharge into freshwater systems before ultimately reaching the sea.

Radionuclides discharged to rivers were modelled using the extended screening model in PC CREAM with complete mixing as described (Mayall, 1997). Three river systems were explicitly modelled, these being the Loire, the Rhine and the Rhone. Each inland nuclear site was allocated to one of these rivers for the purposes of calculating doses from terrestrial pathways. All the exposure pathways arising from airborne and liquid discharges that were considered are given in Table 1.

**TABLE 1 Exposure pathways included for each discharge mode**

| Atmospheric | Marine | River* |
|---|---|---|
| Inhalation of radionuclides in the plume | Consumption of seafish | External gamma from radionuclides in sediments |
| External gamma dose from airborne radionuclides | Consumption of crustaceans | External beta from radionuclides in sediments |
| External beta dose from airborne radionuclides | Consumption of molluscs | Consumption of fish |
| External beta from deposited radionuclides | Inhalation of radionuclides in seaspray | Consumption of radionuclides in drinking water |
| External gamma from deposited radionuclides | External gamma from radionuclides in sediments | |
| Inhalation of resuspended radionuclides | External beta from radionuclides in sediments | |
| Consumption of cow and sheep meat | External beta from radionuclides in fishing gear | |
| Consumption of cow and sheep liver | | |
| Consumption of cow's milk | | |
| Consumption of cow's milk products | | |
| Consumption of green vegetables | | |
| Consumption of root vegetables | | |
| Consumption of fruit* | | |
| Consumption of grain | | |

* Not available in PC CREAM for collective dose assessments

## Results and discussion

Over the reporting period of 1987 to 1996 significant changes took place which affected discharges from EU nuclear sites. Some 23 power reactors on 17 sites were shut down while an additional 23 reactors situated at 13 sites began operation. The operations conducted at reprocessing sites such as Sellafield and Cap de la Hague changed and these changes were reflected in the release profiles for these sites.

The collective exposures of the population of the EU from reported discharges and exposures of individuals living near to the nuclear site were calculated for three selected years (1987, 1991 and 1996). Exposures were broken down by site and form of discharge, ie liquid and atmospheric. More detailed results including radionuclide and pathway breakdowns of individual and collective doses are available on a CD which accompanies the main report (Smith, Bexon, Boyer *et al*, 2002).

The two most important sources over this time period in terms of contributions made to the collective dose were the reprocessing plants at Cap de la Hague and Sellafield.

In all cases individual doses are below the relevant dose limit.

**Collective dose**

Collective doses from releases to the atmosphere from nuclear power stations and reprocessing plants are summarised in Table 2 and Figures 1, 2 and 3 below. These doses comprise two separate components, the non-global component which arises only from the 'first pass' of the radioactive plume and the global component which arises only from radionuclides that have become globally dispersed. The estimated non-global component, summed over all power plants, increased in the latter stages of the study period from 14 man Sv in 1987 to 43 man Sv in 1996. The estimate of the global component also increased between 1987 (5.4 man Sv) and 1996 (27 man Sv). Both components of the estimated collective dose increased because discharges of carbon-14 from UK Nuclear Electric GCRs and AGRs were only reported after 1991 when a revised discharge authorisation came into effect. For Cap de la Hague and Sellafield, doses were calculated for each year between 1987 and 1996 (see Figures 2 and 3). For Sellafield it can be seen that there was little change in the estimate of collective dose over the study period (22 man Sv in 1987 to 16 man Sv in 1996). Important radionuclides were carbon-14 and iodine-129. For Cap de la Hague there was a consistent increase in the estimate of collective dose over the ten-year period (0.95 to 53 man Sv). From 1992 to 1996 the collective dose from this site was almost equally divided between global and non-global components. Significant contributions to the collective dose arose from carbon-14 and iodine-129. However, these radionuclides are not included in the Bilcom97 database prior to 1992 and therefore discharges and doses prior to 1992 may have been higher than those predicted in the assessment.

**TABLE 2 Collective dose truncated at 500 years from all sites (man Sv)**

| Site | 1987 | | | 1991 | | | 1996 | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Airborne** | **Liquid** | **Total** | **Airborne** | **Liquid** | **Total** | **Airborne** | **Liquid** | **Total** |
| All nuclear power stations | $2.0\ 10^{1}$* | $7.4\ 10^{1}$ | $2.1\ 10^{1}$ | $2.1\ 10^{1}$* | $5.2\ 10^{1}$ | $2.2\ 10^{1}$ | $7.0\ 10^{1}$ | $1.3\ 10^{-1}$ | $7.0\ 10^{1}$ |
| Cap de la Hague | $9.5\ 10^{-1}$** | $4.1\ 10^{1}$** | $4.2\ 10^{1}$ | $2.7\ 10^{0}$** | $4.1\ 10^{0}$** | $6.8\ 10^{0}$ | $5.3\ 10^{1}$ | $9.3\ 10^{-1}$** | $5.4\ 10^{1}$ |
| Dounreay | $5.8\ 10^{-2}$ | $4.1\ 10^{-1}$ | $4.7\ 10^{-1}$ | $2.8\ 10^{-2}$ | $1.1\ 10^{-1}$ | $1.4\ 10^{-1}$ | $6.8\ 10^{-3}$ | $1.4\ 10^{-1}$ | $1.5\ 10^{-1}$ |
| Marcoule | | | | | | | $4.9\ 10^{0}$ | $2.4\ 10^{-1}$ | $5.2\ 10^{0}$ |
| Sellafield | $2.2\ 10^{1}$ | $3.7\ 10^{0}$ | $2.6\ 10^{1}$ | $1.4\ 10^{1}$ | $3.9\ 10^{0}$ | $1.8\ 10^{1}$ | $1.6\ 10^{1}$ | $1.1\ 10^{1}$ | $2.7\ 10^{1}$ |
| WAK | $1.9\ 10^{-1}$ | | $1.9\ 10^{-1}$ | $1.3\ 10^{-2}$ | | $1.3\ 10^{-2}$ | | | |
| **TOTAL** | **$4.3\ 10^{1}$** | **$4.6\ 10^{1}$** | **$9.0\ 10^{1}$** | **$3.8\ 10^{1}$** | **$8.6\ 10^{0}$** | **$4.7\ 10^{1}$** | **$1.4\ 10^{2}$** | **$1.2\ 10^{1}$** | **$1.6\ 10^{2}$** |

* Doses do not include contribution from carbon-14 from UK GCRs and AGRs.
** Doses do not include contribution from carbon-14.

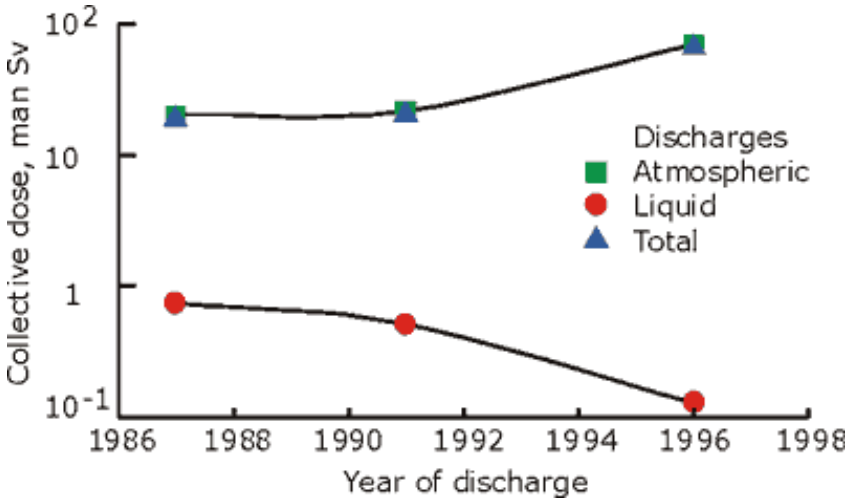



**FIGURE 1 Collective dose truncated at 500 years from discharges from all nuclear power plants**

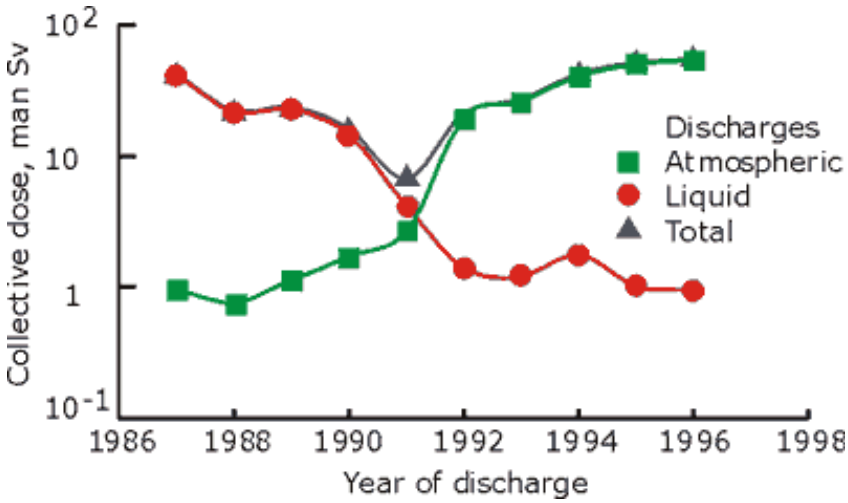



**FIGURE 2 Collective dose truncated at 500 years from discharges from Cap de la Hague**

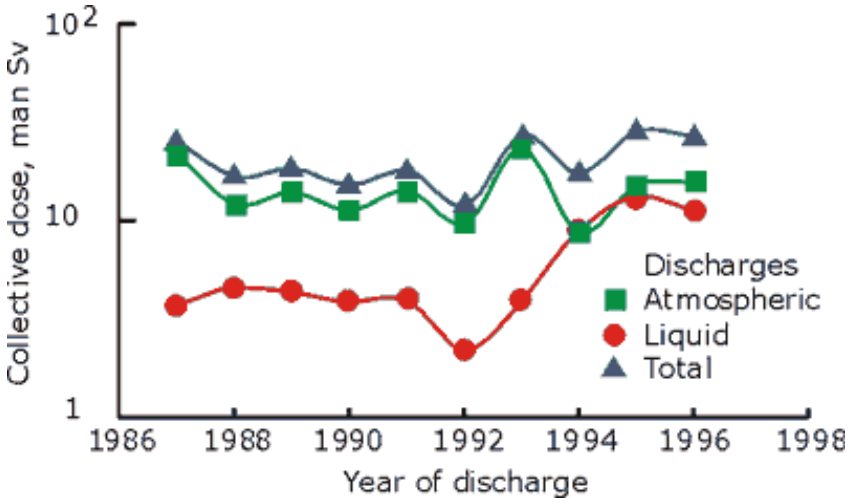



**FIGURE 3 Collective dose truncated at 500 years from discharges from Sellafield**

Collective doses from liquid discharges from nuclear power stations and reprocessing plants are summarised in Table 2 and Figures 1, 2 and 3. The estimated dose summed over all power plants decreased from 0.74 man Sv in 1987 to 0.13 man Sv in 1996. Liquid discharges from power stations tended to decrease over the time period considered, as a consequence of which exposures from airborne releases became relatively more important. For

Cap de la Hague and Sellafield, doses were calculated for each year between 1987 and 1996 (Figures 2 and 3). Collective doses arising from liquid discharges from Sellafield remained fairly steady at around 4 man Sv until 1994 when it more than doubled to around 10 man Sv. This increase was due to an increase in the level of reported discharges of carbon-14. Consequently, the global component of the collective dose made a significant contribution in these later years. The collective dose from liquid discharges from Cap de la Hague steadily declined from 1989 (23 man Sv) to 1996 (0.9 man Sv), mainly due to reductions in the discharge of ruthenium-106.

**Individual dose**

Calculated annual doses to typical adult members of the critical group are summarised in Table 3 for atmospheric releases from selected nuclear sites. These doses were generally higher for discharges from UK sites. In the UK, doses were dominated by discharges of carbon-14,sulphur-35, argon-41 and to a lesser extent tritium from GCRs and AGRs. It is again important to note that at GCRs and AGRs operated by Nuclear Electric discharges of carbon-14 were only reported after 1991 when revised discharge authorisations came into effect. Consequently the estimates of individual dose for these sites, based on the Bilcom97 database, will be underestimated for years prior to 1992. The highest annual dose from a UK site comes from Chapelcross where the dose at the site boundary (0.5 km) was approximately 0.14 and 0.12 mSv for annual releases in 1987 and 1996 respectively. At this site tritium and argon-41 were the main contributors to individual dose.

Annual doses from atmospheric discharges from selected reprocessing plants are given in Table 3. At Sellafield and Cap de la Hague doses only amounted to a few tens of µSv throughout the period of interest. At Marcoule the annual dose received from discharges in 1996 was estimated at 100 µSv and 30 µSv at 0.5 and 5 km from the site respectively. This was dominated by discharges of iodine-129. For Marcoule, the Bilcom97 database actually records halogens as the discharge category and in the absence of better information it was assumed that this comprised entirely iodine-129. This assumption is likely to contribute to the elevated dose that was estimated.

**TABLE 3 Critical group dose to adults in the 50th year from selected sites (µSv)##**

| Site | 1987 | | 1991 | | 1996 | |
|---|---|---|---|---|---|---|
| | **Airborne*** | **Liquid** | **Airborne*** | **Liquid** | **Airborne*** | **Liquid** |
| **Coastal sites** | | | | | | |
| Bradwell A and B | $1.4\ 10^{1}$ | $9.55\ 10^{0}$ | $1.2\ 10^{1}$ | $6.09\ 10^{0}$ | $1.8\ 10^{1}$ | $1.01\ 10^{1}$ |
| Chapelcross A, B, C and D | $1.4\ 10^{2}$ | $1.66\ 10^{0}$ | $1.3\ 10^{2}$ | $3.65\ 10^{-1}$ | $1.2\ 10^{2}$ | $3.64\ 10^{-1}$ |
| Hinkley Point AA and AB | $7.3\ 10^{1}$ | $5.51\ 10^{-1}$ | $4.9\ 10^{1}$ | $1.64\ 10^{-1}$ | $6.5\ 10^{1}$ | $3.1\ 10^{-1}$ |
| Heysham 1A and 1B | $8.6\ 10^{0}$ | $9.24\ 10^{0}$ | $1.2\ 10^{0}$ | $1.01\ 10^{1}$ | $1.0\ 10^{1}$ | $3.09\ 10^{0}$ |
| Paluel 1, 2, 3 and 4 | $5.5\ 10^{-1}$ | $6.97\ 10^{1}$ | $3.2\ 10^{-1}$ | $9.42\ 10^{0}$ | $8.6\ 10^{-2}$ | $5.56\ 10^{-1}$ |
| Cap de la Hague | $4.9\ 10^{-1}$ | $1.73\ 10^{2}$ | $1.4\ 10^{0}$ | $1.16\ 10^{2}$ | $6.9\ 10^{1}$ | $1.87\ 10^{1}$ |
| Sellafield | $3.2\ 10^{1}$ | $1.87\ 10^{2}$ | $2.7\ 10^{1}$ | $1.46\ 10^{2}$ | $3.9\ 10^{1}$ | $1.14\ 10^{2}$ |
| **Inland sites (Group Y)**** | | | | | | |
| Bugey 2, 3,4 and 5 | $1.9\ 10^{-1}$ | $1.98\ 10^{1}$ | $1.8\ 10^{-1}$ | $7.6\ 10^{0}$ | $5.5\ 10^{-2}$ | $4.55\ 10^{-1}$ |
| Chinon B1, B2, B3 and B4 | $1.5\ 10^{-1}$ | $1.19\ 10^{1}$ | $5.6\ 10^{-1}$ | $8.41\ 10^{0}$ | $1.0\ 10^{-1}$ | $2.19\ 10^{0}$ |
| Dampierre 1, 2, 3 and 4 | $4.9\ 10^{-1}$ | $3.90\ 10^{1}$ | $2.3\ 10^{-1}$ | $1.79\ 10^{0}$ | $5.8\ 10^{-2}$ | $1.0\ 10^{0}$ |
| *** | | *$2.77\ 10^{1}$* | | *$1.26\ 10^{0}$* | | *$3.16\ 10^{-1}$* |
| Le Balayais 1, 2, 3 and 4 | $2.8\ 10^{-1}$ | $1.58\ 10^{1}$ | $3.7\ 10^{-1}$ | $3.54\ 10^{0}$ | $6.1\ 10^{-2}$ | $9.61\ 10^{-1}$ |
| Marcoule (APM) | # | # | # | # | $1.0\ 10^{2}$ | $3.07\ 10^{2}$ |

* Exposures indicative of those received by members of the critical group located 0.5 km from the discharge point.

** Individuals residing on the coast near the river mouth who are exposed via the following pathways: consumption of sea fish, molluscs and crustaceans; external gamma and beta from marine sediments and fishing gear; inhalation of seaspray.

*** Doses in italics are for group X critical group members ie individuals residing close to the river who are exposed via the following pathways: external gamma and beta from the river bed sediments; consumption of freshwater fish and drinking water.

# No atmospheric or liquid discharges reported on Bilcom97 database from 1987 to 1995.

## Individual annual doses, typical of those received by members of the critical group, calculated in the 50th year assuming a continuous and constant discharge over 50 years.

Individual exposures from discharges into the aquatic environment are summarised, for selected sites, in Table 3. Exposures to discharges from coastal sites generally gave rise to doses of a few mSv for the majority of power stations.

More significant exposures arose as a result of discharges from reprocessing plants. Because of the radiological importance of Sellafield and Cap de la Hague the individual dose calculation was refined using observed to predicted ratios based on data from IPSN (1999) and Simmonds, Mayall, Lawson *et al* (1993) to calibrate the marine dispersion model. The results presented here are the refined calculations. At Cap de la Hague the refined dose calculation was based on measurement data for the Les Huquets region of the Normandy coast. Doses dropped steadily from 170 µSv in 1987 to 19 µSv in 1996 and were dominated throughout this period by the consumption of molluscs contaminated with ruthenium-106 and plutonium-241 and external exposure to gamma rays from cobalt-60 in sediments. Doses to individuals residing near the Sellafield site also decreased from 187 µSv in 1987 to 114 µSv in 1996. The contribution to dose from various radionuclides and exposure pathways varied considerably over the study period. However, important radionuclides included technetium-99 in crustaceans, carbon-14 and caesium-137 in fish, ruthenium-106 and plutonium-241 in molluscs and external exposure to cobalt-60, zinc-65, zirconium-95, niobium-95, and europium-152.

In the method for modelling exposures from inland sites discharging to rivers, three groups of individuals were considered:

X: those residing close to the river,
Y: consumers of seafood, and
Z: individuals inhabiting the area around the river estuary.

Doses to group X were calculated assuming that these individuals live 10 km downstream of the discharge point and are exposed only to external gamma and beta from river bed sediments, consumption of freshwater fish and drinking water. These doses are generally only a few microsieverts. Doses to groups Y and Z were calculated using activity concentrations derived from the river model as a source term for the marine dispersion model. Group Y individuals are seafood consumers and group Z individuals are exposed to external gamma and beta in marine sediments, external gamma and beta from handling fishing gear, and inhalation of seaspray. Group Y individuals always belong to the country in which the discharging site operates while individuals in group Z will only differ from those in group Y if the river discharges into the sea from a country in which the site does not operate. The highest doses to group Y individuals were calculated for Bugey (1987) at 20 µSv, Chinon (1987) at 12 µSv, Dampierre (1987) at 39 µSv, Le Blayais (1987) at 16 µSv and Marcoule (1996) at 300 µSv. Where group Z individuals differed from group Y the doses to the former were, in general, at least a factor of five lower and in most cases a factor of ten lower than those to group Y.

## References

IPSN (Nord-Cotentin Radioecology Group) (2000) Estimation of exposure levels to ionzsing radiation and associated risks of leukaemia for populations in the Nord-Cotentin. Summary report.

Mayall, A, *et al* (1997) PC-CREAM - Installing and using the PC system for assessing the radiological impact of

routine releases. EUR 17791 EN, NRPB-SR296. Luxembourg, Office for Official Publications of the European Communities.

Simmonds, JR, Mayall, A, Lawson, G, *et al* (1993) Potential critical group doses due to the proposed authorised discharges for the BNFL Sellafield site. NRPB-M420, NRPB, Chilton.

Smith, JG, Bexon, A, Boyer, FHC, *et al* (2002) Assessment of the radiological impact on the population of the European Union of discharges from European Union nuclear sites between 1987 and 1996. Luxembourg, Office for Official Publications of the European Communities.

**Justin Smith**

# External links

- The report is published on the website of the European Union

THE eBulletin

Radiological Protection Bulletin

# Article

**No. 2**
**(December 2002)**

## A gamma radiography accident in Russia - a lesson learned the hard way



**Gamma radiography is frequently used in industrial situations for non-destructive testing to check the integrity of metal objects. A type of equipment commonly used consists of a highly radioactive sealed capsule of iridium-192, attached to a cable so that, from a safe distance, it can be wound out from a shielded container and through a guide tube to the radiography position. When the exposure is over the source is wound back to safety. A, thankfully, rare problem with this equipment occurs when the source becomes detached from its cable and then remains free, but out of sight, inside the guide tube. Radiographers are taught always to check for this remote possibility using a portable radiation monitor. However we do not live in an ideal world; sometimes they do not check and this has occasionally led to serious accidents.**

NRPB staff have collaborated with colleagues in Moscow and Obninsk to describe just such an accident and its medical consequences to three men who were using a 9 TBq (~240 Ci) iridium-192 source to check welds in a gas pipeline in the Samara district of Russia. They were working one evening in a remote location and did not detect that the source had detached because they had no batteries for their radiation monitor. They finished working, packed up the equipment, put it into the back of their lorry, ate a meal, and then slept on bunk beds in the lorry. Early the next morning all three were ill with nausea and vomiting which they blamed on drinking bad water the previous evening. Still feeling sick, they drove back to base, parked the lorry, went home and recovered over the next few days. The lorry remained unused until the three went out again eight days later. As they were setting up to expose more radiographs they discovered the loose source and one man, against proper procedures, retrieved the source with his bare hands and returned it to the shielded container.

They did not report the incident and almost a month passed before they sought medical help whereupon the doctors quickly diagnosed serious radiation overexposures. By this time all three had severely lowered white blood cell counts and the man who had retrieved the source had bad burns on both hands. The man whose bunk bed had been closest to the source was feeling listless, had a raised temperature and throat infection due to his depressed white cell count, and had bleeding into his skin because his platelet count was very low. He later developed pneumonia. All three eventually recovered in a Moscow hospital and returned home to Samara where their medical condition is being followed up. The hand burns healed but there is a possibility that they will eventually require surgery if slowly developing changes cause problems with the local blood circulation.

The men were not supplied with personal dosemeters and so their radiation doses were estimated by several other techniques that are described in the joint NRPB/Russian paper (Sevan'kaev, AV, Lloyd, DC *et al*, 2002). Calculated localised doses to various parts of the burned hands ranged from 30 to 70 Gy. Two men later each had a tooth removed and the enamel was analysed by the technique of electron spin resonance. This indicated doses of 2.6 and 3.8 Gy, which were consistent with their heads being towards the source as they slept. Much of their exposure was received while they were sleeping and this could be estimated from the dose rate emitted by the source, the positions of the bunks and the time. Their accounts of the events during that evening, the journeys to and from base and the later recovery of the source also permitted tentative dose calculations. The averaged whole-body doses were also estimated from the degree of depression of blood cell counts and chromosome aberrations in blood lymphocytes.

Because about a month elapsed before they reported sick, the chromosome analyses were made by the FISH

retrospective method as well as the conventional dicentric assay. There was a good measure of agreement between the various estimates of averaged whole body doses which, in summary, were between 2.5 and 3.0 Gy for the man who slept closest to the source and between 1.0 and 2.0 Gy for the others.

## Reference

Sevan'kaev, AV, Lloyd, DC *et al* (2002). Cytogenetic investigations of serious overexposures to an industrial gamma radiography source. *Radiation Protection Dosimetry*, **102**(3), 201-06.

**David Lloyd**

THE eBulletin

Radiological Protection Bulletin

# Report

**No. 2**
**(December 2002)**

## Current issues in radiation and health



**This report summarises the main issues raised at the 15th American Statistical Association (ASA) Conference on Radiation and Health, which was held in Florida, USA, 23-26 June 2002. The conference was designed to discuss the qualitative aspects of radiation health research in a multi-disciplinary setting and to learn about new quantitative approaches to the problems and applications in health related disciplines. The agenda covered the following topics: residential radon and alpha emitters; bystander effects; diagnostic medical radiation exposures; radiosensitive subpopulations; medical workers expose to radiation. In total, 19 presentations were given by the invited speakers.**

### Residential radon and alpha emitters

This session looked at internal exposures from high-LET alpha emitters. The importance of the Mayak workers cohort from the former USSR was discussed, in particular, their potential to fill important gaps in radiation epidemiology. This group consists of about 20,000 workers of both sexes who received high doses compared to radiation workers in the UK and USA. Significant associations were shown between internal exposures from plutonium and cancers of the lung, liver and bone. However, uncertainty exists in the dose estimates and it was also noted that most of the workers both smoked and consumed alcohol. Further analyses that could be undertaken to improve these risk estimates were discussed.

The results from a new case-control study in China (Wang, Lubin *et al* (2002) *American Journal of Epidemiology*, **155**, 554-64) and from a pooling of North American studies have demonstrated a dose-related lung cancer risk from exposure to residential radon. Study methodologies, statistical models and potential biases were also discussed.

### Bystander effects

David Brenner (Columbia University, New York) presented an overview of his analysis of radon effects (Brenner *et al* (2002) *International Journal of Radiation Biology*, **78**, 593-604). He explained the mechanisms for determining radon risk estimates based on bystander effects on cells that have not received direct radiation doses but that are in close proximity to cells that have been irradiated. The dose-response relationship under the bystander effect was discussed. The study proposes a non-linear relationship with inverse dose-rate effects at low doses, due to the fact that this effect is saturated at high doses. The implications for assessing domestic radon risk using this specific mechanism were addressed.

### Diagnostic medical radiation exposures

This session was concerned with aspects of diagnostic radiation dosimetry and epidemiological perspectives. The problems of reducing patient doses without reducing the benefits to the patients and the variability in doses were addressed. It was noted that doses from x-ray examinations have gradually fallen over time. However, from the mid-1980s, the use of computed tomography (CT) scanners - which can result in high doses - has increased. In some countries, diagnostic radiology may contribute as much as 40% of the collective dose. Moreover, there is a particular concern about the high doses that can be delivered in paediatric CT examinations. Brenner and his colleagues have recently published an analysis which estimated the number of radiation-induced cancers that might result from

paediatric CT scans in USA (Brenner *et al* (2001) *American Journal of Radiology*, **176**, 289-96; Brenner (2002) Pediatric Radiology, **32**, 228-33). A cohort study of 100,000 is being planned in the USA to evaluate cancer and other health effects from CT scans.

In addition, Martha Linet from the US National Cancer Institute (US NCI) presented an overview of studies on children's cancer risk in relation to their exposure to diagnostic medical radiation. She summarised the work that had been already undertaken on childhood cancer and abdominal diagnostic x-ray exposure of mothers during pregnancy, especially in Great Britain, USA and Sweden. She concluded that the risk had declined over time due to substantial reductions in the number of films per examinations. She also noted that there was no association between ultrasound tests during pregnancy and risk of childhood leukaemia. She then discussed a number of methodological issues that needed to be considered for future studies, including the lack of validation of dose estimates, potential confounding factors such as underlying medical conditions, prophylaxis issues - practitioners are uncertain whether to reduce radiological examinations - and policy issues - communication between practitioners and patients, and between population and researchers, needs to be improved.

## Radiosensitive subpopulations

Roger Cox (NRPB) gave a presentation on genetic susceptibility to radiation tumorigenesis. He discussed the complexity, problems and prospects for resolution of radiosensitivity. Martin Lavin (Queensland, Australia) explained the relationship between breast cancer risk and heterozygotes for the radiosensitive human disorder, ataxia-telangiectasia (AT), for which estimates of spontaneous risk vary from study to study. The session also looked at radiation and genetic susceptibility in the DNA repair pathways for non-melanoma skin cancer which indicated the presence of a gene environment interaction.

## Medical workers exposed to radiation

Kiyohiko Mabuchi (US NCI) gave a presentation on radiologists and radiological technologists who were exposed occupationally. They formed the earliest occupational group exposed to radiation, and numbered about 2 million worldwide (UNSCEAR (2000)). A high proportion of radiological technologists were female. In 1902, soon after the discovery of x-rays, the first excess of skin cancer linked to radiation was reported among radiologists. A summary of published studies in the UK, USA, China, Denmark, Japan and Canada of occupational medical exposures was presented.

There are problems with assessing exposures especially in the early part of the 20th century, because regular monitoring of radiation exposure only began in around 1950. Doses have been significantly reduced compared to the past because of improvements in radiological protection and technical improvements. For example, the geometric mean annual exposure for the US radiological technologists decreased from 0.5 mSv in 1977 to 0.04 mSv in 1998. Cancer risks were raised among medical radiation workers in those studies, especially in the early calendar periods. Several studies suggested elevated risk for cancers of the breast, thyroid and leukaemia, and among Chinese x-ray workers non-melanoma skin cancer was increased. Inconsistencies between these studies were discussed, including differences in the choice of reference population, level of cancer ascertainment and method of dose estimation. Also, the importance of characterising exposures derived from diagnostic and treatment purposes in medical settings (x-ray exposure and photon energies) was addressed, as was the importance of designing case/control studies which may allow the use of persistent genetic markers of exposure; however, more research would be needed to investigate this type of exposure assessment and to determine whether it might give rise to significant bias in risk estimation.

This ASA meeting succeeded in its aim of further improving communication between those with interests in the epidemiological, dosimetric and fundamental aspects of research on radiation cancer risks. Impressive breadth topics were covered, discussion was brisk and the proceedings were in no way dampened by the stormy weather that affected Florida during that week.

**Nezahat Hunter**

If you have any feedback or questions for the editor, please contact us at:

National Radiological Protection Board
Chilton
Didcot
Oxon
OX11 0RQ
E-mail: publications@hpa-rp.org.uk

**Editor:** Michael Clark (e-mail: michael.clark@hpa-rp.org.uk)

**Correspondence:** Letters for publication on this issue are invited. They should have no more than 500 words. The Editor's decision is final.

THE eBulletin

Radiological Protection Bulletin

# Report

**No. 2**
**(December 2002)**

## Berlin Colloquium 2002



The 38th Berlin Colloquium was held from 23 to 26 October 2002 in the usual venue, the Institute for Applied Radiation Protection of the Bundesamt für Strahlenschutz (BfS). The format for these German-language meetings is now well established. Five varied topics are chosen for discussion, each session being introduced and moderated by an expert from the host organisation. There is no written record and Chatham House rules apply so that participants can speak freely. This meeting, like earlier ones, attracted participants from over a dozen European countries, though no one from the European Commission.

One of the lessons learned from the Chernobyl accident is that the risk of thyroid cancer in children from radioiodine must not be underestimated. Both a WHO and an UK Expert Group had suggested that intervention levels should be reviewed. There were good scientific reasons for considering an upper age limit of, say, 45, but a number of countries had decided that the risks of intake by older people were low enough to offset the practical and presentational problems of attempting to introduce such a cut-off. Strong opinions were expressed on the question of whether stable iodine should be distributed before a possible accident or only when a need arose. The latter was described as the preferable policy only for accidents which do not happen. There were modest differences in suggested doses for individuals of different ages. In one case these were frankly ascribed to the practical impossibility of dividing a tablet into fractions smaller than a quarter.

If the worst happens and there is a nuclear accident to deal with, there are obvious problems if different countermeasures are instituted in neighbouring countries, delimited only by a line on a map. The solution is obvious: harmonised intervention levels, compatible and consistent accident consequence codes and real-time sharing of monitoring data. It is clear that we are some way from achieving this goal through the recognition of problems is a step in the right direction. In particular, there now seems to be a feeling that 'pulled' information systems in which those with a need access a server to obtain the most up to date information are better in practice than 'pushed' ones in which information is sent to those identified as having a need to know. One delegate remarked that the latter sometimes resulted in the same information echoing around the system and reaching some organisations twice if not three times. This inevitably caused confusion.

One potentially contentious viewpoint was that, where decisions on countermeasures against possible deterministic effects must be made on the basis of scant evidence, then great conservatism should be applied. It is certainly clear that it will often be too late for the effective implementation of many countermeasures if we wait until comprehensive monitoring data are available.

There was an interesting session exploring the possibility of replacing national research programmes in radiation protection by a European or other supranational one. The question was almost answered by the frank admission of many participants that they lacked even the former. Nevertheless, a feeling emerged that, despite the proven strengths of informal links between workers in the same field wherever they might be based, trans-national programmes, like those of the European Union were helpful in building bridges where they did not already exist. As the discussion developed it became clear that, while there were many common themes, there were interesting differences in national emphasis - for example, between research in non-ionising radiation being channelled to mobile phones or to power line research. In one country, a wild boar which had been found to contain 70,000 Bq/Kg of caesium had resulted in its own, posthumous, research programme.

It is well known that different European countries have very different radon levels. Some might have been surprised that the session on control of occupational exposures nevertheless showed a general commonality of approach, albeit with varying Action Levels to help even out difference in size of the potential problem. The European Basic Safety Standard probably played a leading role in this satisfactory outcome. Two groups of nations could be distinguished: those with effective action levels around 1000 Bq $m^{-3}$ and those around 400 Bq $m^{-3}$. In all cases, lip service was paid to the idea that this level might be adjusted in the light of knowledge about the equilibrium factor, but with no real expectation that this would be anything other than an exceptional case. There was now a general recognition that large volumes of water from boreholes or other underground sources could lead to substantial problems of radon in air as the radon out-gassed. Water works are the obvious problem workplaces, but one participant said that he was taking seriously the possibility of problems in breweries with their own water supply. Concern was expressed in case excessive radon levels might arise in Germany where the Reinheitsgebot forbids the addition of anything to water, malt and hops in the production of beer. There were other possible hazards which some participants might have overlooked. Hydroelectric plants offered even greater potential problems than waterworks if the water came from subterranean sources. Radon in mushroom-producing caves was another possibility which it was easy to overlook.

Participants at these meetings often report incidents which seem to belong firmly in the 'stranger than fiction' category. One of these involved a lorry-load of cakes, which underwent a radiological examination as it left one country. The process was observed by a diligent customs officer from the potential destination country, who then refused to allow the lorry in on the grounds that irradiated foodstuffs were forbidden.

As usual, the hosts from BfS are to be congratulated on a well-organised and enjoyable meeting. Only one aspect of the 2002 meeting was an obvious disappointment. A representative of the European Commission had to cancel participation at the last moment. A viewpoint from this source has been very important in the past and this is likely to become increasingly the case as candidate countries try to prepare themselves for entry.

**Gerald Kendall**

THE eBulletin

Radiological Protection Bulletin

# Report

**No. 2**
**(December 2002)**

## International symposium on the measurement and assessment of radon and thoron in the environment



**The Chinese Society for Radiological Protection and the School of Nuclear Science and Technology of Nanhua University jointly organised this international symposium on 27-31 May 2002 in Henyang, China. About fifty scientists from all parts of China, together with a sprinkling of invited speakers from even further away, met to discuss recent advances in knowledge on levels, measurement techniques and effects of radon and thoron in the environment.**

Pan Ziqiang opened the meeting with a short keynote address on exposures to radon and thoron in China. China has, of course, a substantial mining industry, encompassing coal and both ferrous and non-ferrous metals. Coal mining employs about six million underground miners, whose mean exposure is about 5 mSv. The collective dose is between 2 and 3 $10^4$ man Sv per annum. Fewer miners are employed in metal mining, but the numbers still run to many tens of thousands and their mean exposure is perhaps a factor three higher than in coal mines.

Perhaps the most striking feature of this meeting was the prominence given to the short-lived (55 second) isotope of radon with mass number 220 as opposed to the longer lived (4 day) isotope, radon-222. In this account the usual convention of referring to these isotopes as 'thoron' and 'radon' will be followed. It is true that, under most circumstance, the latter is likely to be of greater radiological significance. But the difficulties in measuring thoron also contribute to its lower profile. Since its half life is less than one minute, thoron cannot, for example, diffuse into the kind of sealed etch-track detector which has become the world standard for long-term measurements of radon. Moreover, the concentrations of thoron decrease as one moves away from the source - usually building materials in a domestic context.

Papers on the particular problems of thoron exposures in the so-called 'cave dwellings' of Shaanxi Sheng province were given by Feige (Germany) and Shang Bing. The dose from thoron and decay products can greatly exceed that from radon and decay products (Feige reported means of 15 and of 2.4 mSv per annum respectively). A particular problem can arise if people sleep on a kang or earth bed, a portion of the original substrate, left undisturbed when the dwelling is excavated. A sleeper's nose will be only a few centimetres from the surface and the thoron dose can be much higher than that which would be experienced at a greater separation from the source.

A number of papers, for example, that from Qiu Shoukang, discussed problems of thoron instrumentation. The University of Nanhua has established one of the IAEA Regional Standard Radon Reference Chambers. They are now working towards the much more difficult task of developing a thoron reference chamber.

Undoubtedly one of the high spots of the conference was the presentation by Professor Wang Zuoyuan of the recent case/control study of the effects of residential exposure to radon set in Gansu Province. A brief account of this study will be familiar to *Bulletin* readers. Wang placed this study firmly in the context of the totality of the effects of domestic exposure to radon. He emphasised that no single study will provide a complete understanding of this complex problem. Nevertheless, there is a substantial corpus of knowledge, based on epidemiology, of the effects of exposure to radon which outweighs that on the effects of other types of radiation.

Leung (Hong Kong) extended the horizons for many participants by describing the technique of atomic force

microscopy (AFM). In AFM, a piezo-electric crystal is used to scan a tiny probe over the surface to be investigated. Both contact and non-contact modes are possible. In the latter, the probe is vibrated as it moves over the surface and information is gathered about its Van der Waals interaction with the features below. This technique is in its infancy, but opens up the possibility of, for example, examining the development of an alpha particle track during the etching of a material such CR-39.

A great deal of ground was covered during this interesting meeting. As well as the formal business of the symposium, periods were scheduled for wide-ranging discussions between local scientists and the foreign visitors. There was also considerable focussed activity around the radon chamber as the opportunity was taken for intercomparisons.

The organisers are to be congratulated on a fruitful and well-organised meeting. It is proposed that this should be the first in a series, with a frequency of perhaps every three years. These should provide a useful forum to consider problems of natural radiation as they arise in Asia.

**Gerald Kendall**

- Emergency Response
- Business Activities
- Local & Regional Services


THE eBulletin

Radiological Protection Bulletin

# Report

**No. 2**
**(December 2002)**

## Radioactivity in the environment - an international perspective

eBulletin > No. 2>

**An international conference on radioactivity in the environment was held in Monaco from 1 to 5 September 2002. The conference covered a wide range of topics, notably protection of the environment, the human and societal effects of exposure to radiation, vulnerable ecosystems, remediation and restoration of contaminated ecosystems and radioecology.**

This wide-ranging conference overlapped with the World Summit on Sustainable Development and a number of speakers pointed out the many links between the two events, notably regarding the need to protect the environment as a whole and not just people from ionising radiation. Protection of the environment was one of the main themes of the conference, with presentations on all of the international developments in the area as well as an overview of the recent conference on the topic in Darwin. A number of participants expressed doubts about the need to consider the environment, feeling that ionising radiation would have limited effects compared to many other human activities. However, the need actually to know what effects radiation could have, rather than just assuming that protecting people was sufficient, was generally accepted. It was also reassuring to know that there are some practical studies under way to determine what effects low levels of radiation may have on different species.

The conference was truly international, with over 300 participants from 40 different countries. It was held in the Grimaldi Forum in Monaco, an excellent venue with the best projection facilities we have ever seen, making even overdetailed slides readable. The number of participants and papers submitted did have a downside as it meant for two days there had to be parallel sessions. Inevitably this meant people moving from one room to another to catch the papers they wanted to hear, which was sometimes distracting, especially for the speakers, and one sometimes wanted to be in two places at the same time. There were a large number of posters; unfortunately they could not all be displayed at the same time so there was a limited opportunity to see the many varied and interesting submissons. However, there were two lengthy poster presentation sessions, where participants were limited to four minutes to get across the essence of their work; this worked remarkably well and was useful for information on who to contact to discuss particular topics.

As well as having a good range of nationalities represented at the conference there were also a range of ages, with a significant number of young people. Concern had been expressed early in the conference about the future of radioecology and the need to regain a sense of direction, after focussing on the impact of the accident at Chernobyl for too long. There was also a feeling that young scientists were being lost to the area. The future is always uncertain but it was encouraging to see so many relatively young people attending the conference and presenting worthwhile and interesting projects. To help, the University of Georgia in the USA had sponsored a young investigator's award to encourage young researchers to attend the conference. Five people from Belgium, Canada, Russia, UK and USA had been awarded $1000 travel grants to attend, based on the abstracts they had submitted.

The main themes of the conference were human and societal effects of exposure to radiation; technologically enhanced concentrations of naturally-occurring radionuclides; radioactive waste storage - status and future needs; vulnerable ecosystems and extreme climate conditions; remediation and restoration of contaminated ecosystems; radioecology together with the protection of the environment as already discussed. There were also sessions on two particular projects, the International Atomic Energy Agency (IAEA) Biosphere Modelling and Assessment

programme (BIOMASS) and the European Commission project MARINA II on the impact of radioactivity in the north-east Atlantic. In addition there were summaries of other recent international conferences and the pre-conference workshop on the speciation of radionuclides. The programme had a good balance of overview papers and papers giving detailed findings from a particular study; it could truly be described as having something for everyone. Extended abstracts from the papers presented were published and available at the conference together with a CD containing the abstracts for all of the posters. The conference was organised by the International Union of Radioecology in association with the Norwegian Radiation Protection Authority (NRPA) and the Journal of Environmental Radioactivity in co-operation with IAEA. The organisers, particularly Torun Jølle and her colleagues from NRPA, put in a tremendous amount of hard work which all contributed towards making this conference a success.

**Jane Simmonds and Antony Bexon**

THE eBulletin

Radiological Protection Bulletin

# Report

**No. 2**
**(December 2002)**

## Radon in Berlin 2002



The fifteenth 'Radon Statusgesprach', held in Berlin on 22 and 23 October 2002, followed the model of previous meetings in the same series in offering a wide variety of radon related topics in a compact and sometimes almost hectic format. The breadth of topics on offer made it certain that all participants found a number of immediate interest as well as matters extending their experience. It is impossible to do justice to the whole of a very full programme, what follows are a few personal highlights.

The 2002 meeting was the second with a strong session on epidemiology. Bruske-Huhlfeld (GSF, Neuherberg) reported on a case-control study of workers at the Wismut Uranium Mining Company in the old German Democractic Republic. A clear exposure-related excess of lung cancer was seen with risk factors perhaps a little lower than those of BEIR VI. One intriguing observation was an apparently anomalously increased risk associated with exposures very far in the past. The probable explanation was that exposures were underestimated during the very early 'wild years' of the enterprise.

Kreienbrock (IBEI, Hannover) gave an overview of the published literature on radon epidemiology. We are, of course, awaiting publication of the pooling of European and of North American studies. These combined analyses are not yet available. However, a review of the published components suggested, to this observer at least, that we should expect a refinement of present risk estimates rather than a completely new view of the radon hazard.

Germany has made admirable progress in implementation of controls on occupational exposure to radon. This is despite the fact that naturally higher levels mean that problems are greater than in the UK. A component of their control strategy is the muscular principle that exposures may be neglected if radon concentrations are below 1000 Bq $m^{-3}$ or exposure times less than 50 hours a year.

Von Philipsborn (University of Regensburg) reminded participants of his cheap and simple method for assessing radon decay products in water (*Health Physics* (1997) **72**, 2770281). This makes use of the strong absorption of the decay products on commercially available glass-fibre filters. They could then be measured with a device costing about 600 euros. Participants were spellbound as he produced all the necessary equipment from his pocket. The organisers had skilfully assigned him the last slot of the day, knowing that nobody would relish having to try to follow this storming presentation.

Thoron (radon-220) is generally assumed to present a smaller practical radiological problem than radon (radon-220). Rolle (University of Gottingen) warned participants against putting total faith in this assumption. In particular, some assessments of the activity of radon decay products could be very seriously compromised by the presence of an unrecognised contribution from lead-212, the ten-hour decay product of thoron.

Vigorous debate followed the suggestion that a minute over-pressure in a house with respect to soil gas was an effective radon remedy. The theoretical principle is clear: most radon in a house is sucked in with soil gas as a result of the normal under-pressure in the house. Reversing the pressure differential would indeed stop the flow. However, it was argued forcefully that in reality, if minimum ventilation standards were to be observed, an over-pressure of perhaps 15 Pascals would be required. This was not only expensive but it carried an unacceptable risk of damage to the dwelling, particularly its roof.

It would be unfair, and is not the author's intention, to associate the Radon Statusgesprach with a general observation to be made about several meetings. Powerpoint presentations are now becoming the norm, but with this trend has come a renaissance of the kind of illegible home-made slides which had become rather rare in the era of 35 mm slides, generally, one assumes, produced with professional help.

**Gerald Kendall**