# RADIOACTIVITY IN THE ENVIRONMENT

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# THE NATURAL RADIATION ENVIRONMENT VII

*Seventh International Symposium on*
*The Natural Radiation Environment (NRE-VII)*
*Rhodes, Greece, 20–24 May 2002*

Editors

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# NATURAL RADIATION ENVIRONMENT

Science together with industry towards a sustainable and safer environment

**Seventh International Symposium**

**NATURAL RADIATION ENVIRONMENT (NRE-VII)**

**20–24 May 2002, Rhodes, Greece**

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# Invited Foreword

It seems to me that, of all Conference series in the fields of environmental radioactivity/nuclear geochemistry/radioecology/radiological protection, the Natural Radiation Environment (NRE) series is pre-eminent. Its history, traditions, breadth and sustained high standards distinguish it from and set it above the others. Major international participation and strict peer-review of its papers have helped to ensure that the NRE books have been not just historical records of large meetings, with the normal range of quality variation and research completeness that conferences always entail, but are, in fact, comprehensive, selected, reviewed and revised compilations of current cutting-edge knowledge on a very important topic. And it is indeed a significant, wide-ranging and expanding subject area, fundamental to so many powerful applications across so many disciplines of science and arguably **the** most important of all in the environmental radioactivity field.

As founder of both the *Journal of Environmental Radioactivity* (JER) and this *Radioactivity in The Environment* book series, I believe that together these two publication series should provide a comprehensive service to the specialist scientific community. The book series provides a complementary and parallel forum to the peer-reviewed research functions of JER by producing quality textbooks for students and researchers worldwide. As such, the core of this series is provided by a set of specifically written volumes on the key scientific issues, e.g. separate books on marine, terrestrial and atmospheric radioactivity, on health effects on man and biota, on modelling, on tracers, etc., etc. These books, some still in production, are largely multi-authored, being organised and produced by guest editors. However, there is scope and place also within the series for a limited conference proceedings sub-series, but many provisos must be attached to inclusion of the latter. First, of course, is the necessity that the topic is of particular interest internationally and that a great deal of selection and full peer-review should be involved in the book production process. Not many conference proceedings satisfy these requirements, but certainly NRE VII does. First, the topic is hugely relevant and of wide general impact. Secondly, the organisers and editors of the book have been fastidious in their preparatory work, rejecting many conference papers after peer-review and having most papers revised and improved relative to the original oral presentations. I thank them for carrying out the huge workload of arranging review, revising, rejecting, accepting, selecting, compiling, coordinating, correcting and submitting this volume so efficiently and punctually. Most of my communications on this book have been with Professor Simos E. Simopoulos and Dr. Nick Petropoulos of the National Technical University of Athens and all I can say about that aspect is that it was both efficient and a pleasure. Through their editorial efforts, I am confident that this compilation combines the qualities of a research journal with the size and breadth associated with a textbook.

This book is written by a sizeable and key section of that global community of scientists who devote themselves to studying the consequences of the fundamental and significant fact that this planet is radioactive not at all mainly by man's doing but, if you like, by God's doing. That the man-in-the-street believes that the planet is radioactive because of man's recent experimentations with nuclear weapons, nuclear energy and nuclear applications is sad, made all the more ironic by the fact that natural radioactivity and nuclear processes were so intimately involved in the very creation of the universe, of the planet and of life as we know it. But blame for this lack of common understanding falls at least partly if not largely on our own doorstep since we, the scientific community, have essentially failed to communicate objectively and effectively. Well, here is another database to provide stimulation and resource for such communication in future – an encyclopedic collection of papers on the state of NRE art and science. Let us use it as a source of material not just for research but also for teaching both within academia and beyond. NRE I was, in fact, the first book that I ever used as a research support in my own career for I used it as a reference for my first experimental research project as an undergraduate – on thorium-230 uptake in the oceans by marine sediments – 40 years ago. NRE provided "a bible" for me then. I truly hope that this new volume will be similarly important as an information source to some new young scientists in our exciting field. For what can be more exciting than some of the subjects herein? – the origin of the planet and elements, the age of the Earth and geological timescales, isotopes as tracers of dynamic processes on sea, land and air, the relationship between radiation exposure and cancer, radiation exposures from building materials or from radon in home and workplace, increasing awareness of the occurrence of technological enhancement of the natural radiation environment through non-nuclear industries, dosimetry to future astronauts during space travel, doses from depleted uranium weaponry, health effects of living in areas of high background radiation and so on and so forth. I was recently invited to present a summary of the possible main research needs and challenges in this field (Environmental Radioactivity at 2000: Status and Priorities. In: Inaba, J., Hisamatsu, S., Ohtsuka, Y. (Eds.), Distribution and Speciation of Radionuclides in the Environment. Institute of Environmental Sciences Publishers, Aomori, Japan, 2000, ISBN 4-9980604-3-0 C3040). In reviewing this book, I am happy to find within it invaluable responses and contributions in each of the priority areas of need that I described then, such as for

(a) increased use of radiotracers, particularly natural radionuclides, to further understanding of natural rates and mechanisms,
(b) scientific and socioeconomic study of the remediation and restoration of contaminated sites,
(c) development of radiological protection criteria and frameworks for flora and fauna as well as for humans,
(d) improvement of predictive models of radionuclide distributions in contaminated and natural environments,
(e) improved comparative assessment of contaminant effects via better understanding of the ecotoxicology of radioactive and non-radiological contaminants,
(f) improved experimental investigation of the speciation of radionuclides, their coordination chemistry, kinetics and microbiology and, finally,
(g) the need to enhance public and political understanding by improving communications.

In short, I am convinced that the science contained herein moves the subject forward to a truly significant extent.

In conclusion, the science of the natural radioactivity of the Earth is, in my view, so much more interesting than that of anthropogenic radionuclides – with so many more powerful applications across so many more interdisciplinary boundaries and with generally greater dosimetric significance – that it is a true honour to be instrumental in bringing this book to you. I hope that it will inform and inspire. And, finally again, I thank the volume editors for their great work in bringing this book to you in such very good shape.

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# Preface

The Natural Radiation Environment Symposium (NRE VII), the Seventh in the NRE series, which commenced forty years ago in 1963 at Rice University Texas, was convened in Rhodes (Greece) in May 2002. During the intervening four decades, the research work presented at these NRE Symposia has, in no small way, contributed to a deeper understanding of natural radiation and, in particular, of its contribution to human radiation exposures.

It is clear from the quality and diversity of the 143 papers in this special volume of Elsevier's *Radioactivity in the Environment* book series that the study of the natural radiation environment is an active and continually expanding field of research. The papers in this volume fall into a number of main and topical research areas namely:

- the measurement and behaviour of natural radionuclides in the environment;
- cosmic radiation measurement and dosimetry;
- the external penetrating radiation field at ground level;
- TENR (Technologically Enhanced Natural Radiation) and NORM (Naturally Occurring Radioactive Materials) studies;
- assessment of the health effects of radon;
- regulatory aspects of natural radiation exposures.

In these papers, the results of many new surveys of natural radionuclide levels in the environment and of improved methods of detection are described. While some of the natural radiation sources investigated are unmodified by human activity, many accounts are given here of exposures to natural sources which have been enhanced by technology. Such TENR and NORM exposures are shown to range from activities such as mining, oil and gas exploitation, the use of industrial by-products as building materials, to space travel, to name but a few. In several cases, quite high doses to some individuals are shown to occur. Accounts are given here of methods to prevent and reduce exposures to such sources.

Excluding doses from radiotherapy and radiation accidents, natural radiation exposures are now accepted as being the major contributors to the annual average radiation dose received by humans under normal conditions. In particular, in view of the large range of doses that are due to radon exposure, the common practice in the past of referring to natural radiation as "background radiation", with its connotation of insignificance, is now clearly redundant. In the past, for a variety of reasons, which were not always scientifically based, undue attention was often directed at individual annual doses of a few μSv from artificial radiation sources while ignoring some tens of mSv from natural sources. In contrast to this ethically questionable and unsustainable position, there is now a growing recognition and acceptance by the contemporary radiation protection community of the need to reduce exposures to elevated

levels of natural radiation. This is clearly evidenced by the emergence in recent years – both at various national and international levels – of a large body of recommendations and regulations targeted at the control of natural radiation exposures. These range from the protection of aircrew and astronauts from cosmic radiation and solar flares, to controls on the level of radon in the workplace. A number of accounts are given in this volume of some of these regulations and aspects of their practical implementation.

While the dose limits used in radiation protection are largely based on a no-threshold linear hypothesis, extrapolating from observed health effects at high doses, the actual shape of the dose–response curve at the level of radiation protection dose limits is still uncertain. Studies on the health effects of natural radiation exposures may help to remove some of this uncertainty. To date, epidemiological studies of populations exposed to elevated external penetrating radiation of natural origin have been largely inconclusive in this regard. On the other hand, notwithstanding confounding effects and other problems, recent case-control residential radon epidemiological studies have demonstrated clear evidence of a non-negligible lifetime risk of lung cancer from indoor radon at concentrations comparable to the radon action levels set by various agencies. As the risk from the radon series arises primarily from alpha radiation, these studies assist in quantifying the radiation-weighting factor for alpha radiation. Some recent studies on the assessment of the health risks from exposures to natural radiation are presented in this publication.

The NRE VII Symposium, at which the peer-reviewed papers in this volume were presented, was attended by over 260 scientists from many disciplines. They overwhelmingly expressed the need to improve the coordination of NRE-related research and regulatory activities worldwide. Therefore it was agreed to found the *Natural Radiation Environment Association* (*NREA*) to assist in the planning and implementation of research projects, as well as in the conduct of dedicated training courses and intercalibration exercises. Furthermore, it is intended that the NREA will establish a dedicated electronic database on NRE, TENR and NORM global data. Currently, the organisational details (management, secretariat, funding, membership requirements) are being discussed.

In summary, NRE VII demonstrated clearly the vitality of NRE-related research, the need for strengthening further international cooperation on this truly global issue, and the high value of NRE-based information for radiation protection in general. It is hoped that this will provide sufficient encouragement for the scientific and regulatory community to continue this valuable conference series also in the future.

We wish to gratefully acknowledge all organisations that supported the Symposium, primarily the US Environmental Protection Agency, which was the main sponsor of the Symposium. We also wish to express our appreciation to our colleagues, who voluntarily assisted in reviewing the Symposium manuscripts. Our appreciation is extended to Dr. N.P. Petropoulos for the coordination of the whole process, which led to the publication of this volume.

December 2003

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