Natural Radiation Environment

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Preface

This volume contains the papers presented at the Second Special Symposium on Natural Radiation Environment held at Bombay, India, during January 1981. The first special symposium in this series of special symposia was held in Brazil in 1975. By convention, these special symposia are held between the main symposia in the series under the title Natural Radiation Environment. The first International Symposium on the Natural Radiation Environment was held at Houston, Texas in 1963 and the second and third symposia in the series were held in 1972 and 1978 respectively at the same venue. In view of the large gap between the main symposia and increasing research activity in the field, these special symposia were found necessary.

The Second Special Symposium was jointly sponsored by the Department of Atomic Energy and the Indian Association for Radiation Protection. The programme of the symposium included Invited Lectures and Contributed Papers on the topics, (1) High Natural Radiation Background Areas, (2) Environmental Natural Radioactivity, (3) Measurement Techniques, (4) Technologically Enhanced Natural Radiation, (5) Indoor Radiation Environment, (6) Radon and Daughters in Ambient Air, (7) Applications in Geosciences. Thus, this special Symposium represented almost all the major areas covered in the past under the main symposia series. The same classification has been followed in the inclusion of papers in this volume.

The increasing interest in the subjects of indoor radon exposure and, the high natural radiation background areas and technologically enhanced natural radiation is evident from the number of papers and the size of data presented on these subjects. The highlights of the symposium were discussed in the concluding session which was conducted in the form of Panel Discussion. This session brought out a number of questions on which further research is necessary. It was generally concluded that the research effort on indoor exposure should be intensified. The readers may find the panel discussion particularly interesting.

The editors have made best efforts to include most of the material presented at the symposium. In view of limitation on the size of this volume, some of the papers had to be reduced in size. In the discussion, only those portions are included for which written replies were returned by the authors. The editors had to complete the job in a very short time in view of several constraints but it is hoped that this volume would make an interesting reading.

The financial support for the conduct of the symposium was received from the Bhabha Atomic Research Centre, Indian Council of Medical Research, Indian Space Research Organisation, Defence Research and Development Organisation and the Department of Science and Technology, while Indian Rare Earths Limited provided hospitality to the delegates who participated in the field trip to the high natural radiation background areas. Their help is gratefully acknowledged. The publication of this volume became possible through the generous financial support provided by the Board of Rearches in Nuclear Sciences of the Department of Atomic Energy, Government of India. From the large number of letters received from the participants abroad, it may be said that the symposium did achieve the level of excellence aimed by the organizers.

For the successful conduct of the Symposium a special acknowledgement is due to Dr. H.N. Sethna, Chairman, Atomic Energy Commission and Principal Secretary, Department of Atomic Energy, Government of India, who provided full support to the holding of this Symposium in India and also inaugurated the Symposium. The Indian Association for Radiation Protection as co-sponsor of this Symposium has made significant contribution, not only in terms of scientific papers but also in all aspects of the organizational effort by the members of the Association. Finally, a special word of thanks goes to the authors of the papers included in this volume.

Bombay
January, 1982

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Natural Radiation Environment and Nuclear Programmes—A Perspective

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KEYNOTE ADDRESS

I would like to start my Keynote Address by paying my heartiest compliments to the pioneers who have triggered widespread research in the topic of this Symposium. The First International Conference on Natural Radiation Environment was held at Houston, Texas in April 1963, organised jointly by Prof. John Adams, Chairman of our Advisory Committee and Dr. Wayne M. Lowder now with the US Department of Energy. Prof. Adams and Dr. Lowder continued in this effort and also played active role in organizing the Second and the Third Conferences in 1972 and 1978, respectively, also at Houston. The Proceedings of the Second Conference were dedicated to Prof. K.Z. Morgan and Prof. Yasuo Miyake who retired from their posts in 1972 after nearly 25 years of active work on the subject. The interest in the field of Natural Radiation Environment has now become so widespread that we have several groups working in this field in many countries. This is borne out from such a large attendance at this Symposium. Nearly 95 invited and review papers scheduled for presentation include exciting new information in many areas, and we have with us several leading scientists in the field.

With such a widespread interest, we may be asked as to what are we ultimately looking for and why so much research is necessary in the field of Natural Radiation Environment. To answer the first question, at least partially, I have chosen to present a perspective on the Nuclear Power Programmes and the Natural Radiation Environment. Today, on one hand the world is facing peculiar problems of energy crisis, and on the other, the nuclear programmes are getting a setback which is due to our failure to educate the common man on the effects of low levels of radiation exposure, and exposure to the natural radiations in the living environment. Natural exposures to ionizing radiations are widespread and of varied nature, but neither their dosimetry nor their health effects are fully understood.

It may not be out of place to remind the audience that we get quite a significant amount of radiation exposure from our own body, with dose coming from K-40 in our soft tissues and from radon and its daughters in our breath.

In addition, we also have in our body small quantities of uranium, radium, carbon-14 and tritium. In a full year we get absorbed dose of nearly 30 mrad to the soft tissues and red bone marrow from K-40 alone, and nearly 100 mrad to the bronchial epithelium from inhaled radon daughters, both delivered internally.

Externally also man is exposed to substantial doses, mainly from cosmic rays and terrestrial sources, with a total additional contribution of nearly 60 mrem per year to the whole body. In certain situations human beings are exposed to very high radiation doses, from terrestrial sources, from radon in the air indoors and outdoors, and from radium in drinking water. In many situations doses received by large populations may even exceed the doses received by occupationally exposed persons in the nuclear industry. It will be interesting to look at some of the results of these findings.

Let us look at the problem of human exposure to radon. The daughter products of radon retained in the bronchial tubes primarily contribute to the lung dose. Whereas under normal outdoor living conditions this dose is around 100 mrad, as stated earlier, indoors it can be as high as 1200 mrad per year in houses built with slag blocks and nearly 400 mrad per year in the brick houses. Large populations are exposed to such doses. In the nuclear industry such exposures are limited only to the uranium miners. In a recent study reported from Norway it has been estimated that 50 additional cases of lung cancer per million persons each year could be caused by radon in Norwegian dwellings having radon concentration nearly 20 times the average outdoor level. Much higher concentrations are found in the dwellings in many countries. The problem of radon would become even worse if the ventilation rates are further reduced to conserve power in cold countries. It is important to point out here again that the collective dose equivalent from such exposures received by large population groups all over the world would far exceed that for workers in the nuclear industry.

And now we may compare the exposures from the operation of Nuclear Power Stations with natural exposures. At present nearly 111 gigawatts of electricity is being produced all over the world in nearly 200 nuclear power stations. It is generally possible to estimate the population exposure due to releases from these power stations. Thus, if we consider the global dose commitment from nuclear electricity generation, even a tenfold increase in nuclear power would give additional dose equivalent to only 2% increase in the natural global dose commitment. This increase is insignificant if we consider that several population groups are exposed to orders of magnitude higher natural dose than the normal.

For example, increase in dose equivalent at the boundary of a nuclear power station is only a few mrem per year, whereas dose equivalent due to natural sources range from 75 to 10,000 mrem per year and people have been exposed to these for generations.

Let us also look at the radiation dose due to the accident at "Three Mile Island" Nuclear Power Station. The natural collective dose equivalent to the total population within 50 miles radius around the reactor is estimated to be of the order of 300,000 man rem, whereas the collective dose commitment as a result of the accident is only of the order of 3000 man rem, just about 1% of natural collective dose equivalent. No noticeable increase in radioactivity could be detected in the soil or water samples taken in the vicinity of the station. Only traces of radioiodine were measured in milk.

In India, we have established background monitoring stations around all the nuclear power stations. The findings from these monitoring stations have been quite revealing. For example, significant radiation levels due to natural radioactivity are prevalent in the environment of the projected Madras Atomic Power Station site at Kalpakkam in South India. The background gamma radiation doses are in the range of 100 to 200 millirem per year. The anticipated increase in gamma radiation dose when the station goes into operation may be insignificant compared to the variations in the natural radiation dose.

In addition to the situations of high dose from inhalation of radon and its daughters, large groups of population also gets high dose through drinking water containing higher concentration of Ra-226 and Rn-222. Some of the springs with high radioactive content are located in Iran, India, Italy and Austria. Several wells in USA also contain very large concentration of Ra-226 and Rn-222, particularly the wells in Texas and Argonne areas. The concentrations in many spring waters are of the order of 10 pCi/1, which corresponds to the maximum permissible concentration for water. In some areas the levels are even 10 to 20 times higher, exceeding the limit for occupational exposure for atomic energy workers.

The populations receiving high doses have not shown any abnormal health situations. In fact, one would not expect to see any effects, because the number of exposed persons in each study is small, and the risk factors for ionizing radiations are quite small when considered in the range of natural background. Thus, the Natural Radiation Environment studies do show that the presently estimated low risk factors are valid, and nuclear power production with good engineering practice would not pose radiation health problems of any significance. It is also likely that actual risk factors for ionizing radiations at low doses and dose rates are even lower.

For large populations, natural exposures are orders of magnitude higher than the exposure from the present and projected nuclear programmes.

The second question is as to why so much research is needed in the field of natural radiation environment. I shall give a few examples of the new findings that have emergeu from intensive research in this field:

1. Many sources of human exposure not known earlier have come to light through this research. Assessment of radiation exposure of workers and population due to operation of fossil fuel stations has been a very important development in the study of comparative health effect of nuclear and fossil stations. It seems likely that radiation exposure from fossil stations may be even higher than those for the nuclear stations with certain types of fossil fuels.

2. In the development of agricultural practices, long term implications of phosphatic fertilizer need to be studied in much detail. The assessment of

dose through highly complex routes of uptake by man needs considerable amount of new research effort to optimize the agricultural practices and use of fertilizers.

3. In the design and construction of new houses for residential purposes, it is also necessary to consider long term implications of indoor exposures. This requires careful selection of constructional material, flooring, wall finishes, ventilation, etc., to optimize the conditions so that indoor exposures are kept low. It has also been suggested that the ICRP dose limitation system may be used for such practices.

4. All the natural exposures fall in the category of low level exposures. Today we know very little about the biological effects of such exposures. Natural Radiation Environment thus provides a good scope for such studies on a long term basis in selected areas. Continuing research effort is necessary for finding the effects at cellular level. This, combined with epidemiological studies should probably lead to valuable information on the dose effect relationships at low doses.

In the absence of proper assessment, some practices of today involving enhanced natural radiation exposure of man could lead to serious health problems in the future. Therefore, it is necessary to accelerate the pace of research in the field of natural radiation environment to be able to optimize the human exposures to technologically enhanced natural radiations. This is applicable to all practices, including power production, agriculture and housing, which are an integral part of our daily life.

Extensive cytogenic studies in the high background areas do show higher chromosomal abberations in some very highly exposed groups. However, there is no unequivocal evidence so far of heriditary diseases, congenital deformities, spontaneous abortion rates, or increased malignancies in the groups exposed to high natural dose. Should such an evidence emerge in future, it would serve as a guideline for improving safety standards for nuclear industry. We are still groping in the dark for establishing effects at low doses encountered in nature and in the nuclear industry.

In conclusion I wish to express my hearty thanks to the delegates for coming here. It is a crowded program but I am confident that with the co-operation of all the speakers, we can conduct the sessions smoothly with sufficient time for discussions.

Geologic Reexamination of the Threshold Hypothesis

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Mr. Chairman and members of the Symposium. It was an honor and pleasure to greet you during the Inaugural Session. For my technical contribution I have chosen to review, reexamine, and update the threshold hypothesis regarding the effects of ionizing radiation on the biota. Although the effects of ionizing radiation on the biota were a major underlying concern for the studies reported at the three Natural Radiation Environment Symposia in Houston, Texas, and the First Special Symposium in Brasil, the threshold hypothesis in particular and biological effects in general were not emphasized. In part this lack of emphasis arose from uncertainties in suitably accurate measurements of the natural radioactivities and in part it arose because it has proven politically less strenuous to accept the zero hypothesis that states that any level of ionizing radiation causes biological damage. Ancillary factors that contributed to the silence about effects were the tendencies of specialists to specialize and not take on a problem that spreads across physics, chemistry, biochemistry, medicine, statistics and epidemiology, geology, geophysics, evolution, anthropology, and other specialties. Finally, there is a philosophical or metaphysical aspect as people seek vainly to obtain a deterministic answer to a stochastic problem.

The First Special Symposium in Brasil and this Second Special Symposium in India provided special opportunities to visit and learn about the studies on the biota in regions of high natural radioactivity. In reviewing the evidence from these areas in regard to any threshold hypothesis, we should first note that the human race is ill served if a threshold may exist, but the media and public opinion makers decide public policy and vast expenditure of limited resources as if there were no possibility of a threshold. We should note secondly that we specialists in this symposium may have a special responsibility to our societies, which support our research, to describe accurately the natural radiation environments and report our findings in terms that cannot be misunderstood. Indeed, accurate, unambiguous communication with the public and governmental authorities in recent years may have become a more difficult and important problem than accurate experiments or measurements (see note added in proof).