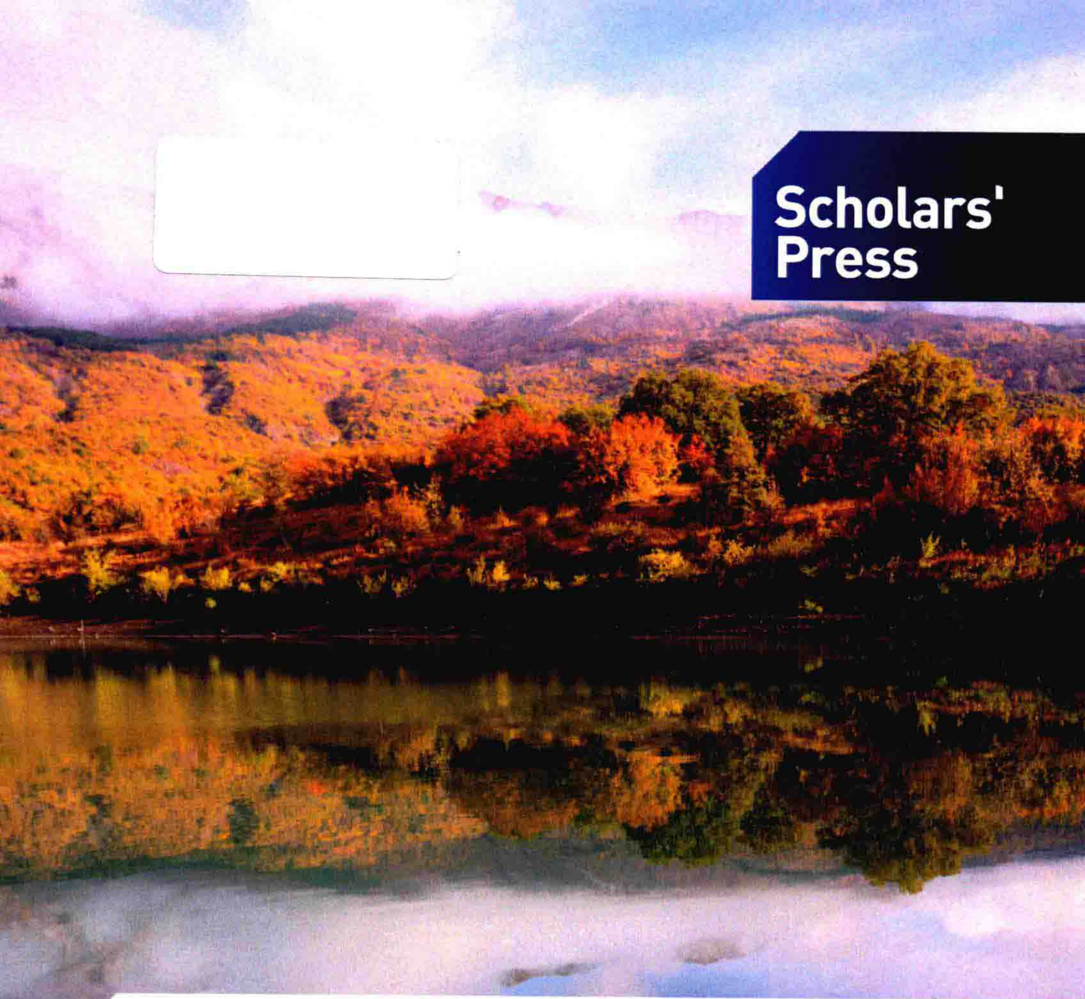

Scholars' Press

Sandeep Kansal
Rohit Mehra

Measurement of Natural Radioactivity in the Environ and Health Effects

A study of Western Haryana, India

Sandeep Kansal
Rohit Mehra

Measurement of Natural Radioactivity in the Environ and Health Effects

A study of Western Haryana, India

Scholar's Press

Impressum / Imprint
Bibliografische Information der Deutschen Nationalbibliothek: Die Deutsche Nationalbibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über http://dnb.d-nb.de abrufbar.
Alle in diesem Buch genannten Marken und Produktnamen unterliegen warenzeichen-, marken- oder patentrechtlichem Schutz bzw. sind Warenzeichen oder eingetragene Warenzeichen der jeweiligen Inhaber. Die Wiedergabe von Marken, Produktnamen, Gebrauchsnamen, Handelsnamen, Warenbezeichnungen u.s.w. in diesem Werk berechtigt auch ohne besondere Kennzeichnung nicht zu der Annahme, dass solche Namen im Sinne der Warenzeichen- und Markenschutzgesetzgebung als frei zu betrachten wären und daher von jedermann benutzt werden dürften.

Bibliographic information published by the Deutsche Nationalbibliothek: The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available in the Internet at http://dnb.d-nb.de.
Any brand names and product names mentioned in this book are subject to trademark, brand or patent protection and are trademarks or registered trademarks of their respective holders. The use of brand names, product names, common names, trade names, product descriptions etc. even without a particular marking in this works is in no way to be construed to mean that such names may be regarded as unrestricted in respect of trademark and brand protection legislation and could thus be used by anyone.

Coverbild / Cover image: www.ingimage.com

Verlag / Publisher:
Scholar's Press
ist ein Imprint der / is a trademark of
OmniScriptum GmbH & Co. KG
Heinrich-Böcking-Str. 6-8, 66121 Saarbrücken, Deutschland / Germany
Email: info@scholars-press.com

Herstellung: siehe letzte Seite /
Printed at: see last page
ISBN: 978-3-639-70844-8

Zugl. / Approved by: BATHINDA, PUNJAB TECHNICAL UNIVERSITY, KAPURTHALA, PUNJAB, INDIA, Ph. D. THESIS, 2012

Sandeep Kansal
Rohit Mehra

Measurement of Natural Radioactivity in the Environ and Health Effects

A BOOK ON

"Measurement of Natural Radioactivity in the Environs and Health Effects"

By

Dr SANDEEP KANSAL, **Associate Professor,** **GZS Punjab Technical University Campus,** **Bathinda (Punjab), INDIA.**	**Dr ROHIT MEHRA,** **Associate Professor,** **Dr BRA National Institute of Technology, Jalandhar (Punjab), INDIA**

ABSTRACT

We live in radioactive world. The exposure of living beings to the natural and manmade ionizing radiation have adversely affected the health of mankind causing short and long term biological consequences and hence is the major cause of concern for the past about hundred years . Extensive literature is available on the risks of radiation exposure to the general public and the mine workers. Various international agencies like UNSCEAR, ICRP, WHO, IAEA, ICAR, OECD, NEA, US EPA, etc. are regularly monitoring the radiation levels, exposure of the public, its health effects and thereby are giving recommendation for the control and protection from radiations. Many epidemiological studies and experimental evidence are available which correlates large number of deadly diseases (like Lung cancer, Liver cancer, Leukaemia, Bone cancer, cancer of prostate, neurological disorders etc.,) with the level of radiations present in the atmosphere surrounding the people.

Out of total radiation exposure from natural and artificial sources, around 90% exposure is only from natural radiations. Of the natural radiation sources, radon (^{222}Rn) and its progeny attached to aerosols present in the ambient air constitute significant radioactive hazards to human lungs. During respiration radon progeny deposits in the lungs and irradiate the tissue thereby damaging the cells and may cause lung cancer. Although kidney is considered to be primary target in both acute and chronic situations, but experimental evidences suggest that the respiratory and reproductive systems are also affected by exposure of radon. The main sources of indoor radon are soil, water and the naturally occurring radioactive materials (NORMs). Therefore measurement of the indoor radon concentrations in the dwelling is very important to assess the radiation levels and its exposure to human beings. In the present study, the measurements of indoor radon in the dwellings and its seasonal variations, estimation of average annual dose and life time fatality risk, measurement of radon exhalation rate in the soil samples and radon levels in water have been carried out for health risk assessment. The measurements of indoor radon concentration have been carried out using both active and passive methods. For the integrated and long term measurement of the indoor radon, most reliable passive technique using Solid State Nuclear track detector (SSNTD) technique has been employed which is based on the detection and counting of alpha particles emitted by radon and its daughters. The cellulose nitrate (CN) plastic detectors, commercially known as LR-115 Type-II plastic track detector films and the bare mode technique have been employed to measure the concentration of radon in the indoor environment. These detectors were replaced on quarterly basis covering four seasons of the

year so as to study the seasonal variations for the indoor radon concentration. The measured overall average annual indoor radon concentration (181.31 Bq m^{-3}) in the dwellings is 4 to 5 times higher than the world average of 40 Bq m^{-3} but this is lower than the ICRP (2009) recommended action level of 200-300 Bq m^{-3}. The average value in about 17% of the samples is higher than the recommended action level. The measured annual effective dose is within the ICRP (1993) recommended safe limit of 3-10 mSv per year. Hence there is no significant threat to the residents due to presence of natural radon in the dwellings. Comparatively high values of radon concentration are reported in poorly ventilated houses as compared with the well ventilated houses. Relatively higher values have been found in winter than in summer and the winter/summer ratio of indoor radon ranges from 0.78 to 2.99 all the studied dwellings.

For the active measurement of radon and thoron concentrations in the indoor air, RAD7 an electronic detector has been used. Also an effort has been made to establish the correlation between active & passive techniques for indoor radon measurements. To establish the correlation between active & passive radon measurements, an electronic radon detector, has been employed to measure indoor radon concentration. The measured values of indoor radon and thoron concentration vary from 45.75 to 576.23 Bq.m^{-3} and below detectable limit (BDL) to 121.26 Bq.m^{-3} with average values of 252.28 Bq.m^{-3} and 46.04 Bq.m^{-3} respectively. The annual average effective dose for indoor radon lies between 1.06 to 14.52 mSv with an average of 6.09 mSv which was calculated using parameters introduced in report by UNSCEAR (2000). A good correlation (= 0.828619) has been found between the two modes of measurement i.e. active mode using RAD7 and passive mode using LR 115.

For the measurement of radon exhalation rate in the soil samples, Closed Can Technique has been used in which LR-115 type-II plastic track detectors were suspended inside the bottles in a bare mode. The crushed and dried fine powder of collected soil samples were packed and sealed in an airtight PVC container of about 1 litre capacity which was used as an emanation chamber. By measuring the track density of alpha particles on the LR-115 films, **The 'radon exhalation rate' in terms of area (E_A) and the radon exhalation rate in terms of mass (E_M)** was obtained from the standard expressions. The radon surface exhalation rate E_A (and mass exhalation rates E_M) varies from 189.74 mBq m^{-2} h^{-1} (2.29 mBq kg^{-1} h^{-1}) to 500.74 mBq m^{-2} h^{-1} (14.25 mBq kg^{-1} h^{-1})with an average of 293.89 mBq m^{-2} h^{-1} (10.15 mBq kg^{-1} h^{1}). The high exhalation rates may be due the high emanation rate of radon gas from the underneath soil as it permeates from the soil through cracks, fissures, porosity of the soil etc and enters our environment.

Waterborne radon leads to health risk by two pathways: inhalation of radon and its decay products following the release of radon gas from water into household air, and the direct ingestion of radon in drinking water. The cancer risk due to ingestion, primarily cancer of the stomach and digestive organs, has been estimated from studies of the movement of radon through the gastrointestinal tract and bloodstream. The measured values of radon gas concentration in water are found to be below the max recommended values of 11 $Bq\ l^{-1}$ by the US Environmental Protection Agency (1991). But these values are more than the recommended action levels of 0.1Bq m^{-3} (100 $Bq\ l^{-1}$) for public water supplies and are less than the recommended action levels 100 kBq m^{-3} (1,00,000 $Bq\ l^{-1}$) for private water supplies as compared to the European Commission Recommendations on the protection of the public against exposure to radon in drinking water supplies (2001/928/Euratom).

Uranium, a primordial radionuclide occurs in a dispersed state naturally in the earth's crust, surface, rocks, air and groundwater. Uranium has both chemical and radiological toxicity with the two important target organs being the kidneys and lungs. Uranium nuclides emit alpha rays of high ionization power and therefore it may be hazardous if inhaled or ingested in higher quantity or dose. The aim of the present investigations is to study the health risk assessments in western districts of Haryana by measuring uranium concentration in water. For the assessment of uranium concentration level in the underground water samples collected from randomly chosen hand pumps in the studied area, fission track registration technique using plastic polycarbonate detectors (lexan) have been employed. Then the prepared lexan samples, enclosed in capsules were irradiated with thermal neutrons in the reactor at Bhabha Atomic Research Centre, Mumbai, India with a thermal neutron dose of about $2x10^{15}$ (n cm^{-2}). From the fission tracks the uranium concentrations in the water samples were determined using the technique given by Fleischer and Lovett in 1968. Further to estimate the radiological and chemical risk assessment because of uranium in water, the cancer mortality and morbidity risks, the chemical toxicity risk of uranium over lifetime consumption of water were calculated. Uranium concentration in all the studied samples is above the ICRP (1993) recommended value of 1.9 $\mu g\ l^{-1}$ but most of the values are comparable to WHO (2008) safe limit of 15 $\mu g\ l^{-1}$. In only 15% of the studied samples from Bhiwani, Baliyal and Tusham area, the values are higher than the USEPA (2003) recommended safe level of 30 $\mu g\ l^{-1}$. The cancer mortality and morbidity risks of uranium over lifetime consumption of water were of the order 10^{-4} which is low as compared to the acceptable level of 10^{-3} for the radiological risk. By comparing the lifetime average daily dose (LADD) of uranium through drinking water intake obtained in this study and the reference dose (RFD) of 0.6 μg kg^{-1} day^{-1} that is an acceptable level, the chemical toxicity risk due to uranium in the 30% water samples were above the RFD and in remaining samples , it is below the RFD. This shows that there may be health risks associated with uranium in the water samples which are mainly due to the chemical toxicity risk.

Natural terrestrial radionuclides in soils, belonging to ^{232}Th and ^{238}U series as well as radioisotope of potassium ^{40}K are the main sources of gamma radiation dose which contributes to the outdoor terrestrial natural radiation. The knowledge of radionuclides distribution and radiation level in the environment is important for assessing the effects of radiation exposure. External gamma dose estimation due to terrestrial sources is essential not only because it contributes considerably (0.46 mSv y^{-1}) to the collective dose but also because of the variations of individual doses related to these pathways. For the measurement of the activity concentration of radium, thorium and potassium in the soil samples, a HP-Ge detector with a high-resolution gamma spectrometry system available at IUAC, New Delhi, was used. Further Ra_{eq} activity, air absorbed dose rate, annual effective doses and the external hazard index (H_{ex}) has also been calculated. The averages value of the activity concentration of ^{226}Ra is comparable to the world average value where as for ^{232}Th and ^{40}K activity concentrations are higher than the world average values as reported above which might be due the high content of thorium and potassium in the soil. The values of ^{226}Ra in all the soil samples are within the range (2.5–207.0 Bq kg^{-1}) as reported for Indian soils. The radium equivalent activity (Ra_{eq}) in all these soil samples is less than the world's average value 370 Bq kg^{-1} reported by Organization of Economic and Control Department. The total absorbed dose, annual effective dose and external hazard index (H_{ex}) in the study area have also been calculated. These values suggest that soil from these regions is safe and can be used as a construction material without posing any significant radiological threat to population.

From the review of literature it has been observed that though the data on the content of radioactive elements is available for some states of India, but the data available for western parts of Haryana is quite meagre. So the detailed investigations for natural radiation studies in the environs of Western Haryana for health risk assessments have been carried out for the first.

DEDICATION

My Work is
Dedicated To My Loving Parents

TABLE OF CONTENTS

PREFACE

For the detailed investigations for natural radiation studies in the environs of Western Haryana for health risk assessments the samples of soil, water and air has been collected from the studied area and were studied using various active and passive techniques. The data has been compiled and the results were calculated using standard methods and are presented here. This book has been divided in to the following six chapters:

CHAPTER 1

This chapter deals with the Introduction and Literature review regarding the history of natural radioactivity, major radionuclides, the radiations, and types of radiations and hazardous effects of ionizing radiations. National and international agencies, type, exposure, dose, unit. A detailed literature review dealing with natural radiations has been discussed and finally the objectives of the present study are reported in this chapter.

CHAPTER 2

This chapter deals with various materials, instruments and experimental techniques used in the present study of natural radioactivity in soil, water and air in the study area. Both long-term (passive) as well as short-term (active) techniques have been used in the present experimental measurements.

CHAPTER 3

This chapter deals with the measurement of Indoor Radon concentration in the dwellings in Western parts of Haryana and soil exhalation rates using Solid State Nuclear Track Detectors (SSNTDs). The indoor radon concentration has been calculated for the four seasons of the year on quarterly basis. The average annual radon concentration, Life time fatality risk, annual effective dose estimated from the calculation of indoor radon concentration. The winter to summer ratio for indoor radon concentration in the various types of dwellings has also been calculated. This chapter also deals with the measurements of radon exhalation rates in the soils samples collected from various parts of the Western districts of Haryana. A closed 'Can Technique' using LR-115 type II SSNTD's is used for this purpose.

CHAPTER 4

This chapter deals with the measurement of Indoor radon concentration in the dwellings by active method using RAD7, an electronic detector. A comparison has been made between the results obtained with both active and passive techniques.

CHAPTER 5

This chapter deals with the measurement of Uranium and Radon concentration in ground water samples. The groundwater samples were collected from the hand pumps in the studied area. Fission track registration has been used to study uranium concentration in water. Also further mortality and morbidity rates have been calculated from the values of uranium concentration water to estimate the health risk to the residents of the studies area.

This chapter also deals with the measurement of radon gas in the ground water samples at different places of various villages/towns of Western districts of Haryana. The active method using RAD7, an active method an electronic radon detector has been used for the measurement of radon in ground water.

CHAPTER 6

This chapter deals with the Analysis of terrestrial naturally occurring Radionuclides (^{238}U, ^{232}Th, ^{40}K) in soil samples using Gamma ray Spectroscopy. The HPGe detector, based on high-resolution gamma spectroscopy has been used for the activity concentrations of terrestrial radionuclides viz. ^{238}U, ^{232}Th and ^{40}K in soil samples collected from the studied area. The experiments have been performed at the Inter University Accelerator Centre (IUAC), New Delhi, India. Also the total absorbed dose, external hazard index and annual effective indoor and outdoor doses have been calculated for the measurement of health risk to the residents.

At the end, the summary and future perspectives have been discussed.