Radioprotection 2001
Vol. 36, n° 3, pages 329 à 332

Note technique

Radiation dose calculation in the human body for building materials and soil exposure pathways

F. ÖNER[1], N.T. OKUMUŞOĞLU[2]

(Manuscript received 30 October 2000, accepted 19 May 2001)

ABSTRACT **In the present work, external annual radiation doses in human body due to presence of ^{226}Ra, ^{232}Th, ^{238}U and ^{40}K in conventional building materials and by-products from coal power plants which are being used or have the potential for use in buildings and soil in India were calculated in the human body by using GENII radiation dose calculation computer programme (Napier *et al.*, 1988). In the calculations, human beings receive the most radiation dose from building materials from 1.0×10^{-6} Sv from ^{40}K and the least from 2.3×10^{-11} Sv from ^{232}Th. It has been calculated that human beings receive total $6.3 \times 10^{-7} \pm 2 \times 10^{-7}$ Sv radiation dose exposure from soil. Data obtained are acceptable in comparison with radiation doses attributable to building materials in OECD countries.**

RÉSUMÉ **Calculs de la dose de radiation dans le corps humain due au contact de matériaux de construction et du sol.**

La dose de radiation dans le corps human due aux matériaux de construction (utilisés ou potentiellement utilisables) et aux sols en Inde a été calculée grâce au programme GENII (Napier *et al.*, 1988). Nous avons montré qu'elle variait pour les matériaux de construction : de $1,0 \times 10^{-6}$ Sv pour ^{40}K à $2,3 \times 10^{-11}$ Sv pour ^{232}Th et que l'irradiation due aux sols était de $6,3 \pm 2 \times 10^{-7}$ Sv. Ces données sont acceptables en comparaison des doses mesurées pour les matériaux de construction des pays de l'OECD.

1. Introduction

Everything in our world contains small amounts of radioactive atoms like ^{226}Ra, ^{232}Th, ^{235}U, ^{238}U, ^{40}K and ^{222}Rn. Radionuclides are found naturally in air, water and soil. Natural radioactivity is common in rocks and soil that makes up our planet, in water and oceans and in our building materials and homes. Human beings are exposed to natural gamma radiation emitted by the primordial radionuclides ^{40}K, and the radionuclides of the different chains that originate with ^{238}U and ^{232}Th in soil and rocks all the time (Ajayi *et al.*, 1999). People and organisms in the environment are exposed to radiation and radionuclides from

[1]Department of Physics, Faculty of Education, Ondokuz Mayıs Üniversity, Amasya, Turkey.
[2]Department of Physics, Faculty of Arts and Science, Ondokuz Mayıs Üniversity, Kurupelit, Samsun, Turkey.

natural sources. People can be exposed to radiation while settling on contaminated soils. Besides whether there are radioactive nuclei in the building materials, people can receive external exposure. If a marble contain radioactive nuclei and, furthermore, used as a building material, people who live in this building can be exposed to radiation (Tufail *et al.*, 2000). Absorbed dose-rates in humans from exposure to environmental gamma rays were given by O'Brien *et al.* (1976). GENII calculates all the radiation doses that the whole body receives through external exposure. Common natural materials, the by-products of coal power plants used in India as a building material and soil have been used in this study.

2. Method

In this study, the GENII radiation dose calculation computer programme is used. GENII is composed of seven linked computer codes and their associated data libraries. The programme consists of APPRENTICE, ENVIN, ENV, DOSE, INTDF, EXTDF and DITTY.

APPRENTICE interactively prepares a text input file for the near-term environmental dosimetry programmes and a batch processing file to manage the file handling needed to control the operations of the five subsequent codes and prepare an output report. ENVIN controls the reading and organization of the input files for ENV, which then calculates the environmental transfer, uptake and human exposure to radionuclides that result from the chosen scenario for the defined source term. ENV writes the annual media concentrations and intake rates to intermediate data transfer files for use by DOSE. DOSE converts these data to radiation dose, calculating the external dose using factors generated by EXTDF and the internal dose using factors generated in INTDF. DOSE calculates the one-year dose, committed dose, cumulative dose, and maximum annual dose and prepares the normal output report of doses and optional doses by pathway and by radionuclide. EXTDF calculates the external dose-rate factors for submersion in an infinite cloud of radioactive materials, immersion in contaminated water, and direct exposure to plane or slab sources of contamination. The EXTDF code is a modification and enhancement of the well-known shielding code ISOSHLD (Engel *et al.*, 1966). INTDF estimates the dose equivalents in a number of target organs from the activity in a given source organ based on ICRP 30 (1982) models and biokinetic values for radionuclide residency and transport in the body. The dose equivalent in a target organ is the product of the total number or nuclear transformations of the radionuclide and the energy absorbed per gram in the target organ. DITTY calculates long-term total population exposure based on air and water source terms, atmospheric dispersion patterns, and exposed population. GENII use exposure pathways. Exposure pathways include direct exposure

TABLE I

Annual radiation for a human body through external exposure by building materials and by-products used in the building construction in India.

Radiation annuelle due aux matériaux de construction en Inde.

Materials	external dose (Sv)		
	^{226}Ra	^{232}Th	^{40}K
soil	1.7×10^{-9}	5.9×10^{-11}	1.0×10^{-6}
sand	1.8×10^{-9}	5.9×10^{-11}	1.0×10^{-6}
portland cement	1.5×10^{-9}	2.3×10^{-11}	9.9×10^{-7}
plaster of cement and sand	1.6×10^{-9}	5.5×10^{-11}	4.6×10^{-7}
fly ash	1.8×10^{-9}	3.8×10^{-11}	2.0×10^{-7}
slag	2.7×10^{-9}	7.2×10^{-11}	3.3×10^{-7}
clay brick (unfired)	1.6×10^{-9}	4.7×10^{-11}	8.0×10^{-7}
clay brick (fired)	2.0×10^{-9}	5.1×10^{-11}	8.7×10^{-7}
clay brick (fired and plastered with cement and sand)	2.0×10^{-9}	2.8×10^{-11}	8.1×10^{-7}

TABLE II

Annual radiation external doses for the human body through external exposure from soil in India.

Radiation annuelle due aux sols en Inde.

Material	external dose (Sv)		
	^{238}U	^{232}Th	^{40}K
soil	$1.6 \times 10^{-11} \pm 9 \times 10^{-12}$	$1.1 \times 10^{-10} \pm 5 \times 10^{-11}$	$6.3 \times 10^{-7} \pm 2 \times 10^{-7}$

via water, soil, air, inhalation, and ingestion pathways. In this study, EXTDF subprogramme of GENII and other supplementary programmes are used.

3. Result and discussion

Annual external radiation dose exposure to the human body annually by external dose is calculated using concentrations of ^{238}U, ^{232}Th, ^{40}K radioactive elements measured in soil and ^{226}Ra, ^{232}Th, ^{40}K in building materials used in India by Selvasekarapandian *et al.* (1999) and Kumar *et al.* (1999), respectively. In this study, the amount of dose accumulated in the human body through external exposure for each radioactive nucleus is calculated. In Table I amount of doses taken from building materials and in Table II amount of doses taken from soil annually by exposure pathway are given. Human beings exposure radiation through external exposure from the building materials which contain radioactive nuclei. Here human beings receive the most radiation dose from 1.0×10^{-6} Sv from ^{40}K in soil and sand, and the least from 2.3×10^{-11} Sv from ^{232}Th in Portland cement. It has no harm on people where these building materials used.

In addition, external doses were calculated using the activities of ^{238}U, ^{232}Th, ^{40}K radionuclides measured by Selvasekarapandian *et al.* (1999) in soil samples of Udagamandalam (Ooty) in India. People living in this region receive approximately $6.3 \pm 2 \times 10^{-7}$ Sv total radiation from ^{238}U, ^{232}Th and ^{40}K. The calculated radiation doses of conventional building materials such as clay bricks, sand, cement, fly ash and slag and soil have been found below the acceptable radiation doses limit of the OECD countries.

REFERENCES

Ajayi I.R., Ajayi O.S. (1999) Estimation of Absorbed Dose Rate and Collective Effective Dose Equivalent Due to Gamma Radiation from Selected Radionuclides in Soil in Ondo and Ekiti State, South-Western Nigeria, *Radiat. Prot. Dosim.* **86,** 221-224.

Engel R.L., Greenborg J. (1966) Hendrickson M.M. ISOSHLD-A Computer Code for General Purpose Isotope Shielding Analysis, BNWL-236, Pacific Northwest Lab., Richland, Washington.

ICRP Publication 30 (1982) Limits for Intakes of Radionuclides by Workers, Pergamon Press, New York.

Kumar V., Ramachandran T.V., Prasad R. (1999) Natural Radioactivity of Indian Building Materials and by-Products, *Appl. Radiat. Isot.* **51,** 93-96.

Napier B.A., Peloquin R.A, Strenge D.L, Ramsdell J.V. (1988) GENII-The Hanford environmental Radiation Dosimetry Software System, Vols. 1, 2, Pacific Northwest Laboratory, Washington.

O'Brien K., Sanna R. (1976) The Distribution of Absorbed Dose-Rates in Humans from Exposure to Environmental Gamma Rays, *Health Phys.* **30,** 71-78.

Selvasekarapandian S., Manikandan N.M., Sivakumar R., Balasubramanian S., Venkatesan T., Meenakshisundram V., Ragunath V.M., Gajendran V. (1999) Gamma Radiation Dose from Radionuclides in Soil Samples of Udagamandalam (Ooty) in India, *Radiat. Prot. Dosim.* **82** (3), 225-228.

Tufail M., Iqbal M., Mirza S.M. (2000) Radiation Doses due to the Natural Radioactivity in Pakistan Marble, *Radioprotection* **35**, 299-310.