A Novel Estimation of the Exposure of the Population of Israel to Natural Sources of Ionizing Radiation

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1. Introduction

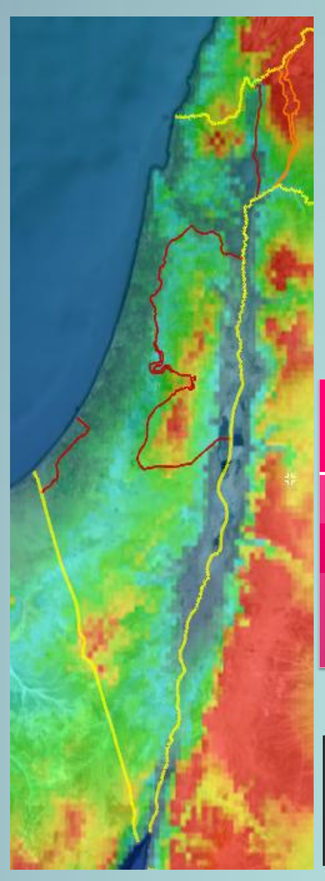
The goal of this study was to assess the average radiation dose from natural sources to the population of Israel, taking into account local characteristics (geology, geography) as well as specific features of the local lifestyle.

The building industry in Israel has a few unique characteristics that have an effect on the annual dose from the terrestrial radionuclides:

- A DSS (Dwelling Shielded Space) is built in every apartment since the early 1990s. The DSS is a room built from massive concrete walls, floor and ceiling that can be hermetically sealed and is intended to protect its residents from a missile attack.
- The use of building materials with relatively high concentrations of the natural radionuclides in the last 20 years.
- The improvement in sealing achieved through the building techniques used in the last 20 years.

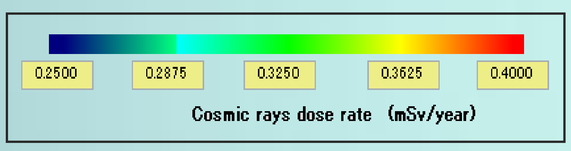
2. Methods and Results

2.1 Cosmic Radiation



The average annual dose from cosmic radiation was assessed by means of the EXPACS code[(1,2)], taking into account the elevation above sea level of the different cities and towns and the distribution of the population.

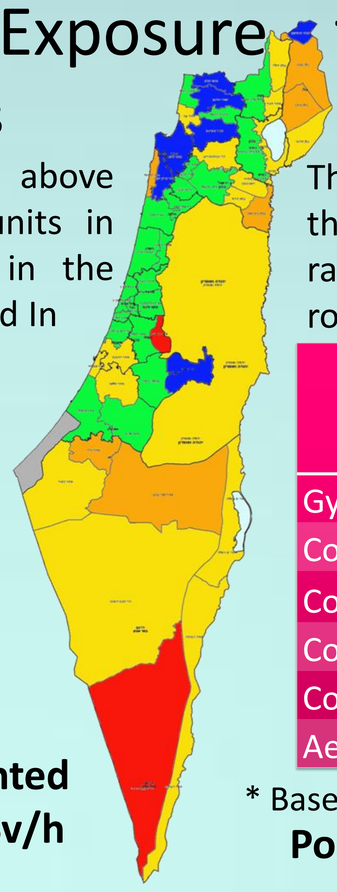
	Average Dose (mSv/y)	Range (mSv/y)
Outdoors	0.28	0.24-0.39
Indoors	0.18	0.15-0.25
Weighted Total	0.20	0.17-0.28



2.2 External Exposure to Terrestrial Radionuclides

2.2.1 Outdoors

The dose rates above different geological units in Israel, as measured in the aerial survey conducted In 1998[(3)], were used to calculate the average dose rate outdoors.



Population weighted dose rate – 20 nSv/h

2.2.2 Indoors

The dose rate inside buildings was assessed using a model[(4,5)] that takes into account the concentrations of natural radionuclides in the building materials, the dimensions of the room and the density and thickness of the walls.

Building Material	Density (kg/m³)	Concentration (Bq/kg) ^{232}Th	^{226}Ra	^{40}K	Wall Dose Rate* (nSv/h)
Gypsum	1200	11	6	51	1.8-2.0
Concrete without fly-ash	2300	9	31	52	3.0-3.7
Concrete with 1.5% fly-ash	2300	11	33	55	3.4-6.1
Concrete with 6% fly-ash	2300	16	40	64	5.3-7.8
Concrete block	1300	9	31	52	2.2-4.2
Aerated concrete	500	9	31	52	1.0-3.0

* Based on the wall location and openings in the wall (door/window)

Population weighted dose rate – 25 nSv/h

The average dose rate inside buildings is approximately 1.3 times the average dose rate outdoors and the average annual dose due to the external terrestrial radiation is 0.21 mSv.

2.3 Radon

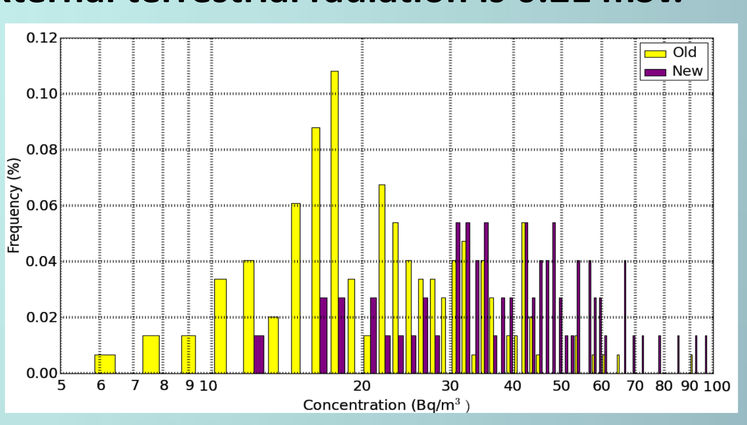
In order to assess the average indoor radon concentration, results of a 2006 radon survey in single-family houses were combined with results from a radon survey performed in the present study in apartments of multistory buildings. The average (geometric mean) radon concentration in single-family houses was found to be 47.3 Bq/m³ (geometric standard deviation: 2.0) [(6)].

The combined influence of the above mentioned building characteristics on the radon concentration was estimated by dividing the dwellings into two groups:

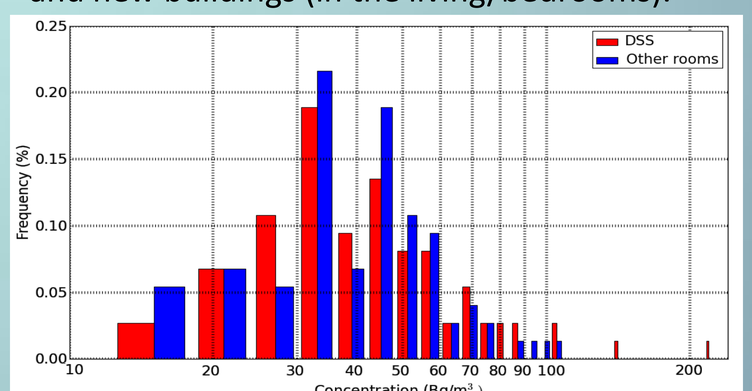
1. Apartments in buildings older than 20 years, built using building materials with low concentrations of the natural radionuclides and without a DSS.
2. Apartments in buildings newer than 10 years, built using building materials with relatively high concentrations of the natural radionuclides, improved sealing and including a DSS.

The measurements were conducted using CR-39 SSNTDs that were placed in one of the bedrooms or the living room for a minimal period of 3 months. A second detector was placed in the DSS of dwellings in new buildings. The average radon concentration inside Israeli dwellings was calculated according to the distribution of apartment types and was found to be 31.1 Bq/m³. The average dose due to radon inhalation was estimated to be 1.2 mSv, based on the updated information included in the 2009 ICRP Statement on Radon [(7)].

	Geometric mean (Bq/m³)	Geometric standard deviation
Living/bedrooms in old buildings	22.9	1.6
Living/bedrooms in new buildings	41.3	1.5
DSS in new buildings	43.6	1.6



The distribution of radon concentrations in old and new buildings (in the living/bedrooms).



The distribution of radon concentrations in DSS and in living/bedrooms in new buildings.

2.4 Internal Exposure other than Radon

Internal exposure due to food and water consumption was estimated on the basis of the average consumption of different food categories in Israel[(8)] and the average concentrations of natural radionuclides in each food category. The annual dose was found to be 0.4 mSv.

3. Conclusions

The average annual dose to the population of Israel from all natural sources was found to be 2.0 mSv (range: 1.7 - 2.7 mSv).

4. References

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