INDOOR EXPOSURE TO GAMMA RADIATION IN ITALY

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ABSTRACT

A representative survey to evaluate the exposure to natural radiation in dwellings was conducted in Italy from 1989 to 1994. The survey was coordinated by ANPA (former ENEA/DISP) and Istituto Superiore di Sanità, and it was carried out in collaboration with 19 Regional Laboratories. Beside radon concentration, absorbed dose rate in air was also measured. For gamma measurements, whose results are reported in the present paper, ENEA collaborated, too. Thermoluminescent dosemeters (TLDs) were used as detectors. Four TLDs were exposed for six months in a bedroom of each surveyed dwelling. Particular attention was devoted to calibration and treatment procedures of the dosemeters (annealing, transport dose etc.), according to detailed protocols. Intercomparison exercises were conducted for all the Laboratories involved. The national and regional averages were calculated from the results in the actual sample (4234 dwellings) taking into account the sampling scheme. The national average absorbed dose rate in air was around 105 nGy/h, after the subtraction of the cosmic ray contribution. This value is located in the high range of the national average values of other Countries given in the 1993 UNSCEAR Report. Using the dose factors assumed in the same report, the estimated effective dose due to indoor gamma exposure at home results about 0.4 mSv/y. Appreciable differences exist among the average dose rates measured in various Italian Regions. The highest values were found in Central Italy where natural building materials with high uranium and thorium content are widely used.

INTRODUCTION

In the period 1989-1994, a representative national survey was conducted in Italy, to evaluate the indoor exposure to natural radiation, both radon and gamma radiation. The characteristics of the survey, its organisation, the sampling criteria and the general policy adopted have been described elsewhere (1,2,3). Although it is well known that radon is the main source of indoor exposure (4), measurements of outdoor gammas carried out during the seventies and indoor gamma measurements conducted in the eighties, pointed out the existence of areas where the exposure rate was particularly high (5,6). These areas are characterised from the geological point of view by the existence of effusive and explosive materials (recent volcanitis); moreover, building industry generally makes use of local materials which significantly contribute to the indoor exposure (6).

MATERIALS AND METHODS

As described in ref. 3, 19 Regional Laboratories participated in the survey. Standardised measurement protocols were used in order to assure comparability and to minimise uncertainties. Detailed information on the procedures for gamma measurements are reported elsewhere (7) and are summarised here. Thermoluminescent dosemeters were used, in particular LiF sintered chips from the same batch doped with Mg and Ti or Mg, Cu and P. Two dosemeters

were positioned in one room of each dwelling, usually the main bedroom, and exposed aside the radon detectors for six months. Each dosemeter was made of two chips enclosed in a light-tight plastic sachet of 100 mg cm^{-2} thickness. As far as quality assurance procedures are concerned, intercalibration exercises were carried out, exposing dosemeters both to a reference Cs–137 gamma beam (see Fig. 1), with a dose of 500–1500 μGy, and to environmental radiation in high background room, where the dose rate (~320 nGy/h) was measured by means of a ionisation chamber.

RESULTS AND DISCUSSION

Gamma measurements were carried out in 18 Regions. The national distribution of absorbed dose rate in air detected indoors is shown in Fig. 2. A cosmic ray contribution of 32 nGy/h has been subtracted from TLD results. This contribution has been estimated applying a building shield factor of 0.8 (4) to the measured value of 40±9 nGy/h (6), which is compatible with the value calculated taking into account latitude and altitude. The national average value is 105 nGy/h (3), with an estimated overall uncertainty of about 10%, which takes into account both statistical and systematic errors. The world population weighted average assessed by UNSCEAR is 83 nGy/h (4). This value was obtained from surveys of different statistical significance, whose averages are generally lower than the Italian one, e.g. 71 nGy/h in Austria, 60 nGy/h in UK and 37 nGy/h in USA, while only few values are equal or higher, such as 103 nGy/h in Australia, 105 nGy/h in Portugal and 110 nGy/h in Sweden. Regional averages in Italy are quite different, with the lowest figures in Emilia–Romagna, Toscana, Veneto and Puglia (40–50 nGy/h), and the highest ones in Lazio and Campania (>210 nGy/h). For the dose assessment, an average occupancy factor at home equal to 0.6 – obtained from the survey questionnaires (3) – was applied to the average dose rate in air. The estimated gamma radiation contribution to the effective dose at home resulted around 0.4 mSv/y.

CONCLUSIONS

The average absorbed dose rate in indoor air, obtained through the Italian national survey, is about 105 nGy/h, which is rather high when compared with the values obtained in other national surveys. The regional averages show a large variability over the Italian country: the highest values have been detected in those Regions, such as Lazio and Campania, where local building materials with high uranium and thorium content are widely used. These data stress the importance of studying natural building materials, as both gamma radiation and radon sources, in order to reduce the presence of radioactivity indoors. In authors' opinion, a regulation to limit the radioactivity content and the radon exhalation rate for building materials of future dwellings should be promulgated.

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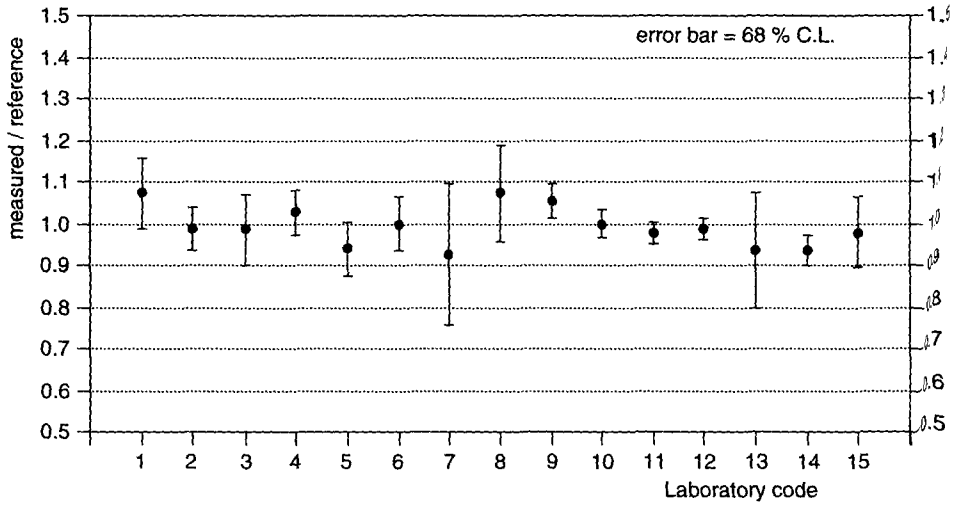

Figure 1. Results of the intercomparison exercises with a reference Cs–137 gamma beam.

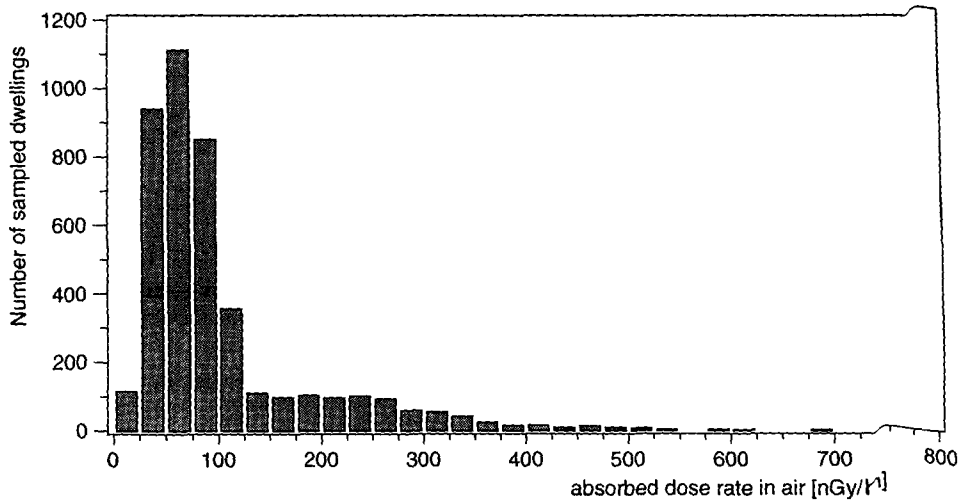

Figure 2. Distribution of the absorbed dose rate in air due to gamma radiation in the sampled dwellings. The cosmic ray contribution, estimated as 32 nGy/h, has been subtracted from measured values.