NATURAL RADIATION INDOOR EXPOSURE OF ITALIAN POPULATION

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ABSTRACT

A natural radiation survey based on the choice of a statistically representative sample of 5000 dwellings began in Italy in 1989. The paper analyses the radon results obtained in 45% of the national sample. The arithmetic mean of the concentration is equal to 80 Bq/m^3 and the number of dwellings exceeding 200 and 400 Bq/m^3 is around 5% and 1% of the total, respectively. The concentration distribution could be described by a log-normal curve, but with a significant underestimation of the high concentration tail.

INTRODUCTION

The aim of the national survey was: i) to obtain the distribution of radon concentration and of absorbed dose rate in air; ii) to evaluate the average exposure of the population to natural radiation. These data might allow an assessment of the percentage of dwellings, which exceeds some reference levels of radon concentration, and the average risk - according to present knowledge - for the population due to radon indoors. The opportunity and the social and economical cost of regulatory choices could thus be evaluated.

The strategy chosen - a two stage stratified sampling according to administrative districts and population - is described in ref.1. The peculiarity of the survey is the involvement of several public laboratories in carrying out the measurements and local health authorities in approaching the families. The survey was designed to give representative data of radon concentration both at district and at national level, allowing also to proceed in different time steps.

The organization and the state of art of the survey, the experimental set up, the protocols and the questionnaires adopted, the acceptance of the public, have been presented elsewhere (ref. 2, 3). In this paper the quality control methodology and the experimental results in 45% of the sample are presented.

QUALITY ASSURANCE AND QUALITY CONTROL PROCEDURES

As the survey involves around twenty laboratories with different operational experience, a sound quality assurance/quality control programme has been set up. It foresees: the intercomparison among laboratories at the beginning of the measurement phase, the use of duplicate dosemeters (each containing two detectors), a strict protocol to assemble the detectors, to perform the measurements and to analyse the data. The QA/QC programme is

carried out by the two National Institutes in order to guarantee the comparability of the various data sets.

Regarding the quality assurance of the measurement apparatus, the dosemeters used in the survey were previously calibrated both at the NRPB radon chamber (twice) and at the USDOE-EML (once). The three calibration factors have a coefficient of variation of 5%. In the first two intercomparison runs organized in Italy at central level the coefficients of variation among the different laboratories were 8% and 11%.

The complete set of data from detector pairs (one detector for each dosemeter) were compared by means of parametric and non parametric tests (ref.4) to verify their consistency and to identify possible outliers. In these cases, the third detector is processed and, sometimes, even the fourth (used as back up detector by the National Institutes).

An evaluation of the errors affecting the measurements of the laboratories involved - connected with differences in batch, in etching procedure, in track counting, etc. - was performed. A first analysis allowed to assign a global uncertainty around 30% for radon concentrations up to 50 Bq/m^3 and 20% for concentrations above the same value. A more detailed study is at present being carried out.

RESULTS

The survey is still in progress. Data from 45% of the national sample (northern and central districts) have been analysed. The distribution of annual radon concentration in dwellings (see fig.1) has approximately a log-normal shape. The Kolmogorov-Smirnov test was performed to assess the *goodness-of-fit* of the actual distribution with a log-normal curve. A negative result ($p < 10^{-6}$) was obtained.

The arithmetic mean of radon distribution in the different districts ranges from 43 to 117 Bq/m^3 and the overall mean is 80 Bq/m^3, with an estimated statistical uncertainty of 3 Bq/m^3 (95% of confidence level). The median is equal to 61 Bq/m^3, close to the geometric mean, which is equal to 62 Bq/m^3, with a statistical uncertainty of 2 Bq/m^3 (95% c.l.).

The fraction of dwellings with mean radon concentration exceeding 200 Bq/m^3 and 400 Bq/m^3 - the reference levels adopted by the European Community for new and existing dwellings - ranges in the different districts from 0.6% to 9.9% and from 0% to 4.9%, respectively. In the total measured sample this quantity is 5.1% and 1.3% respectively, with a statistical uncertainty of 1.0% and 0.6% (95% c.l.). The values obtained by the log-normal fit are 3.9% and 0.2%.

In conclusion, whereas the log-normal approximation gives a fairly good estimation of the distribution central value, it significantly underestimates the high radon concentration tail, as reported also by other authors (ref.5).

The mean ratio of the winter/summer concentrations ranges from 1.1 to 2.7 for different districts, with a mean value of 1.5. The correlation of radon concentration with floor level is shown in fig.2. The mean concentration decreases from basement to the ground and the first floor, becoming almost constant after the second floor.

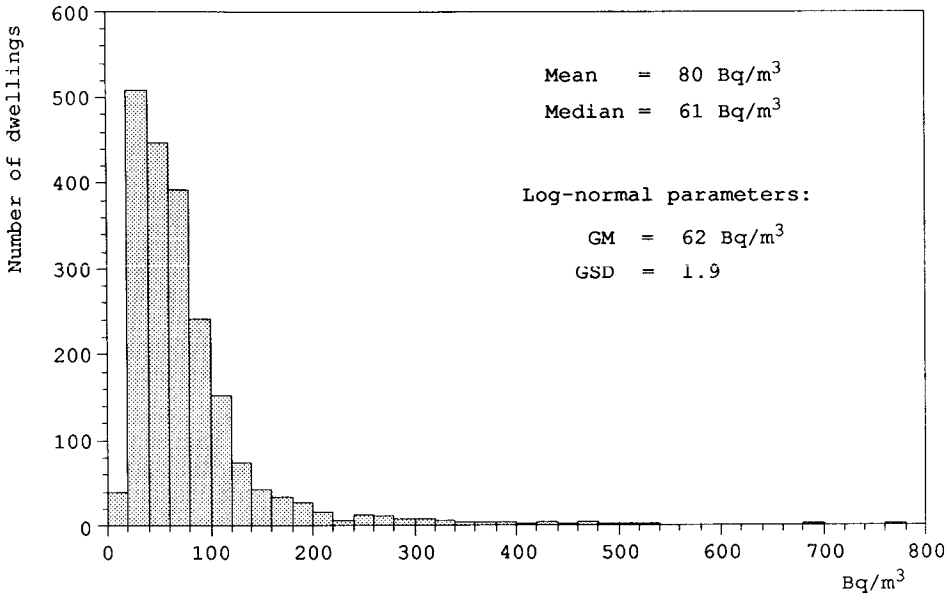


Fig.1 Distribution of annual radon concentration

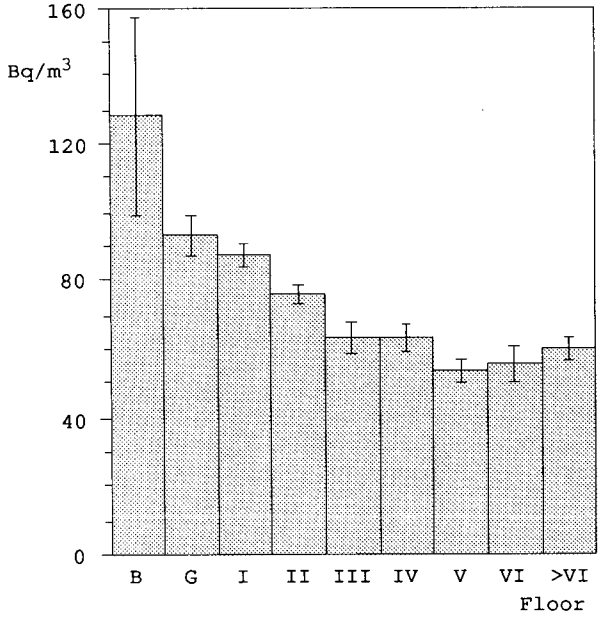
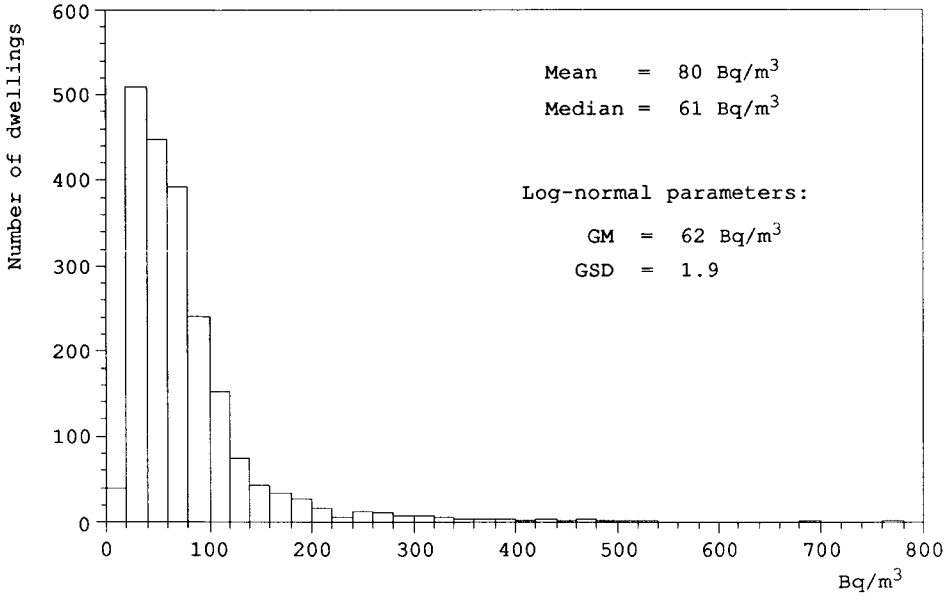


Fig.2 Mean annual radon concentration vs floor.
The error bars represent one standard error.



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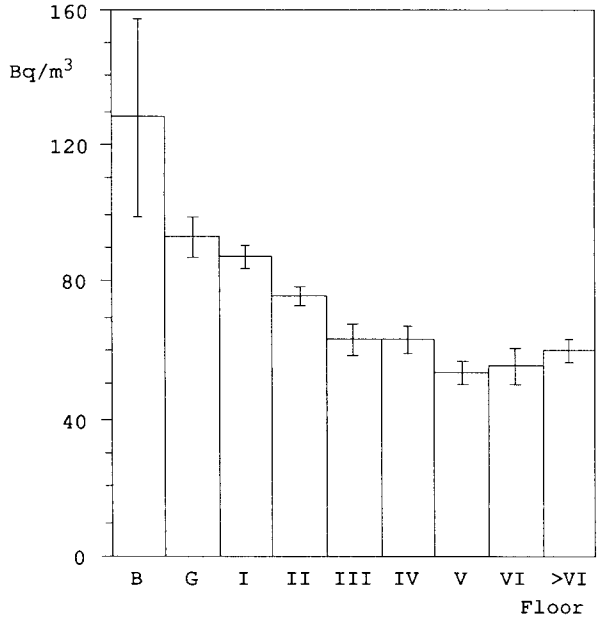

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The error bars represent one standard error.

CONCLUSIONS

Taking into account the occupation factors indoors at home and elsewhere, obtained in the survey through questionnaires, the mean effective dose has been calculated (ref.6). The value ranges from 2.2 to 6.1 mSv/y in the different districts, with a mean of 4.1 mSv/y.

This evaluation confirms even in Italy the relevance of radon as a source of exposure to ionizing radiation.

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