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Relevance of air conditioning for ^{222}Radon concentration in shops of the Savona Province, Italy

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Abstract

Radon (^{222}Rn) concentration was evaluated in shops of the Savona Province, Italy, between summer 2002 and winter 2002–2003. The main characteristics of each shops were recorded through a questionnaire investigating the ventilation rate and factors related to ^{222}Rn precursors in the soil and the construction materials. The main variables that were related to radon concentration were the following: age of the building, level of the shop above ground, season of the year, wind exposure, active windows, and type of heating system. Shops equipped with individual air heating/conditioning systems exhibited radon concentrations that were three times higher than those of shops heated by centralized furnaces. Our data indicate that the level of pollution in the shops was of medium level, with an expected low impact on the salespersons' health. Only in wintertime, the action level of 200 Bq m^{-3} for the confined environment was reached in 10 shops equipped with individual air heating/conditioning systems.

Keywords: Radon; Shops; Air conditioning–heating systems

1. Introduction

Radon (^{222}Rn) is a major natural source of ionizing radiation. Hazard to the general population is due to its concentration in the confined environment, where most of our time is spent. ^{222}Rn decays to a sequence of radioactive isotopes, known as radon progeny. These solid isotopes are found in aerosol and, when inhaled, they constitute the major source of health risk. In fact, they adhere to the internal wall of the respiratory tract, and can induce lung cancer (Marley et al., 2000). The alpha energy of the ^{222}Rn progeny in relation to its parent compound is defined equilibrium factor (F) (Postendorfer, 1984).

Retail shops and workshops constitute a special case of confined environment, for they are usually located at ground or underground level and may be inconvenienced by reduced ventilation, two major risk factors for radon accumulation. Our aim was to verify radon concentration in these premises in the Savona Province. This area of the Liguria Region was chosen because, in our previous study on ^{222}Rn in human

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dwellings (Gallelli et al., 1998), it exhibited higher concentrations than those of Genoa, the regional capital city. The postulate was that this difference could be ascribed to higher levels of ^{222}Rn precursors in the soil.

2. Materials and methods

Managers of shops and workshops located in Savona and the neighboring towns were invited to participate in this study. The agreeing participants received a questionnaire investigating the following variables: age of the building, presence of spaces (e.g., cellars, garages) underlying the premises, windows and additional ventilation systems, type of window frame, and heating/ventilation system. Between summer 2002 and winter 2002–2003, 56 shops were studied. Two determinations were performed for each of them in these two seasons, with a total of 224 determinations.

2.1. ^{222}Rn determination

^{222}Rn concentration in the air was measured with the activated-carbon canister method, as reported by Cohen and Cohen (1982) and standardized by the Environmental Protection Agency. The canisters were located at a height of 1.5 m above the floor. After a exposure time of about 3 days, canisters were examined in the laboratory with a NaI 3 in.×3 in. detector (Tl activated) and a Silena Snip 201N multichannel (1024 channel) analyzer connected to a computer via serial port. The range of gamma emission of the ^{222}Rn progeny (i.e. 295–352-keV photo peaks of 214 Pb and 609-keV photo peak of 214 Bi) was used. The minimum measuring time was fixed at 2000 s for each sample; 3000 s for zero; and 100 s for a standard reference canister with a known concentration of 226 Ra (Isotope Product Laboratories, Burbank, CA).

2.2. Effective dose calculation

The effective dose (EC) to the population has been calculated as suggested by UNSCEAR (2000),

$$EC = CRn \times F \times HC \times DC \quad (1)$$

where\ CRn is the ^{222}Rn indoor concentration (Bq m^{-3}), F the equilibrium factor, HC occupancy (h year^{-1}), and DC the dose coefficient (nSv (Bq h m^{-3})$^{-1}$).

Since experimental values of F are unknown for Savona, we employed a default value of 0.4, as suggested by UNSCEAR (2000).

Occupancy was assumed to amount to 1936 h/year , a value corresponding to an 8-hour daily working shift for 22 days/month and 11 months/year and a breathing rate of 0.6 m 3 h−1 independent of seasonal variations. General population occupancy in the shops was postulated at 360 h/year , a value amounting to 1 h/day. A mean value of 9 nSv (Bq h m^{-3})$^{-1}$ for DC has been reported by UNSCEAR (2000).

2.3. Statistical analysis

The breakdown of the indoor ^{222}Rn concentration values into frequency classes indicated a log normal distribution (Fig. 1). As a result, statistical analysis was performed on log-converted concentration data. The arithmetic mean (AM), standard deviation (SD), geometric mean (GM), Confidence interval (95% CI) and standard deviation of the log-converted values (SDg) were calculated.

Differences between means for each variable were investigated with analysis of variance (ANOVA); the Sheffé test was used for internal comparisons. Statistical workup was performed with the StatView IV (Abacus Concept Inc.) program.

3. Results

The arithmetic mean of ^{222}Rn concentration was 61.46 Bq m^{-3}±52.9 SD. The geometric mean was 48.97 Bq m^{-3} (95% CI 46.13–53.70). Concentrations ranging in between 200 Bq m^{-3} and 400 Bq m^{-3} , corresponding to UNSCEAR, 2000 action level, were reported in 10 shops.

The mean ^{222}Rn concentration was broken down by (i) building characteristics, (ii) air ventilation, and (iii) heating/conditioning systems.

3.1. Building characteristics

The area where the building is located is the main variable affecting indoor ^{222}Rn concentration. Additional variables that are to be considered include age