Indoor radon concentration survey in Mexico

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Indoor radon evaluations in specific regions of the country have been performed in an effort to assess the magnitude of the radon problem and its public health consequences. The survey of this paper covers four large non-tropical regions of north and central Mexico, and reports the results of measurements of indoor radon concentrations in houses of towns with between 100,001 and 500,000 inhabitants. The measurements were done by using passive detectors, namely, the closed-end-cup system with CR-39 polycarbonate chips as detector material. The measurements were performed throughout the two coldest seasons (between 5 and 20 °C), winter and spring, in integration periods of 28 days covering the six month cycle. The results show a moderate average radon concentration below 200 $Bq \cdot m^{-3}$ with occasional higher values. This is very probably due to the climate conditions and the traditional habits of open door and window ventilation. The IFUNAM (Instituto de Física, Universidad Nacional Autónoma de México) Laboratory, where the closed-end cup system for radon was developed, has gained experience though this survey and is willing to share it for future surveys at regional or national levels.

Introduction+

The natural generation of radon (^{222}Rn) from radium (^{226}Ra) is considered as the main source for the indoor radon environmental level. Although the half-life of ^{222}Rn gas is only 3.82 days, its high mobility and the generation of polonium (^{210}Po) as the decay product with a half-life of 138.38 days, make the inhalation of radon to be one of the most important environmental factors associated with the risk of lung cancer for the general public,[1] behind tobacco smoking.

The concentration of indoor natural radon is due fundamentally to the geological characteristics of the site, to the existence of uranium deposits and groundwater, to the construction materials of houses and buildings, and to the concentration of outdoor radon on the external environment.

In Mexico and other countries with similar economic and climatic conditions, the main factors that must be considered for the indoor concentration of radon are: the habits of ventilation of the population, the architecture type and style of the construction of houses.

The Environmental Protection Agency (EPA-USA)[2] and the National Radiation Protection Board (NRPB),[3] recommend 150 $Bq \cdot m^{-3}$ and 200 $Bq \cdot m^{-3}$, respectively, as the limits to start mitigation action (action levels).

In Mexico, under the auspices of UNAM (IFUNAM, Dosimetry Applications Project) and with our own technology, a survey of the most important cities, by population, has been undertaken to determine the concentration and incidence of indoor radon. This survey was made in homes in non-tropical areas, with particular attention in the north and central areas of the Mexican territory, where the volcanic rocks, limestones and sedimentary rocks can be potential radon generators. This study includes towns with 100,001 to 500,000 inhabitants for logistic and budget reasons.

Experimental

Method

Passive alpha-track methodology was used for the measurements, with the closed-end cup system developed for large scale measurements.[4] CR-39 polycarbonate was used as the detector material, because of its high sensitivity to radon gas and its efficient energy response for the 5.5 MeV alpha particles.

The detectors were exposed to radon environment, inside of the living rooms and bed rooms of the chosen homes. The measurements were taken for periods of 28 days during six months; three throughout the winter and three in the spring, during which the lowest temperatures occur in the four regions. Measurements were carried out in 100 to 200 houses in each location, in order to provide statistical control and have a better knowledge of each region. Eventually, the places with highest concentrations were reevaluated with a dynamic radon monitor.

One step chemical etching, in KOH solution, 6.25M at 60 °C for 16 hours was chosen for the track development process. A Digital Image System (DIS) was used to evaluate the track density,[5] using the tracks formed on only one side of the detector. The calibration radon chamber from ORNL, USA, was used as a reference for the calibration of the closed-end cup radon monitor.

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Characteristics of the regions under study

Geographic and geological characteristics. The indoor radon survey was made at the north and central areas of Mexico. For this purpose the territory was divided into four regions, depending basically on the climate from desert to arid.[6]

The desert region (D) corresponding to the Mexican states of Sonora, Chihuahua and Durango, at the cities of Hermosillo, Obregón, Juárez, Chihuahua and Durango. The semidesert region (SD), corresponding to the states of Zacatecas, Coahuila, San Luis Potosi, at the cities of Zacatecas, Coahuila, Torreon, Saltillo and San Luis Potosí. Semiarid (SA), corresponding to the states of Jalisco, Michoacan, Aguascalientes, at the cities of Guadalajara, Morelia, Uruapan and Aguascalientes. And the arid climate (A) corresponding to the states of Hidalgo, Queretaro, Guanajuato, at the cities of Pachuca, Queretaro, Guanajuato and León. The bedrock and soils on the four regions are predominantly volcanic rocks, volcanic ashes, sedimentary rocks, solonchack, andisoils and vertisoils.

All the locations under study have the common characteristic of populations of more than 100,001 inhabitants. This characteristic opens the possibility to analyze the public health effects due radon, in houses with similarities on the type of architecture, building construction materials and ventilation habits. Most of the houses and buildings can be considered as built in a rustic style. The wind flows freely through the rooms, from open windows and doors, producing an almost continuous exchange of gases in the air in the interior. Even though the construction is predominantly of clay bricks, concrete, gypsum and lime, the ventilation habits and ventilation systems are the more important factor on the indoor radon concentration.

Results

The results from the six month measurements, are shown in Table 1, grouped according to the climate of the area. The number of houses measured, lowest and highest radon concentration levels found, average value for each location, and the standard deviation from this value are included in the table. It is important to point out that three of the locations are very well known for their mining activities, and up to now, some mines still exist inside the cities, where it could be expected to find higher levels of radon concentration. The town of Chihuahua is a very rich area with uranium mines.

From the results it can be observed that the average radon concentration is lower than the 200 Bq·m^{-3} action level. Some of these values were really not expected because the locations are full of mines and uranium ores. These data confirm that the ventilation habits and types of construction are the fundamental factors making most of the houses in the cold climate regions in Mexico not to present high risks concerning the indoor radon concentration.

Table 1. Range and average indoor radon concentration in the houses of the Mexican central and north region

Code	Location	Number of houses studied	Minimum concentration, Bq/m^3	Maximum concentration, Bq/m^3	Average concentration, Bq/m^3	Standard deviation, bq/m^3 from average
D1	Cd. Obregón, Son.	120	30	132	87	23.30
D2	Hermosillo, Son.	150	27	157	91	20.11
D3	Cd. Juárez, Chih.	150	63	252	159	31.45
D4	Chihuahua, Chih.	150	69	273	169	30.25
D5	Durango, Dur.	150	33	159	73	21.15
SD1	Coahuila, Coah.	150	61	152	81	23.52
SD2	Saltillo, Coah.	150	35	127	79	25.32
SD3	Torreón, Coah.	120	61	160	87	32.15
SD4	Zacatecas, Zac.	200	70	263	130	26.00
SD5	San Luis Potosí, SLP	200	33	148	73	36.12
A1	León, Gto.	150	34	130	85	33.10
A2	Guadalajara, Jal.	200	75	214	179	33.20
A3	Pachuca, Hgo.	150	47	187	137	36.99
A4	Quertaro, Qro.	200	39	193	110	18.70
SA1	Guanajuato, Gto.	150	57	263	153	33.42
SA2	Uruapan, Mich.	120	31	139	73	26.00
SA3	Morelia, Mich.	150	40	165	80	23.70
SA4	Aguascalientes, Ags.	200	39	154	79	21.33

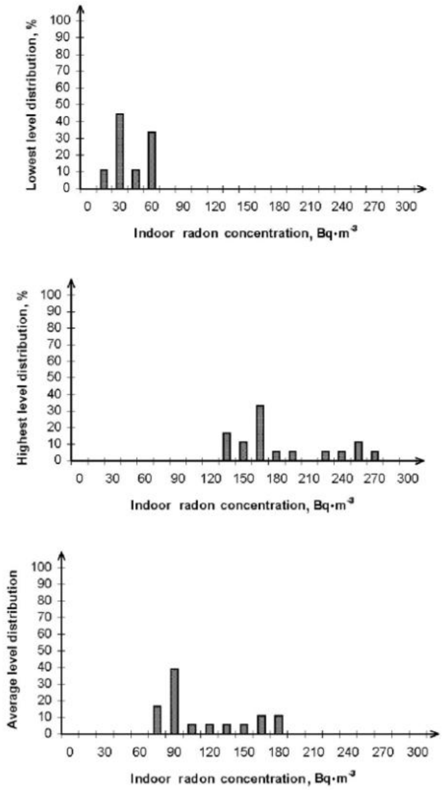

Fig. 1. Indoor radon concentration versus percent of distribution of the different locations under study

Figure 1 shows the distribution of indoor radon concentration for lowest, highest, and the average values for the regions under this study.

Conclusions

The values of the radon concentration survey on the central and north regions of Mexico, show low and moderate levels, compared with measurements in nearby regions of USA, with similar geological, soil and climate characteristics, confirming that the main factors for the differences are the habits of ventilation and types of construction and architecture styles. These habits and construction characteristics make the situation unique concerning the concentrations of indoor radon, making these houses radiologically safe. In this way, the risk of lung cancer due to indoor radon inhalation becomes less probable for the inhabitants.

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