# INDOOR RADON AND RADON DAUGHTERS SURVEY AT CAMPINAS-BRAZIL USING CR-39: FIRST RESULTS

S. GUEDES *, J.C. HADLER N.*, P.J. IUNES *, L.M.S. NAVIA *, R.S. NEMAN *, S.R. PAULO **, V.C. RODRIGUES *, W.F. SOUZA *, C.A. TELLO S. * AND A. ZÚÑIGA *,***

* Instituto de Física, UNICAMP, 13083-970 Campinas-SP, Brazil

** Depto. Física, ICET, UFMT, Av. Fernando Correa, S/N, 78060-900 Cuiabá-MT, Brazil

*** Instituto Peruano de Energia Nuclear, IPEN, Av. Canadá, 1470, Lima 41, Peru

## ABSTRACT

The first results of a radon and radon daughters (RD) survey performed at Campinas-SP, Brazil, are presented. We employed a technique that, potentially, makes possible to measure the radon and RD activity in the air and to separate from this result the activity of radon, alone. In this preliminary paper only the former activity is studied.

## KEYWORDS

Radon; radon daughters; survey; Brazil.

## INTRODUCTION

During the two last decades indoor radon and RD contamination have been intensively studied. It has been observed that the research works on this contamination are focused on the radon activity measurement. We believe that the direct measurement of RD is a significant step toward understanding of the real importance of indoor contamination by radon and RD.

This paper deals with the utilization, in indoor survey at Campinas, SP, Brazil, of a detection technique where CR-39 is used as an alpha-spectrometer if only round tracks are analyzed. This technique, developed at UNICAMP (Paulo, 1991; Hadler and Paulo, 1994), potentially allows to measure radon and RD activity in the air and to separate from this result the activity of radon, alone. In this preliminary paper only the former activity is studied, utilizing the results of measurements performed on detectors exposed in 15 dwellings.

## EXPOSURE CONDITIONS

The exposures concerning the Campinas survey were carried out in dwellings selected by a weighted random process taking into account IBGE (Brazilian Institute of Geography and Statistics) annual income per capita. The unitary censual regions drawn in this way were constituted by approximately 200 families. To select a dwelling inside the unitary regions a new restriction was considered: the dwelling must be inhabited by a family where one of its members was professor or employee of UNICAMP (amounting approximately 16,000 families). Besides, the dwellings chosen had to have external aspects (building area, quality and conservation of the employed building material, etc.) similar to the neighboring houses. In the cases where this was not observed the dwellings were ruled out.

The advantage of this restriction was that we made a first contact with the chosen professors and employees at the Campus of our University, where the purposes of our research were explained and written texts about the matter were given to them. Usually some days after this first contact the


PII: S1350-4487(99)00122-5

correspondent dwelling was visited by members of our group and the exposure began. During this visit a questionnaire about characteristics of the dwelling (conditions of the floor, internal walls, ventilation, etc.) and some other useful information was filled; besides, a plan of the dwelling was schematically drawn. It is worth to mention that the detectors were exposed on a wall at the height of 2 m (to be out of the "children range") usually in one of the bedrooms of the dwelling.

Our survey was divided in two steps. A first 100 dwellings exposure covered the period between November of 1996 to May of 1997 (summer exposure). A second exposure started in May of 1997 and ended in December of 1997 (winter exposure). The second exposure include 89 out of the 100 dwellings selected for the first exposition. The detectors were placed in the same rooms in the same dwellings as for the first exposure. The purpose of repeating the exposure in the same locations was to study whether there are differences between winter and summer exposure. In this paper, the 15 analyzed detectors refer to the summer survey.

## METHODOLOGY

The measurement of radon and RD activities are performed by means of exposing assemblies made up of 2 parallel square plates (4mm apart and having a width of approximately 14cm) of acrylic containing 2 sheets of CR-39. Both detectors are attached to the acrylic plates, near the center of the assembly. One detector is exposed between the plates while the other is placed outside the assembly, under a $2\pi$ geometry. In principle, the internal detector should be used to measure the radon gas activity, only. Efforts to attain this goal are in course. However, the core of the technique we developed is based on the external detector, because it contains information on the radon and RD activity in the air.

Concerning the external detector, if only round tracks (ratio between major and minor diameters smaller than 1.10) are measured under an automatic optical microscopy system, a characteristic double peak (at our standard chemical etching: NaOH 6.25 N at 70°C for 400 min) is observed in the histogram of S, the product of the major and minor diameters of each track (see Fig. 1). The peak of lower S values is constituted by alpha tracks from RD plated-out on the detector surface during exposure (tracks with low grey level) and radon and RD reaching the detector with very low energy (tracks with high grey level). The peak of higher S values, whose tracks present intermediary grey level, is produced by radon and RD decays, taking place in the air neighboring the detector.

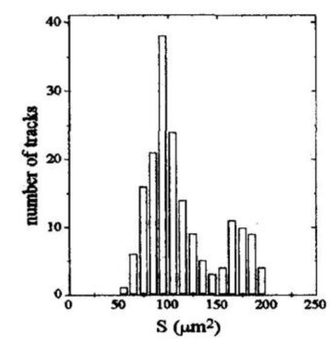


Fig. 1. A typical S histogram observed when round tracks are measured in an external detector. This case refers to assembly number 19 (see Table 1).

The radon and RD activity in the air, is related to the correspondent track density (tracks of higher S values and those of lower S values presenting high grey level), ρ, by

$$\rho = t\chi \sum_{i=0,1,3} A_i \tag{1}$$

where t is the expoure time, $\chi$ = (0.16 ± 0.016) cm is an efficiency factor related to the effective volume of each alpha emitter, i.e. the volume neighboring the detector in which the decays, taking place inside it, produce round tracks and $A_i$ are the activities, where i = 0, 1 and 3 for Rn-222, Po-218 and Po-214, respectively.

## RESULTS

Our results are presented in Table 1, where there are also some qualitative features of the rooms in which the assemblies were exposed, extracted from the questionnaire answered by the dwelling owners, as quoted above. Its first column gives the detector number, the second one contains information on ventilation, the third column contains information on the internal paint, the fourth column informs weather the rooms belong to a flat (f) or a house (h), the fifth column gives the radon plus RD activity in the air, obtained by equation 1 and the last column gives the activity of the RD plated-out on the detector surface during exposure, G, described by

$$G = \frac{2\rho_{po}}{t\chi_{po}} \tag{2}$$

where $\rho_{po}$ is the areal track density corresponding to the plated-out RD, i. e. the tracks belonging to the peak of lower S values and presenting low grey level, and $\chi_{po}$ = (6.4 ± 0.5)% is an efficiency factor (Hadler and Paulo, 1994).

Table 1. Some dwelling characteristics and the measurement results carried out in the external detectors of 15 assemblies of the summer survey at Campinas.

| Assembly number | Ventilation | Internal paint | House or flat | Radon plus RD in the air (x 43.98 Bq $m^{-3}$) | Plated-out RD (x 9.30 x $10^3$ $cm^{-2}$ $a^{-1}$) |
|---|---|---|---|---|---|
| 4 | Good | Acrylic | H | 0.56±0.14 | 0.54±0.11 |
| 19 | very low | Unpainted | H | 2.18±0.28 | 2.88±0.27 |
| 23 | Good | Unpainted | H | 3.43±0.34 | 5.39±0.36 |
| 26 | Good | Latex | H | 1.20±0.21 | 1.00±0.16 |
| 28 | Low | Latex | F | 0.72±0.16 | 0.84±0.15 |
| 41 | Good | Latex | H | 1.23±0.21 | 1.10±0.17 |
| 46 | Good | Latex | H | 1.21±0.20 | 1.56±0.20 |
| 53 | Good | Latex | H | 0.97±0.18 | 0.75±0.14 |
| 61 | Good | Latex | H | 0.88±0.18 | 1.02±0.16 |
| 66 | Good | Latex | F | 0.74±0.16 | 0.74±0.14 |
| 67 | Low | Latex | H | 0.91±0.18 | 0.89±0.15 |
| 69 | very low | Latex | H | 2.01±0.27 | 2.59±0.26 |
| 70 | very low | Latex | H | 0.82±0.17 | 0.59±0.12 |
| 84 | Low | Latex | H | 0.86±0.17 | 0.70±0.13 |
| 86 | Good | Latex | F | 0.97±0.19 | 1.80±0.21 |

In the two last columns of this Table, activities given are normalized to the weighted mean value of each column, which is 43.98 Bq $m^{-3}$ for the fifth column and 9.30 x $10^3$ $cm^{-2}$ $a^{-1}$ for the last column. Analyzing these two columns, one can observe a strong correlation between radon plus RD activity in the air and RD plated-out on the detector surface, which is depicted in Fig. 2.

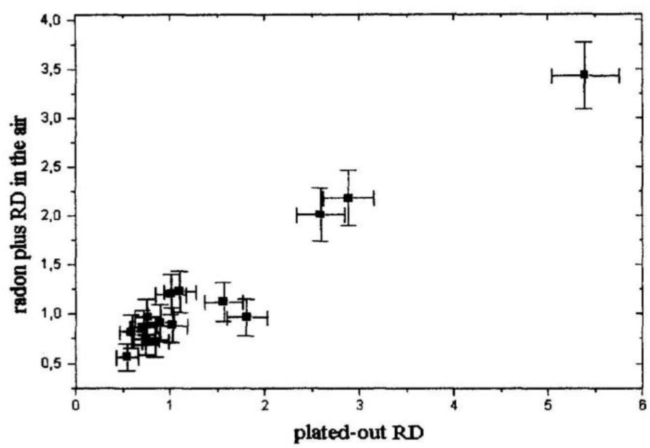


Fig. 2. Radon plus RD activity in the air versus plated-out RD activity for the detectors analyzed in this paper.

Concerning the radon and RD activity and the qualitative features of the rooms shown in Table 1, some comments can be made: i) two dwellings without internal painting (assemblies 19 and 23) presented activities higher than average and the dwelling painted internally with acrylic paint presented the lower activity, ii) flats (assemblies 28, 66 and 86) showed lower but comparable activities with houses and iii) it is difficult to establish a correlation between ventilation and activity. Items i) and ii) indicate that radon and RD activity originate mainly from the building material (brick and concrete) making up the environment where the detectors were exposed (walls, floor and roof).

**Acknowledgement** – This work was supported by FAPESP, Brazil.

## REFERENCES


Hadler J.C. and Paulo S. R. (1994) Indoor radon daughters contamination monitoring: the absolute efficiency of CR-39 taking into Account the plate-out effect and environmental conditions. *Radiat. Prot. Dosim.* **51**, 283-296.

Paulo S. R. (1991) *Dosimetria ambiental de Rn-222 e filhos: Medida da eficiência absoluta do CR-39 levando-se em conta os efeitos do plate-out e fatores ambientais*. PhD. Thesis, IFGW, UNICAMP, Brazil.