Estimating the radiological impacts in a Natural High Background Radiation area: the case of Horta da Vilariça (Northeastern Portugal)

Pereira, A.J.S.C. [1,2]; **Pinto P.G.A.N.** [1,3] & **Neves, L.J.P.F.** [1,4]

[1]IMAR, Department of Earth Sciences, University of Coimbra, Largo Marquês de Pombal, 3000-272 Coimbra, Portugal

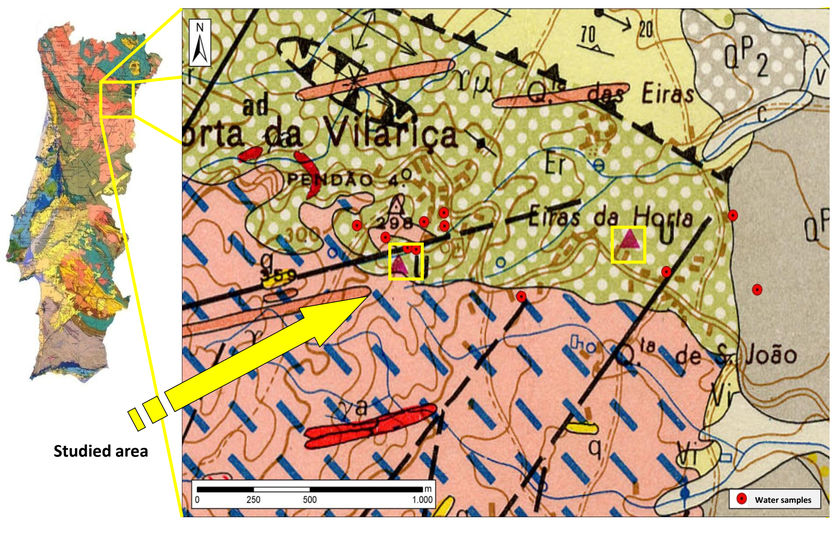
[2]apereira@dct.uc.pt | [3]ppinto@dct.uc.pt | [4]luisneves@dct.uc.pt

1. Introduction

From uranium mining prospecting works, carried out a few years ago, the occurrence of high background radiation in the area surrounding the Horta da Vilariça village (Northeastern Portugal) was recognized (HRBA). The source of the radiation is related with the natural occurrence of uranium-enriched rocks in the geological bedrock. Farming is, at present, the main land use and permanent dwellings were not build until now. Research works have been carried out in the area to estimate the radiological impacts induced by the radioactive isotopes in soils, water and air.

1.1 Geological setting

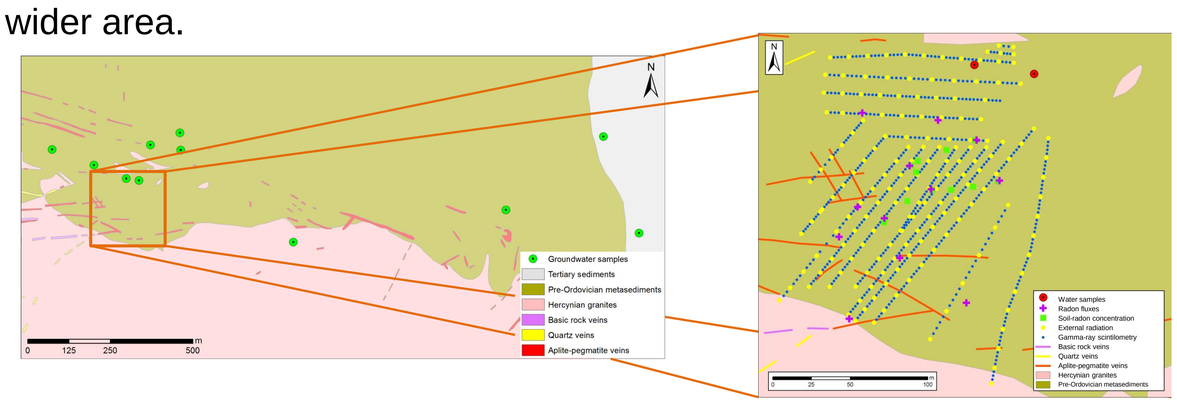
The source of radiation is the uranium-enriched pre-Ordovician metasedimentary rocks (green color) occurring in the metamorphic aureole of an hercynian granite (pink color - *see figure below*).



2. Methods

2.1 Sampling

The dataset was build from measurements of gamma-ray dose rate in air (177 points), surface radon fluxes (12 samples), soil-radon concentrations (13 samples) – *see figure below*. All the data were obtained in the HRBA, with the exception of water samples collected in a wider area.



2.2 Techniques

Besides the use of the techniques shown below to get experimental data, calculations were also carried out, based in a deterministic approach methodology using realistic scenarios, to estimate outdoor and indoor radon gas concentrations. The absence of dwellings in the HBRA was the reason for this approach.

Gamma-ray scintilometry

Soil-radon concentration

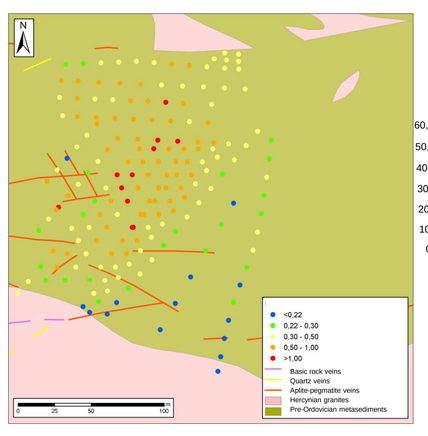
Gamma-ray dose rate in air

^{238}U, ^{234}U, ^{226}Ra and ^{222}Rn activities

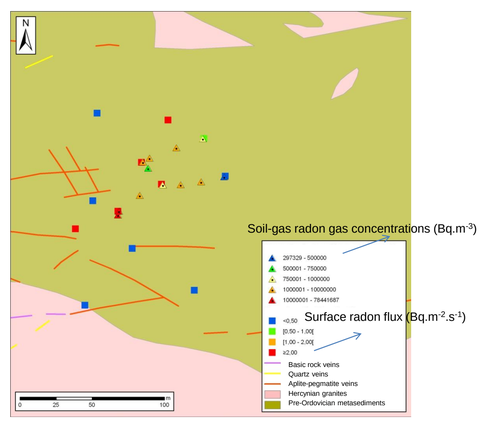
Surface radon fluxes

3. Results

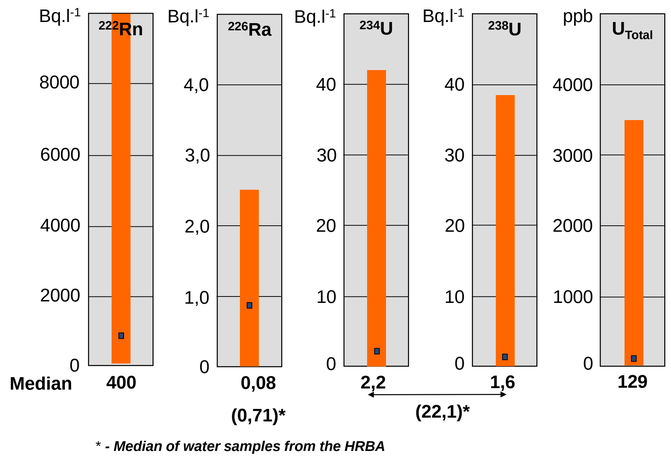
3.1 Gamma-ray dose rate in air [μGy.h^{-1}]



3.2 Soil-gas radon concentration and surface radon fluxes

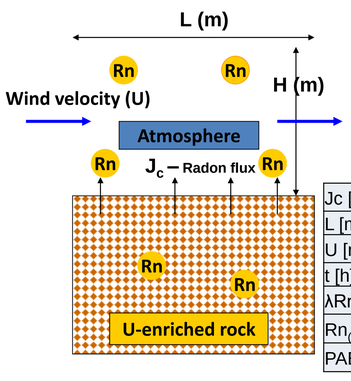


3.3 ^{222}Rn, ^{226}Ra, ^{234}U and ^{238}U activities in groundwater



* - *Median of water samples from the HRBA*

3.4 Radon concentration in outdoor air (estimated)

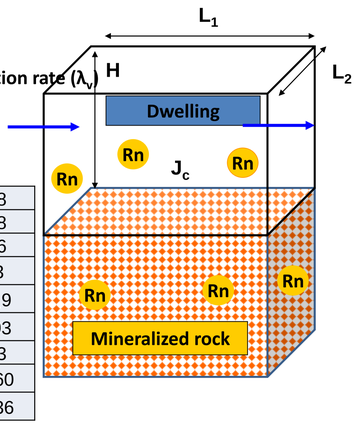


Jc [Bq.m^{-2}.s^{-1}]	0,99
L [m]	130
U [m.s^{-1}]	2
t [h]	10
λRn [s^{-1}]	2,1x10^{-6}
$Rn_{(outdoor)}$ [Bq.m^{-3}]	60
$PAE_{(outdoor)}$ [nJ.m^{-3}]	268

$$\frac{\partial C_0(t)}{\partial t} = \frac{J_c(t)}{H} - \left[\lambda_{Rn} + \frac{U}{L}\right] \cdot C_0(t)$$

$$C_0(t) = \frac{J_c(t) \cdot \left[1 - \exp\{-(\lambda_{Rn} + U/L)\} \cdot t\right]}{H \cdot (\lambda_{Rn} + U/L)}$$

3.5 Radon concentration in indoor air (estimated)



L1 [m]	4,8
L2 [m]	4,8
H [m]	2,6
Area [m^2]	23
Volume (V) [m^3]	59,9
Jc [Bq.m^{-2}.s^{-1}]	0,93
Ventilation rate [h]	0,3
Indoor Radon [Bq.m^{-3}]	1860
PAE indoor [nJ.m^{-3}]	4136

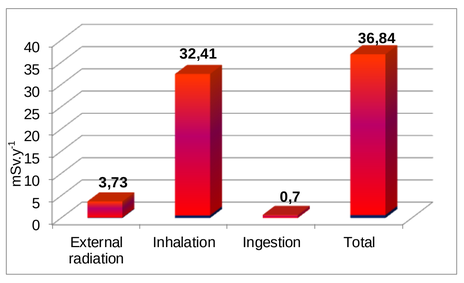
$$\frac{dRn}{dt} = \frac{J_c}{V}(\lambda_v - \lambda_{Rn})$$

3.6 Estimation of the effective dose due to natural ionizing radiation exposure

External radiation	Inhalation (radon and progeny in the air)	Ingestion (water)
$(A.t_2.10^{-6}.1 + A.t_1.0,7.10^{-1})$	+ $C_1.t_1.10^{-6}.1,1 + C_2.t_2.10^{-6}.1,1$	+ $Ra.b_1.2,8.10^{-4} + U.b_1.4,5.10^{-5} + \ldots$

Modified from Daroussin et al. (2000)

Time indoor (t_1) [h]	7000
Time outdoor (t_2) [h]	1760
Inhalation rate	0,8
^{226}Ra in water [Bq.l^{-1}]	0,71
Total U in water [Bq.l^{-1}]	22,1
Water consumption, b1 [l]	584
External radiation, A [nGy.h^{-1}]	560
PAE* (outdoor – C2) [nJ.m^{-3}]	268
PAE* (indoor – C1) [nJ.m^{-3}]	4136



Data from other areas

Region	Dose [mSv.y^{-1}]
Portugal	5,4
World	2,5

* - *Potential Alpha Energy*

4. Conclusions

The results obtained in this study, indicated that the studied area is inserted in the designated natural high background radiation area (HBRA), with an estimated annual effective dose around 7 times higher than the national average, and about 15 times higher than the world average. These data are likely to be used as an estimation of the natural background, if the exploitation of the uranium ore go forward.