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# Openings and temperature are important factors to decrease the lung cancer rate in mine workers

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# 1. Introduction

- The new solutions have coherence with data of recent experimental works. The analysis show that more than one opening in mine environments makes the radon concentration decrease and leaves it subject to large seasonal fluctuations due to the natural ventilation, which depends on the outside temperature changes. Thus, in this work, we discuss how temperature, natural openings and ventilation system are able to reduce doses of miners to values below of 100 Bq $m^{-3}$ (limit determined by UNSCEAR [2006]) and consequently the incidence of cancer in workers.

UNSCEAR (2006). Annex E: United Nations.

# 2. Method

Despite the complexity of radon exhalation and transport processes inside the mine tunnels, the analysis of radon concentration distribution can be made with the help of models like the advective reacting diffusion equation, (Valladares et al., 2014; Lacerda, 2015) which in the one dimensional case:

$$\frac{\partial C(x,t)}{\partial t} - D\frac{\partial^2 C(x,t)}{\partial x^2} + v\frac{\partial C(x,t)}{\partial x} = -(K\Delta\mathrm{T} + \lambda)C(x,t) + \phi \quad (1)$$

Lacerda (2015). Thesis, Universidade Federal Fluminense.

Valladares et al. (2014). Science of the Total Environment, 468: 12

# 2. Method

For the case of one tube without ends, transiency, diffusion and advection have:

$$C(x)=\frac{\phi}{\lambda}\left(1+\frac{\exp\left(\frac{L\upsilon\lambda}{2D\phi}\left(\left(1+\sqrt{1+\frac{4D\phi}{\upsilon^2}}\right)\frac{x}{L}+\left(1-\sqrt{1+\frac{4D\phi}{\upsilon^2}}\right)\right)\right)}{\exp\left(\frac{L\upsilon\lambda}{2D\phi}\left(1+\sqrt{1+\frac{4D\phi}{\upsilon^2}}\right)\right)-\exp\left(\frac{L\upsilon\lambda}{2D\phi}\left(1-\sqrt{1+\frac{4D\phi}{\upsilon^2}}\right)\right)}-\frac{\exp\left(\frac{L\upsilon\lambda}{2D\phi}\left(\left(1-\sqrt{1+\frac{4D\phi}{\upsilon^2}}\right)\frac{x}{L}+\left(1+\sqrt{1+\frac{4D\phi}{\upsilon^2}}\right)\right)\right)}{\exp\left(\frac{L\upsilon\lambda}{2D\phi}\left(1+\sqrt{1+\frac{4D\phi}{\upsilon^2}}\right)\right)-\exp\left(\frac{L\upsilon\lambda}{2D\phi}\left(1-\sqrt{1+\frac{4D\phi}{\upsilon^2}}\right)\right)}\right) \quad \textbf{(2)}$$

For the case of one tube with two ends, transiency, temperature term and advection: have:

$$C(x)=\frac{\phi}{K\Delta T+\lambda}\left(1-e^{-(K\Delta T+\lambda)/\nu\, x}\right) \quad (3)$$

# 3. Results

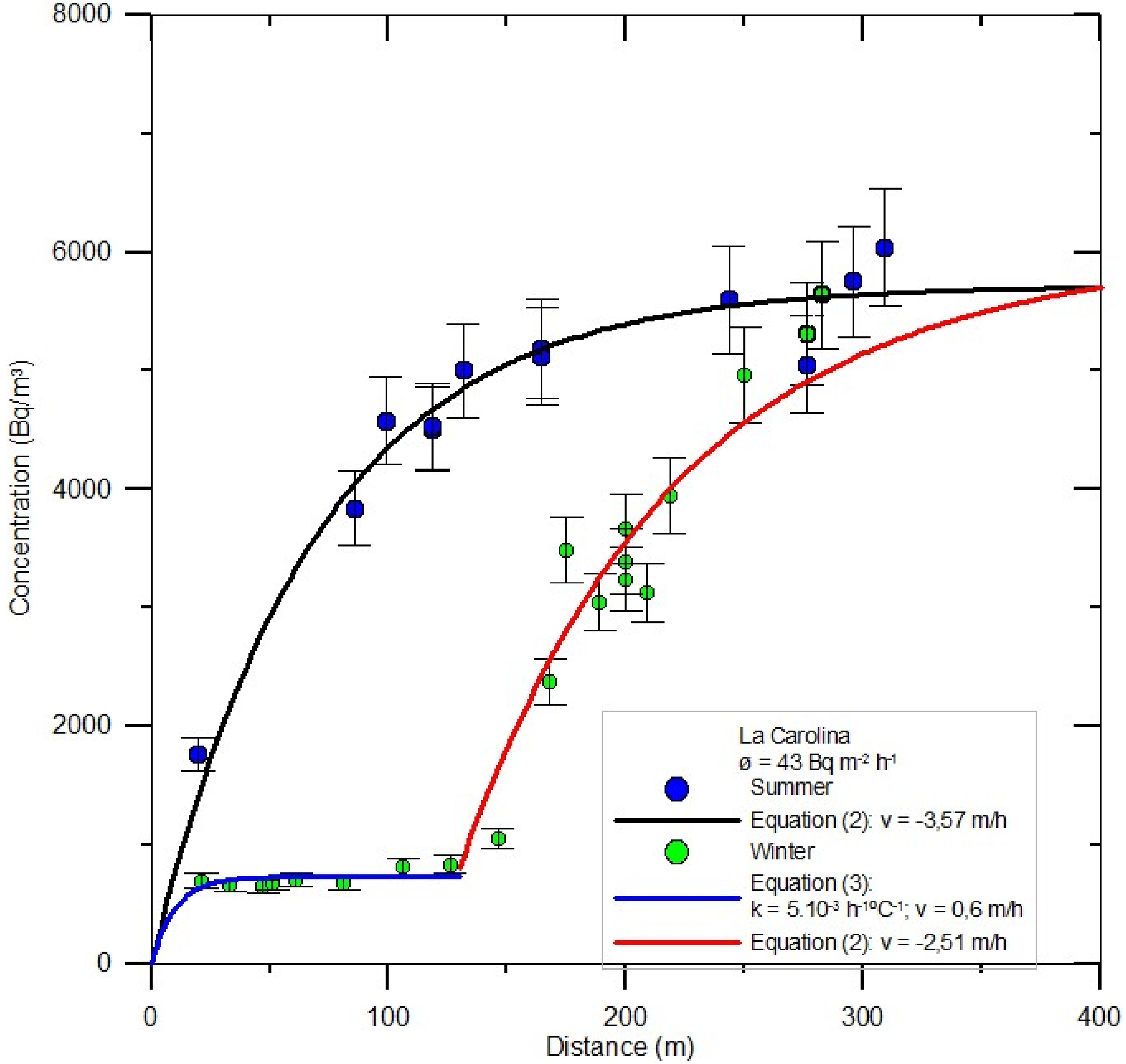


Figure shows data of Valladares et al. (2014) and fit at summer and winter for the radon concentration at La Carolina. This seasonal change could be explained by the existence of an air current produced by invisible crack inside of tunnel The winter results show radon concentrations below 400 Bq $m^{-3}$ because grows ventilation, what is a dose acceptable.

We have a good theoretical tool able to fit different data patterns, which allows speculate on the dose of mine workers without many measures

Valladares et al. (2014). Science of the Total Environment, 468: 12

THANK YOU

POSTER 150