POSSIBLE SOURCE OF UNCERTAINTY IN RADON EPIDEMIOLOGICAL STUDIES AT LOW RADON CONCENTRATIONS

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INTRODUCTION

In the last decade, the epidemiological evidence of the carcinogenicity of radon exposure in dwellings was greatly supported by a number of studies that showed a significant relative risk (RR) for lung cancer even at relatively low radon concentrations that are commonly found in most countries. Moreover, some of these studies claimed that a threshold, if any, should be fixed at a concentration of the order of 100-150 Bq/m^3, corresponding to an effective dose of the order of a mSv per year, a quite low level.
As a consequence, National and International regulation bodies have encouraged a general decrease in the established limits and in the Action levels for radon and its decay products. These limits, in some situations and countries, approach the values of the local natural background and thus could be very difficult to be respected. It is therefore important to investigate in detail the credibility and reliability of these assertions.
In this paper we will try to demonstrate that the correlation existing between radon concentrations and any other generic domestic pollutants is a possible source of bias for such studies, acting as possible confounding factor.

MATERIALS AND METHODS

The experimentally observed distributions of the indoor radon concentration data in any given area can generally be well described by lognormal shaped functions like the following:

$$f(c) = \frac{e^{\frac{-(\ln c-\mu)^2}{2\sigma^2}}}{\sqrt{2\pi}\cdot\sigma\cdot c} \quad (1)$$

where the variable c in the radon concentration that can be considered as the time averaged radon concentration. For that quantity, a simple model can be assumed:

$$c_{Rn} = \frac{k_{Rn}}{(\lambda+\lambda v)} \quad (2)$$

where c_{Rn} is the average radon concentration (Bq/m^3), k_{Rn} is the radon entry rate (Bq/[h·m^3]), λ is the radon decay constant and λ_v is the ventilation rate (h^{-1}). The two relevant parameters in equation (2) are of course k_{Rn} and λ_v. The latter varies typically in the range (0.1 – 1.5 h^{-1}), while for k_{Rn} a lognormal distribution can be assumed, with k_{Rn} varying in the range (0, +∞) :

$$g(k_{Rn}) = \frac{e^{\frac{-(\ln k_{Rn}-\mu)^2}{2\sigma^2}}}{\sqrt{2\pi}\cdot\sigma\cdot k_{Rn}} \quad (3)$$

As λ_V is limited below, by the value λ_{vMIN}, from equation (2) we can calculate, for any given radon concentration value $\hat{c}_{Rn}$, the corresponding minimum value for k_{Rn}, i.e. $kmin_{Rn}$:

$$k_{RnMIN} = (\lambda+\lambda_{vMIN})\cdot\hat{C}_{Rn} \quad (4)$$

The choice of a given radon concentration $\hat{c}_{Rn}$ limits the range of variation of the variable k_{Rn} in the sub-interval ($kmin_{Rn}$, +∞). Therefore, a modified distribution function in the restricted range ($kmin_{Rn}$, +∞) applies:

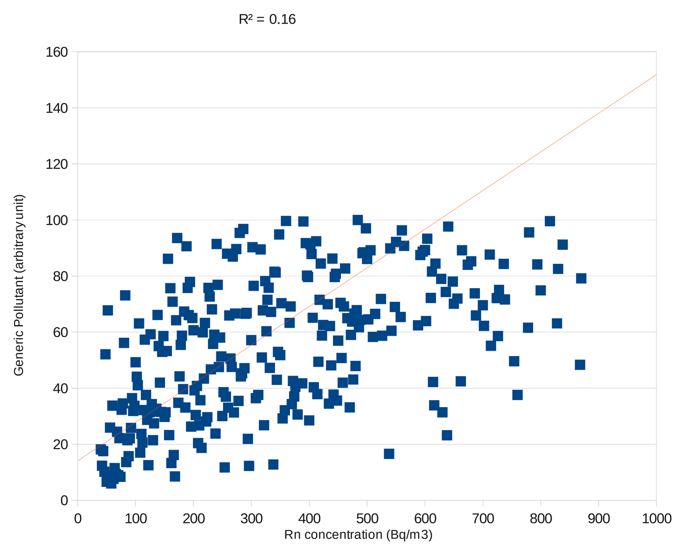
$$g_R(kRn) \approx \frac{e^{\frac{-(\ln k_{Rn}-\mu)^2}{2\sigma^2}}}{\sqrt{2\pi}\cdot\sigma\cdot k_{Rn}} \cdot \frac{1}{\int_{kMINRn}^{+\infty}\frac{e^{\frac{-(\ln k_{Rn}-\mu)^2}{2\sigma^2}}}{\sqrt{2\pi}\cdot\sigma\cdot k_{Rn}}} \quad (5)$$

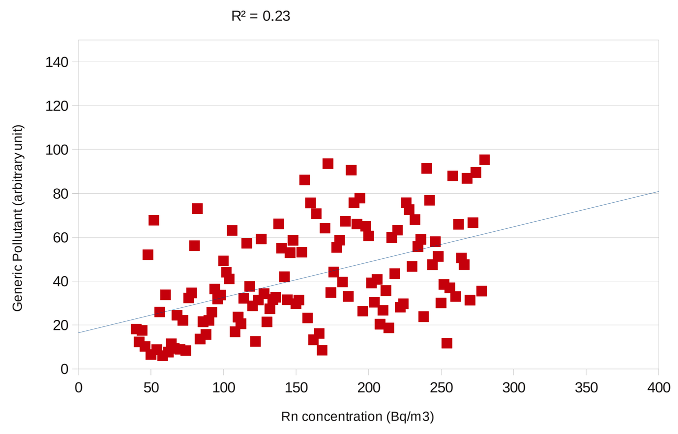
Given a set of $\hat{c}_{Rnj}$ experimental radon concentration , we can extract randomly from equation (5) N k_{Rnj} values and then, by means of the (2), to calculate the corresponding ventilation rate λ_{vj} and thus, from the (6), to obtain N c_{Rpollj} concentration values of a generic domestic pollutant :

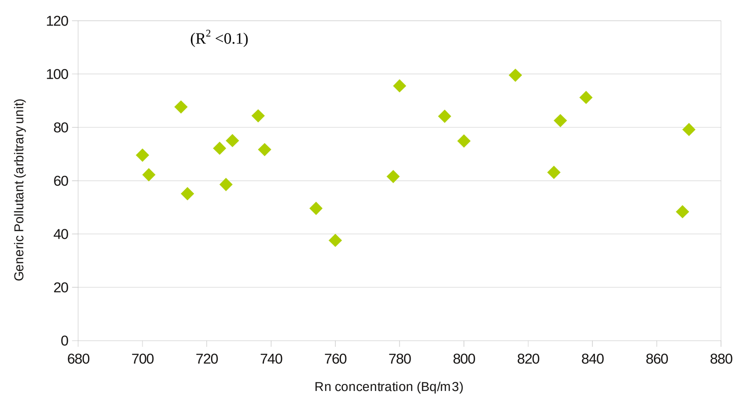
$$c_{poll} = \frac{k_{poll}}{\lambda v} \quad (6)$$

RESULTS

We can study now the correlation between $\hat{c}_{Rnj}$ and c_{Rpollj} .
From these scatter plots we can notice that the correlation is stronger for low radon concentration and disappears at higher radon levels







CONCLUSIONS

It has been shown that the correlation radon—generic domestic pollutant doesn't hold in the same way in the whole range of variation of the typical radon concentrations found in dwellings. In fact, the correlation significantly weakens as the radon concentration increases and completely disappears at high radon levels (> 700 Bq/m^3). In particular the correlation is stronger for low radon concentration (<200 Bq/m^3).
Thus, for low class radon concentration data (for instance, below 200 Bq/m^3) a more detailed evaluation of all the possible domestic pollutants that could have a significant health impact would be useful in order to give a more robust and reliable evaluation of lung cancer risk at low radon concentration.

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