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# SOME FACTORS AFFECTING THE CONCENTRATION OF RADON AND ITS DAUGHTERS INSIDE HOUSES

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## Abstract

Plastic track detectors LR-115 and CR-39 were used to estimate the concentration of radon-222 and its daughters products ($^{218}Po$,$^{214}Po$) in a room by recording their $\alpha$-particles' tracks. Although the ventilation rate is the main factor that effected the concentration of radon and daughters in a room; but there are other factors that vary the concentration. Some of these were studied: running a fan will reduce the activity in air of the room due to plateout on wall surfaces and on fan's blades. Internal wall covers may decrease or increase radon emanation depending on type of the wall covers. Generally paint will reduce the emanation from building materials, while wallpaper effect depend on the uranium content of the material. Long-term measurements in different positions in the room some time may show different concentrations due to convection currents in the room and due to dilution from the inlet air near the window. Different seasons showed different concentrations and this may be attributed to different ventilation. Concentrations in high-rise building rooms were found to depend on their ventilation rate but not depends on its height above the ground, but the geometrical mean of radon daughters concentration in high-rise buildings room were about half of that in normal houses in the same city, this may be due to extra radon emanation from the subfloor materials.

## Introduction

It is very well known that the main source of radon ($^{222}Rn$) activity inside houses will be due to emanation of radon from walls and subfloor materials. Other sources like water and natural gas contribute very little activity, furthermore their contribution depends on the gas and water origin and on the rate of consumption. The primary source of radon in all of these is radium ($^{226}Ra$).

The main factor that affect the radon concentration from the various sources in the house would be mainly the ventilation rate (15, 17 ). However, some other factors such as temperature, pressure, turbulence of air, internal wall cover, seasons and height affect the radon concentration. Dependence of radon concentration on temperature and pressure have been shown (13,14). In the present work we report the dependence of radon and daughters concentration on air turbulence, internal wall cover, position variation in a room, seasonal variation and room's height above the ground.

## Technique

Solid State Nuclear Track Detectors LR-115 (Kodak Pathe of France), CR-39 (Pershore Moulding Ltd. Pershore, England) were used to detect alpha tracks from the decay of radon and its daughters ($^{218}Po$, $^{214}Po$). A third type, Lexan, was used to detect the uranium fission tracks from wallpaper materials when irradiated by thermal neutrons flux from a reactor. Experimental details are given (1-5).

## The Factors

### Fan Effect

It was found (4) that the effect of turbulence of air by a fan in room will increase the plateout of radon duaghters to the wall surfaces and to the blades of the running fan. The number of radon daughters plated-out per unit area on the fan's blades were more than those plated-out per unit area on the walls by a factor ranging from 8-15. The total surface area of fan's blades areas is about 0.2 % that of the walls. Therefore the total activity plated-out on blads was about 2 % of that plated-out on the walls.

Measuring of radon daughter concentration in the air in the room revealed that the concentration decreased by about 30% when the fan was turned on. This reduced activity can be attributed mainly due to the plate-out activity on walls' surfaces. The number of acrosols particles in the indoor air for the diameter ranges, 20µm >d> 0.5µm, where reducing gradually while the fan being on. The number also reduced by increasing the size range. Because the equipment limitations, no diameter measured less than 0.5µm which is the size where most of the radon daughters activities will attached to. These results agreed generally with other investigators results (10,11).

### Internal Wall Covers

The internal wall decoration used to cover the building materials will act in such a way as to decrease or increase the emanation of radon from the building material. This depend on whether the internal cover material act as a sealer against radon emanation or as extra source for it. Using the by-product gypsum in ceilings estimated to produce an additional exposure to $^{222}Rn$ daughters (10) while using epoxy paint was found the most effective Sealant ( 7 ). The internal wall cover material might be paints, emulsion, wallpaper, plaster etc. It was shown (2) generally, that paint is the most efficient in reducing the radon emanation. It will reduce it to at least one-third of the bare brick value. The most effective one is the epoxy paint which reduced it to 7 % of the bare brick values. It was found also that the emanation per unit area from the unpainted area in the partially painted building materials bricks (made from crushed stone and cement), was more than that for unpainted bricks by a factor of 3 to 14 with an average of 7. This may possibly result from reduced radon emanation from the painted areas. The paint may act as a Sealant to the pores between the grains thus reducing the gas emanation and increasing emanation per unit area from unpainted surface. Paint might be responsible for more $\gamma$-emission (0.3, 0.35, 0.61, 1.12 and 1.76 MeV) from radon daughters $^{214}Pb$ and $^{214}Bi$ in the building materials.

In an another experiment effect of wallpaper on emanation were studied. We observed the radiation was higher as compared with that for the bare brick. This could be possibly explained by the extra radioactivity emitted by the wallpaper and thus was further confirmed by the following experiment which was to find the uranium content of wallpapers materials. This carried out by placing different samples of wallpaper adjucent to sheets of fission-detectors (Lexan) and irradiated it with a fluence of about $10^{15}$ thermal neutrons per $cm^2$. The results of this showed that some types of wallpapers were free of uranium, while other types showed 6 and 0.3 ppm for the front and back faces respectively. The front faces of those types were decorated with coulouring paint. This indicates that the uranium content on the front face is mainly from the paint itself. Thus, using this type of wall-paper might increase the radon activity inside the room by being an additional source of radon in the room.

## Dependance of Concentration on Different Location Inside the Room

In surveys for long term measurements of radon concentration indoors passive plastic track detectors are generally used (6, 8, 18). The detectors can be kept inside closed container or directly exposed to the indoor air. Urban and Piesch (18) have observed variation in bare detector results in a room up to a factor of three. The bare plastic detectors will be affected by the activity of radon-222 and alpha emitter daughters $^{218}Po$, $^{214}Po$ near the surface of the plastic and also by the plate-out of the radon daughter activities on the surface of the detectors. If group of bare detectors kept at one place in a room will repeatedly register a similar number of counts due to the approximately homogeneity of the concentration of radon and its daughters products in the small volume of air surrounding them (1). But if group of three detectors placed at different positions in particular room. The number of $\alpha$-tracks on them do not always show a consistent pattern. This variation is attributed in part to the inhomogeneity of radon and its daughters in the air of the room. This may be caused by convection currents inside the room which result from the temperature gradients in the room. In addition, continuous inlet air from around closed windows will always reduce the concentration close to them.

Variation of concentration with positions in the same room were demonstrated also in another experiment where concentration of two tracer gases (Freon-12 and Halothane) in a room were measured by a gas chromotographic technique. The automatic readings of the gas chromotograph from different sites in the room showed that the variation was different at different sites, and the largest differences in concentration were shown at site located near the window. Thus it may concluded that one site measurement with a bare plastic detectors in a position near one of the walls may not yield a representative true value of the radon concentration in the room. Average for a group of three detectors or more located in different positions in the room for long term measurements may be the best for estimating the concentration.

## Seasonal Variation

Long-term integrated measurements for radon in houses should give a better estimation of population dose than short time ones. They give long term average exposures for normal living conditions of houses inhabitants. The results of short time measurements may overestimate or underestimate the average radon concentration. Since they depend on the levels over an hour or two of such factors as the ventilation rate, wind direction and atmospheric pressure, which may not represent the average of these through the whole year.

To find if there is a seasonal variation of radon concentration indoors, a long-term measurements survey in 85 houses extended from February 1981 to March 1982. Data was collected in three different four-months periods as following: February-June, 1981 - Called the 'Spring batch', June-October, 1981 - Called the 'Summer batch', and October 1981-March 1982 - Called the 'Winter batch' (5).

The average concentration in the three different seasons: winter, spring and summer were $0.42 \pm 0.02$, $0.31 \pm 0.02$ and $0.24 \pm 0.01$ $PCi.1^{-1}$ respectively. The highest concentration in winter and the lowest in summer, we believe is due to the variation of the average ventilation rate from one season to another. The average of summer and winter results $(0.24+0.42)/2 = 0.33$ $PCi.1^{-1}$ is nearly equal to the average of the spring season. Thus if estimation of population exposure to be done, it will be best to keep the passive detectors inside the house for the entire year, or if it has to be done in a limited period, it will be better to make measurements in a season which might give reasonable representation for the whole year which of course would be spring. Fleischer et al. (8 ) found that winter to summer concentration ratios in a few rooms ranges from 3 to 10, averaging 5.3, emphasizing the danger of brief readings taken in a single season and the importance and usefulness of integrating reading over a full year.

## Height Level of the Room

Some investigators tried to find a relation between the height of the room above the ground level and its radon and daughter concentration. Toth (16) was found that the radon daughters concentrations decrease with increased distance from the ground level, this was not confirmed by other worker in similar measurements (3, 11, 19). We studied the radon daughters concentration as a function of different level in high rise buildings (3). We observed that radon daughter concentrations was independent of the level of the room and only depend on ventilation rate. Basement was the only exception having much higher concentration as compared with other levels. The more concentration in basement is due to extra emanation from subfloor materials. The geometrical mean for radon daughters concentration in 65 rooms near ground level compared with that for 38 rooms in high rise buildings in the same city was 2:1 mwL respectively. Extra emanation from subfloor materials may be the reason for this difference.

## Conclusion

From the previous, it might be concluded that concentration of radon and its daughters in houses may be affected by some factors other than the main factor which is the ventilation rate. Turbulence of air in the room might reduce the daughters concentration inside it. Paint as internal wall cover, generally reduces radon gas emanation from building materials, while wallpaper might increase it because of its uranium content. Different sites in the room and different seasons might show different radon concentration. Location of the room near the ground level might show more concentration than higher locations because of subfloor emanation.

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