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THE SIGNIFICANCE OF MEASUREMENT OF RADON-220(THORON) IN HOMES

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ABSTRACT

Radon-222 (also known as radon) is a relatively long-lived isotope of radon and originates from uranium present in the earth's crust. Radon-220 (also known as thoron) is a short-lived isotope of radon and originates from thorium present in the earth's crust. Fundamental properties and health hazards of these gases are compared. On the average, the thoron contribution to the total dose to the lungs is in the range of 10% to 15% of that from radon. In homes with elevated levels of radon progeny concentration there is no corresponding elevation of thoron progeny levels, making the contribution from thoron progeny quite insignificant. However, there are certain situations where thoron measurements are important. They are: 1) areas rich in thorium, 2) thorium refineries and 3) while measuring soil gas concentrations. Thoron can interfere in certain flow-through radon monitors, by causing an additional signal. If the total signal is interpreted as due to radon, such monitors overestimate the radon levels. A large (18 liter) double filter unit used to measure the thoron gas concentration in a low radon basement gave 0.5 pCi/L of thoron and the corresponding level for radon was 1.5 pCi/L. Some radon test

chambers use soil gas as a source of radon. Several measurements were also carried out in one such chamber, and the levels were below 0.5 pCi/L irrespective of the levels of radon, indicating an insignificant contribution to the flow-through radon monitors.

Key words: radon, thoron, radon progeny, and thoron progeny.

INTRODUCTION

Radon-222 is a gaseous isotope from uranium series and is conventionally known as radon. Radon-220 is a gaseous isotope from thorium series and is conventionally known as thoron. Uranium and thorium are equally abundant in the earth's crust, but there could be a predominance of one over the other in certain locations rich either in uranium or thorium.

There have been very few measurements of thoron in the indoor and outdoor environment for several reasons. The most important reason is that thoron and thoron progeny cause a relatively lower hazard in the indoor environment. After reviewing the world data, the United Nations Scientific Committee (UNSCEAR) has come to the conclusion (Mettler, et al, 1990) that the ratio of the dose to the general public by thoron and thoron progeny is in the range of 10% to 15% of the total dose caused by radon, thoron and their progenies combined.

The purpose of this paper is to review the literature on actual indoor measurements and draw some conclusions as to where and when it is important to make a thoron measurement.

COMPARISON OF PHYSICAL PROPERTIES

Radon has a relatively long half-life of about four days. It can accumulate and build up to high concentrations in relatively less ventilated areas such as basements. Thoron has a relatively short half-life (about 1 minute) and decays substantially and therefore cannot build up to high concentrations over time in basements. The concentration of these gases are expressed in units of either pCi/L or Bq/m3.

It is well known that the main hazard from radon or thoron is not due to the gases themselves but to the radioactive decay products of these gases. The concentration of the decay products is expressed in units of WL or mWL.

The decay products of radon have a relatively shorter half-life (about 30 minutes). Because of the short half-life of decay products compared to the radon gas, the decay products build up rapidly and it is hard to find radon gas without the associated decay products. In normal homes it is common to find an equilibrium ratio of about 50%. It is not difficult to make an assessment of the decay product concentration from the radon gas concentration or vice versa. The decay products of thoron have a relatively long half-life (about 10 hours) compared to the parent thoron gas. Because of this property, the equilibrium is virtually not possible in typical homes. It is difficult to predict a thoron decay product concentration from the measured thoron gas or vice versa. Very close to the source of thoron, the gas concentration can be high with very little decay product concentration. Similarly, at some farther distance, there can be no thoron gas but the decay products carried by ventilation can still be present.

COMPARISON OF BIOLOGICAL PROPERTIES

It has already been pointed out that the dose to the lung is primarily by inhalation of decay products. The definition of the unit of decay product concentration in terms of WL takes into account the dose received by the lung not only by the deposited decay products but also due to all the decay products which subsequently form at the site of deposition. That is why the WL unit is also known as the potential alpha energy concentration (PAEC). The methods of measurements do measure the working level in accordance with this definition. In our further discussion, PAEC(Rn) and PAEC(Tn) are used as abbreviations for the potential energy concentrations of radon and thoron progeny concentrations in units of working levels (WL) or milli working levels (mWL).

It is very important to understand that one WL of radon decay products does not give the same dose to the lungs as 1 WL of thoron decay products, even though they mean the same potential alpha energy concentration. This comes about because of the biological processes involved in clearing the deposited decay products from human lungs. Radon decay products with a half-life of only 30 minutes will give out all their dose before being cleared out of the site of deposition. Whereas, if the decay products of thoron have a relatively longer half-life, a portion of these is cleared out from the site of deposition before giving out all the potential energy to the lungs. The

International Commission on Radiological Protection (1982) has stated that the decay products of thoron cause only one third the dose caused by the equivalent quantity of radon progeny measured in WL units. In other words, if 1 WL of radon progeny causes a dose of x units to the lung, then 1 WL of thoron progeny causes only one third of x units of dose to the lung. If both are present, then the total dose is 1.33 times x units of dose.

METHODS OF MEASUREMENT

There are several excellent methods of measuring radon concentrations both indoor and outdoor. The only useful method for measurement of the concentration of thoron gas is by using a large double filter unit (Thomas, 1971; Kotrappa, et al, 1979). Several methods are available for measuring radon and thoron progeny concentrations. Description of these methods is not within in the scope of this paper.

SURVEY OF DATA ON INDOOR THORON MEASUREMENTS

Two excellent studies (Martz, et al, 1990, and Dudney, et al, 1990) on the measurement of indoor radon and thoron decay product concentrations have been published during the current year. These studies give references to earlier measurements. These constitute the best available data.

The first study (Martz, et al, 1990) covered 12 carefully chosen homes. Time averaged PAEC(Tn) varied from 0.3 to 6.9 mWL and the PAEC(Rn) varied from 1 to 59 mWL with the ratio varying from 0.09 to 0.58. These results are in agreement with a few similar studies done before.

The second study covered 70 homes in four Southern states in the United States. This again was a very well planned study. At the upper level of dwellings, the ratio varied from 0.03 to 0.64 and at the lower levels of dwellings, the ratio varied from 0.02 to 0.85. It was observed that the PAEC(Tn) did not vary much from home to home whereas the PAEC(Rn) varied widely. The ratio start reaching the upper limit only at very low levels of PAEC(Rn).

Even assuming the highest possible ratio of 0.85, the hazard of thoron progeny relative to that of radon progeny is only 0.28. This means that, in the most conservative case, the hazard due to thoron progeny can be a maximum of only 28% of that from radon progeny. Further this drastically decreases when the radon progeny concentration increases. At or near the U.S. EPA action level (20 mWL for radon progeny), the ratio becomes insignificant (0.02 to 0.12), causing hazard ratios to be much less than 4%.

Based on these studies, it can be concluded that the hazard due to thoron progeny is insignificant in homes which have been surveyed so for. Routine survey of homes for thoron and thoron progeny levels is considered unnecessary.

SITUATIONS WHERE THORON MEASUREMENT IS IMPORTANT

There are several situations where measurement of thoron and thoron progeny is important.

1. In thorium refineries and in areas rich in thorium, such as those found in Brazil and India, it is important to make measurements of thoron and thoron progeny. These contribute

significantly to the dose received by lungs.

2. If you suck air from under the soil at a fast rate, then the air can have relatively high levels of thoron. Usually flow-through instruments are calibrated for giving results of radon concentrations. If such instruments are used for making soil gas measurements, the result will not be a true value of radon but some value higher than the true value. One way to overcome this problem is to build in a delay loop long enough to decay the thoron. If passive devices are used for making such soil gas measurements, only those which discriminate thoron should be used if the correct radon concentration is needed.

THORON GAS MEASUREMENTS

Measurement of low levels of thoron concentration in the air is usually difficult but is possible by using a specially built large double filter unit and an associated alpha counting system (Thomas, 1971; Kotrappa, et al, 1979). These units are capable of making both radon and thoron measurements by doing a programmed alpha counting of the sample. One such unit with a volume of 18 liters was built in our laboratory to make thoron measurements. It was used to measure the thoron gas concentration in the basement of a home with low radon levels. The thoron levels were about 0.5 pCi/L; the corresponding level for radon was 1.5 pCi/L.

Some radon test chambers use soil gas as a source of radon. If some thoron is present in such a chamber then the continuous air monitors may give higher than the true radon readings. A few measurements were carried out in one such chamber (QC Chamber, Palmer, PA) and the levels were found to be below 0.5 pCi/L irrespective of the levels of radon, indicating insignificant contribution to the flow-through radon monitors. This was also confirmed by incorporating a delay loop in front of these monitors and observing that the reading did not change.

CONCLUSIONS

1. In most cases, it is not necessary to make indoor thoron or thoron progeny concentrations. These contribute insignificant health hazards compared to radon and radon progeny.
2. While sampling for soil gas, the thoron can cause significant interference in the estimation of radon concentration if proper instruments are not chosen.

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