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Underground Air Radon Monitoring
First Experiment

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SNO-STR-95-057

Abstract

A first measurement of Radon in underground air was made. The first results showed that Radon level does not vary in different SNO underground laboratory, but it might vary with time. The Radon level was measured to be as high as 3.3 pCi per liter and as low as just over1 pCi per litre. As Radon level varies, a longer period of monitoring would be needed.

The mobile air radon monitor

The mobile air radon monitor was designed based on one of the electrostatic chambers (ESC) in the operation building used for counting radon from Ra & Th in the water. It consists of a sampling pump, a flow meter with needle valve and an air drying facility. The high voltage power supplier and the data acquisition system are as usual. The whole system was designed as a mobile system. Every thing is on a cart of 24"(W)x40"(L)x48"(H, including chamber and electronics). Only one power plug is needed for the operation. A 50 foot long air sampling tubing is attached to the input to take air sample from nearby without moving the system.

The mobile air radon monitor is now sitting in the control room outside the cavity deck.

Operation of the radon monitor

Air in the SNO underground laboratory has been measured. The temperature is between 20 and 25 degree Celsius and the relative humidity is between 40 and 55 percent. As the radon detection efficiency of the ESC varies with humidity, a drying facility is needed. We used a 1.5" diameter and 12" long column filled with indicating 'Dryerite' as the air dryer. It's one of least expensive and convenient dryers. This will reduce the sampled air humidity to nearly zero.

The sample air is continuously taken into and sent out of the chamber by a diaphragm pump. The flow rate is adjusted to 0.5 - 1.0 litre per minute through the chamber of a volume about 11 litres. Half-an-hour counting will provide good statistics.

An operation procedure is attached on the monitor. If needed, every one can operate it after advising Dr. Henry Lee in the SNO surface building.

Efficiency calibration and background measurement of the system

1. How does the ESC measure Radon:

The ESC measures Radon through its decay products. The Rn is introduced into the chamber alone with sampled air. When it decays, about 3/4 of its progeny ^{218}Po is positively charged. These charges are collected onto Si alpha detector by an electrical field. It detects the decay daughters of Radon. Radon is then calculated based on the daughter Po decays.

2. The calibration source:

Ra-226 solution was absorbed onto MnO_2 beads. Then the beads were sealed in a stainless steel ring with 0.1μm filters and stainless steel valves at both ends. It served as the calibration source for the ESC. The source itself was calibrated on the Ge detector against a standard. The advantage of using the solid source is no leakage of Ra and easy to handle. First Rn was flushed out of the source; after t hours, an amount of Rn is built up:

$$A_{Rn}=A_{Ra}\,(1-\exp(-\lambda t))$$

with λ=7.5536e-3 h^{-1} of ^{222}Rn. This amount of Rn was then introduced into the ESC. The count rate over A_{Rn} is the radon detection efficiency of the ESC. Results showed that nearly 100% of Rn built in the source was introduced into the chamber.

3. Efficiency of radon detection:

One result is shown in the following table:

Pressure (mb)	Efficiency (%)	Media gas
25	31.5±0.9	nitrogen
52	33.6±1.0	nitrogen
100	33.0±1.0	nitrogen
230	31.7±0.9	nitrogen
560	31.5±0.9	nitrogen
1000	30.9±0.9	nitrogen
1000	30.8±0.9	dry air

This result confirms again that the efficiency for ^{222}Rn measurement doesn't vary significantly with pressure. There is no difference between N_2 gas and dry air pressure media.

4. Background:

The 'Dryerite' was used as drying agent for the air sampling, although it contains U and Th like any other inorganic materials. The Rn emanated from the 'Dryerite' has been measured. Under the air sampling condition, it was considered as the background of the Radon measurement.

Nitrogen gas from a liquid nitrogen duel has been circulated into the ESC system without the 'Dryerite' column. All detected radon was contributed by the system and the nitrogen gas. Then the 'Dryerite' column was attached to the system. The sum is the total background for the radon monitoring and the difference is the contribution of the 'Dryerite' column.

Background	Equivalent Rn in air
Without dryer	0.02 pCi/l
With dryer	0.03 pCi/l

As the radon in air level in any surface location would be at least 5 to 10 times higher than the background and 20 to 100 times higher for underground radon, this background will not interfere the measurements.

Radon in air:

1. Preliminary results:

In October and November, 4 series of measurements have been made underground:

Location	Radon level	Notes
Guelph SNO laboratory	0.1 to 0.2 pCi/l	higher at midnight and noon
Sudbury SNO surface building	0.2 pCi/l	time variations not been done
SNO underground laboratory:		
week of Oct. 11	3.2 pCi/l	
week of Oct. 18	3.3 pCi/l	
week of Nov. 1	2.4 pCi/l	
week of Nov. 15	1.3 pCi/l	new air filter used

2. Discussion:

The radon levels in different places are constant. There is no difference between control room and the deck nor between utility room and the control room.

The difference we observed so far is that radon level changed from October to November and this difference is as large a factor of 2.5. There might be two possibilities for this difference. One is that the radon level did change from time to time. That was the reason for us keeping the radon monitor underground for a longer period rather than terminating the measurement early. Another possibility is that we have changed to a new kind of air filter for the week of November 15 run. This kind of filter has more air resistance than the early one. As the air sample is 'sucked' by a pump at the output side, a pressure drop has been produced inside the chamber. This gives less air mass, and then less radon in air in the ESC chamber. Therefore, less radon counts have been observed.

An experiment we have done might support the latter possibility:

Flow meter reading*	Relative radon count rate
0.5	0.40cps
1.0	0.34cps
2.0	0.31cps
4.0	0.24cps
*1 reading ~ 1.6 l/min	

The faster the pumping speed, the larger the pressure drop has been made in the chamber, and a lower count rate has been observed. The pressure drop caused by air resistance of the air filters is unlikely to be large enough to acount for the count rate drop. Time variation of radon level in the underground laboratory is possible. We will check this in the future measurements.

3. Further work:

Literature showed that radon in air does vary from time to time and depends on temperature. We have to investigate the dependence of radon count rate versus filter resistance and pressure drop as well as experiments of *zero air flow*. These are the plans for immediate work.

Acknowledgment:

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To: Dr. Henry Lee 705 692 7001

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