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Radon Measurements with a Portable Air Sampler Coupled to the Mobile Electrostatic Chamber

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Introduction

A mobile electrostatic chamber (ESC) was installed as a radon monitor[1] in the SNO underground laboratory at INCO Creighton mine, and was used to monitor radon (^{222}Rn) with a flow through pump for sampling air in various areas on location. Recently, this system was adapted for mapping the radon concentrations across the SNO site at the mine as a first step to deal with the radon reduction requirement from the point of view of background radioactivity in the water supply to the SNO detector.

A passive air sampling cylinder of about 8 l volume was employed to sample air from various locations at the SNO site at Creighton and also from University of Guelph. A description of the procedure used to make the measurements with the ESC, and the results from these measurements are presented below.

Experimental details

The ESC consisted of a chamber of approximately 11 l in volume providing a shaped electric field to precipitate the radon decay products on to a windowless α particle detector from the air inside. The electric field was established by applying a bias of 2000V to the detector with respect to the chamber. For routine monitoring of radon in room air, the ESC was moved from place to place in the laboratory. An air flow of about 1 lpm was established through the chamber by running a suction pump in series with a chemical air drier. This flow maintained a nominal pressure of one atmosphere inside the chamber.

The pulse height spectrum from the α detector coupled to suitable electronics was recorded on a personal computer (PC) based multichannel analyzer (MCA) and analysis system. The intensity of the α particle peak at 6 MeV in the pulse height spectrum corresponding to the decay of ^{218}Po was proportional to the radon activity in air.

A procedure for the calculation of activity from the observed count rate in the 6 MeV peak in the pulse height spectrum from the detector was given by Wang[2].

Modifications to the experimental details for mapping radon

Even though the radon monitor was mobile it was still not easily moved around because of its weight and bulky set up, and the sensitivity of the PC to the dusty mine environment. Therefore, a passive sampling cylinder of about 8 l in volume made of clear acrylic was adapted for sampling air at various locations. The cylinder had two end caps with O-ring seals, and was held together to a cylindrical tube by four long bolts and easily removable nuts. The top cap had a vacuum gauge and an air inlet valve of the snap on/off type.

In open locations air was sampled by removing the end caps from the cylindrical tube and reassembling together with the valve closed. However, for sampling air from confined locations, the sampling cylinder was first pumped down to a vacuum of 35 mbar, purged with dry nitrogen, and again pumped down to 35 mbar vacuum. Air was then sampled from the confined space by drawing it into the cylinder through a "Tygon" tubing of suitable length.

The ESC was prepared for counting in a similar manner by pumping it down and purging with dry nitrogen to a vacuum of 35 mbar with the bias voltage off. The ESC was also pumped down and kept filled with dry nitrogen at 1 bar when not in use in order to minimize or eliminate the build up of ^{214}Po activity on the detector surface which produces counts at the 7.8 MeV α particle peak, and a tail towards lower energies giving rise to a continuum background under the peak at 6 MeV.

Air from the sampling cylinder was introduced into the ESC by connecting the sampling cylinder to the inlet port of the ESC which was evacuated to 35 mbar , and opening the valve on the port. Equilibrium was established between the ESC and the sampling cylinder in about 2 minutes. The port was then closed.

When air was sampled at the surface and taken underground to the 6800 level the vacuum gauge on the sampling cylinder indicated a vacuum of 7" Hg registering the pressure difference for a depth of 2 km from the surface. After air was transferred to the ESC the gauge on the sampling cylinder registered a vacuum of 23.5"Hg. The gauge on the ESC (Edwards APG-M-NW16) indicated a voltage output of 9.60 (35 mbar) and 9.95 (616 mbar) for the pressures before and after the air sample was transferred into the ESC.

When air was sampled underground the pressure in the sampling cylinder was first normalized to a gauge reading of 7" Hg vacuum before it was transferred into the ESC in order to normalize the initial pressure in the sampling cylinder to the pressure when sampling at the surface of the mine.

A reduced bias of 1000 V was applied after the air sample was transferred in order to eliminate the possibility of sparking and consequent damage to the α detector, and the electronics. Two counts of duration 1000 s each were recorded after the bias was applied to the ESC. After recording the second count the bias was switched off, the ESC was pumped down, purged with dry nitrogen, and pumped down to 35 mbar to get the ESC ready for a next sample.

All the air samples for mapping were collected and counted within a few hours after sampling. The mapping was completed over a period of two weeks.The air from the utility room was sampled each day as a standard of known concentration for comparison with the samples from various locations.

Radon concentration was calculated from the counts under the peak at 6 MeV with respect to the average count rate of 125 counts / 1000 s from the air in the utility room.

Air in the utility room of the underground laboratory is taken to be nominally at 3 pCi/l even though variations of a factor of two were observed when monthly averages were determined over several months.

Locations chosen for mapping radon

The following locations were chosen in order to map radon concentrations in air across the SNO site at Creighton. On the surface: 1. outside the Operations Control Building (OCB), 2. inside the head frame near the collar of the #9 shaft, and underground: 3. at 6800' level near the #9 shaft, 4. outside the entrance to the car-wash at the air in-take area of air handling unit #5 (AHU #5) , 5. inside the utility room, 6. at the platform level at the bottom of the cavity, 7. in the air-lock behind the ramp clean room. In addition, air inside the OCB water room and air outside the Physics department at the University of Guelph were also sampled.

Results and discussion

The results are given in table below:

Location	raw counts/1000s	Radon pCi/l
At the surface:		
outside OCB	7	<0.1
collar#9shaft	12	0.1
Underground:		
6800level#9shaft	63	1.5
outside car wash	117	3
utility room	125*	3
cavity platform	89	2.1
ramp room vent	90	2.1
ramp room air-lock	116	2.8
ramp floor drain	96	2.3
Rm 020: Guelph	20	0.5

The counts reported in the table for the utility room are the average from four observations. The average background counts from the ESC are 10 from four observations.

The counts for the air at the surface outside the OCB are the average of three observations. This average is actually less than the average background counts from the ESC before each sample was counted. There was only one sample when the counts were 59.

From these observations it may be pointed out that the air at the surface is much less than 0.1 pCi/l most of the time, at the 6800 level of #9 shaft it is already 1.5 pCi/l and in the utility room of the underground laboratory it is 3 pCi/l.

The urylon coated cavity may be about 30% lower than the utility room, and the air-lock near the ramp clean room is closer to the radon concentration in the ramp air outside the air-lock.

References

1. J. -X. Wang and J.J. Simpson, SNO-STR-95-057: "Underground air radon monitoring first experiment".
2. J.-X. Wang, SNO-STR-95-066: "Data Analysis of ESC counting for Ra and Rn"