Soreq Nuclear Research Center

In Memory of Dr. Barbu Lang
A Scholar and Friend
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Glass implanted ^{210}Po as a method of defining long-term retrospective exposure to radon: First experiments in Israel

In most epidemiological studies, contemporary radon measurements are used as a proxy for radon concentrations during the latency period even though extreme changes in radon levels may have occurred. Airborne radon decay products are deposited and implanted through alpha recoil into exposed glass surfaces, providing a measure of time-integrated retrospective radon concentration in the environment in which the glass has been located.

2. Technique and materials used
The “surface trap” technique uses a small area alpha-track detector CR-39 (polyallyldiglycol carbonate) placed on both sides of a chosen flat glass surface. The CR-39 is sensitive to alpha particles with an energy range between less than 1 MeV to 8 MeV. The maximum alpha energy of a radon decay product is 7.68 MeV, emitted by ^{214}Po . Glass may contain different concentrations of natural radionuclides as ^{226}Ra and ^{232}Th and their decay products. Some of these radionuclides disintegrate by alpha particle radiation. Hence, the resultant alpha-tracks are added (on the CR-39 detector) to those generated by the decay of ^{210}Po implanted by recoil into the glass due to the radon concentration in the air. The alpha-tracks recorded on the unexposed part of the glass surface (i.e. outdoor side of a window; inner side of a painting cover) represent the alpha particle background of the glass.

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SURFACE TRAP RETROSPECTIVE METHOD
1.Principles of the method
The formation of a permanent deposit of the long-lived radon progeny on glass surfaces is known for a long. According to Cornelis et al., 1993, this implant is a result of alpha recoil following the decays of ^{218}Po and ^{214}Po . Both isotopes have short half-lives (3.05 min and 1 microsecond respectively). The next formed progeny in the decay chain is ^{210}Pb with a half-life of 22.3 years. It is followed by ^{210}Bi (5.01 days half-life) and ^{210}Po (138.4 days half-life), which as alpha emitter can easily be measured by track-etch detectors. Therefore, the implanted activity of ^{210}Po is measured in-situ and the glass surface trap can be considered as recording past radon concentrations and its progeny in homes. The calibration of the SSNTD detectors is carried out by determining the complete alpha emission energy spectrum of the glass, including the emission of the reference glass itself. The principle of the method as well as ways of calibration of retro-detectors were described among others by Samuelsson (1988).

Calibration of alpha track counting vs. radon concentrations

Artifact	Time of exposure (years)	Radon conc. in air (Bg/m ³)	Pits/cm ² /day (Net value)
Picture cover	4	370	3.0
Window in Rock samples storage	20	800	2.2
Phosphate jars	2	16500	170

EXPERIMENTAL ^{210}Po SURFACE TRAPS (Lang et Al. 2001)

Experiments on different ^{210}Po surface traps were conducted for retrospective radon measurement in three different exposed glasses as well as one non-exposed glass. The exposed glasses resemble different source of glass, radon concentration and exposure time.

[1] a glass cover of a picture hanging in a home in Ma'ale Adumim (a known radon-prone region), [2] jars containing uranium bearing phosphate ore, and [3] a glass windowpane from a warehouse in which uranium bearing rocks are stored. Alpha spectrometry measurements showed unequivocally the presence of ^{210}Po in the glass surface as the sole contributor to the recorded alpha tracks. A calibration factor for the SSNTD measured alpha track concentration per day of exposure and indoor radon concentration for the three experiments was found to be in the range of 24 to 51 (Bq/m3/year)/(pits/cm2/day). cm²/day.

Glass jars: A – partially filled with phosphate; B – empty, with the location of CR-39 detectors.

Further work should focus on four paths:

- (1) Improving the analytical techniques and creating mathematical models (tools) for converting the measurements of surface activity into airborne radon concentrations.
- (2) Measurements of glass artifacts in homes located in high radon environments in which radon was monitored frequently
- (3) Alpha spectrometry experiments in order to quantify the ^{210}Po and correlate it to the results obtained with the CR-39. Energy response experiments of the CR-39 to check the linearity response of it for high-energy alpha particles.
- (4) Measuring the ^{210}Po activity of typical glasses in Israel.

Microscope photo of a CR-39 detector covering the limit between the areas with phosphate (lower part) and without phosphate (upper part). Note the difference in the number of pits. The diameter of the pits is between 10 and 30 microns.

Lang B¹., Shirav M¹., Even O²., Asael Y²., Shamai Y²., Margaliot M². and Hradonaquin G².,2001
Glass implanted ^{210}Po as a method of determination of long term exposure to : First experiments in Israel. SNRC report 3150

Samuelsson, C., 1988, Retrospective determination of radon in houses. Nature, 334, 338 – 340.