Health and Safety

Chris Stavroudis, column editor

Let's start with a direct lift from my favorite source of information, *Scientific American* (August 2008, p. 14). The *50, 100, & 150 Years Ago* column, which summarizes stories in *Scientific American* 50, 100, and 150 years ago, discusses beryllium as it was reported in August of 1958:

> "Beryllium – 'The story of berylliosis is one of the most fascinating, contradictory, infuriating and controversial episodes in medical history. Some medical people argue even now that beryllium is incapable of causing disease. When one examines the clinical, biochemical and toxicological evidence, however, one cannot escape the fact that beryllium has caused at least 500 cases of poisoning in the U.S. alone during the past two decades. The story of beryllium highlights the whole problem of occupational disease in the present era. Advances in technology now develop so rapidly that the rare material of yesterday becomes the widely used material of today.'"

This sounds so familiar. Things change so rapidly that we cannot keep up. While we don't seem to have any direct parallels to the use of beryllium, which is now known to be very toxic, how often have we heard statements that "chemical x is incapable of causing disease"?

How about a known hazard in an unlikely place? An item in the August 2008 issue of *ACTS FACTS* reports on an article, "What's Lurking in Your Countertop," in the *New York Times* from July 24. The reporter, Kate Murphy, wrote about a New Jersey woman who was having her summer home tested for radon gas. The sampling results were quite odd. Sampling in the basement showed 6 picocuries per liter (pCi/L), just above the recommended actionable levels of 4 pCi/L, but the kitchen tested with a whopping 100 pCi/L.

Radon concentrations are determined via air sampling followed by laboratory analysis. Normally, samples collected in basements have a higher concentration and samples elsewhere in the living space are lower. Oddly, in this house, samples taken from the kitchen revealed the highest concentration of radon. The source: a granite countertop. Who'da thunk? More on this later.

Radon is hazardous due to its and its daughters' radioactivity. (We'll meet the daughters later.) When this naturally occurring gas is concentrated in a structure or storage area, it becomes a health hazard. Radon is the second most common cause of lung cancer, right after smoking, and radon induced lung cancer is thought to be the 6th leading cause of cancer deaths overall.

Radon is a product of the radioactive decay of uranium. It is a gas, and when it makes its way to the surface, radon is dissipated into the atmosphere and poses no more than a background health risk. However if we build a house on the surface of earth, and insulate and weatherproof it so we don't loose any heat in the winter or cool in the summer, we also trap the radon in our living space, effectively concentrating it.

The potential for radon exposure varies geographically. Areas laden with uranium generate the most – and it was in uranium mines that the high worker incidence of lung cancer was first noticed in the mid 1950s and was correlated with radon exposure. Granite, in counter tops, rocks, or weathered in soil, can also be a source, although not all granite contains uranium.

Radon is itself the decay product from uranium 238, which, it turns out, is fairly widely dispersed on the surface of the earth. ^{238}U has a half-life of 4.47 billion years. The uranium in our planet is what's left of the uranium that was created in the supernova that made the heavier elements that comprise our solar system. The lead isotope ^{206}Pb, which has a natural abundance of 24% (the other 76% being different lead isotopes), is the end product of the decay of the long-lived uranium.

The most common radon isotope, ^{222}Rn, decays to a number of elements, called radon daughters. Daughters include the radioactive lead 210 (^{210}Pb) and two radioactive isotopes of polonium (^{218}Po and ^{210}Po) and ultimately end with a stable lead isotope (^{206}Pb).

Radon is a heavier than air gas. We breathe it into our lungs and exhale it out of our lungs. Chemically, it is a noble gas and is non-reactive. Radon's half-life is 3.8 days, which means that half the radon in a sample will have undergone radioactive decay in 3.8 days. If we are unfortunate enough to have an atom of radon decay while in our lungs, the trouble begins.

Radon decays by alpha emission. An alpha particle is basically a helium ion that goes barreling through our tissues leaving a trail of broken chemical bonds. Worse, when radon loses the alpha particle, it transmutes into ^{218}Po, which is a solid. Albeit only a single atom it is as likely as not to stay in our lung. ^{218}Po decays by alpha emission and begets ^{214}Pb, which begets ^{214}Bi, which begets ^{210}Tl by another alpha emission, which begets ^{210}Pb with a half-life of 23 years, which begets ^{210}Bi, which begets ^{210}Po with a half life of about half a year and decays by alpha emission to the stable ^{206}Pb. So, in this whole process, the single radon atom has released four alpha particles and 4 beta particles. Now you have met radon and all of its daughters – a lovely family.

As mentioned, alpha particles are highly ionizing and fly out from the decaying atom, literally leaving a trail of broken chemical bonds in their wake. If the chemical bond that has been broken happens to be a strand of DNA, we have ourselves a little mutation. The mutation can be harmless, can kill the cell outright, or can lead to transcription errors, leading, in a few cases, to carcinoma.

There is no filter for radon – it is an inert gas. The only solution is ventilation so that the radon is diluted to its natural background level. (Radon daughters can be trapped in a HEPA filter, so many P100 respirator cartridges do list radon daughters as one of the baddies they filter out.)

The folks familiar with natural history collections are, or at least should be, familiar with the potential for radon emissions from collection items. But what about the rest of us working with museum collections?

Fossils can have formed with trace uranium in their structure or matrix. Historic items like watch dials and instrument buttons that glow in the dark are probably using radium as the luminescent source. And guess what the decay of radium produces? Well, radon is a contraction of its original name *radium emanation*.

What about mineral specimens that contain uranium and are therefore natural sources of radon? (What about historic ceramic glazes and glasses that contain uranium? Actually, I don't know if the radon can escape the vitreous material.)

So just like a well-sealed house with a permeable basement in a zone where radon is naturally emitted from the soil, a storage cabinet filled with fossils, or a display case housing an uranic mineral specimen can accumulate radon emitted by the slow decay of uranium in the collection items. And when we open the doors to the cabinet or work in a room with lots of these sorts of things, there can be a significant exposure.

The solution is surprisingly simple. Ventilation. Good air exchange, with sufficient make-up air added into the mix in all areas is all it takes. Active ventilation of cases and storage cabinets would also be necessary.

More and more, I think the idea of using respirator cartridges and small "muffin" fans should be incorporated into museum storage furniture. A HEPA filtered air intake and a low power, low airflow exhaust that pushes the air through a combination mercury vapor/acid gas/formaldehyde/HEPA filter would, I suggest, take care of a number of conservation and health and safety problems common in collections' storage.

So, back to the granite countertops. As usual, Monona Rossol, the editor of *ACTS FACTS* has included additional information and commentary in her article. I quote, with permission, from Vol. 22, No. 8:

HISTORY: Allegations that granite countertops emit dangerous levels of radon and radiation have been raised periodically over the past decade. In the past, the Marble Institute of America has said such claims are "ludicrous" because, although granite is known to contain uranium and other radioactive materials like thorium and potassium, the amounts are not enough to pose a health threat.

In the past, health physicists and radiation experts agreed that most granite countertops emit radiation and radon at extremely low levels. But more recently, preliminary results from research scientists at Rice University in Houston and at the New York State Department of Health show that of the 55 samples collected from fabricators and wholesalers, all of which emit radiation at higher-than-background levels, a handful have tested at levels 100 times or more above background.

RADIATION STANDARDS: Lou Witt, a program analyst with EPA's Indoor Environments Division explained that countertops that emit extremely high levels of radiation, as a small number of commercially available samples have in recent tests, could expose body parts that were in close proximity to the counter for two hours a day to a localized dose of 100 millirem in just a few months. This is significantly above the 100 millirem per year that is the limit of additional radiation exposure set by the Nuclear Regulatory Commission for people living near nuclear reactors.

(This 100 millirem radiation limit/year is the amount allowed in addition to the 360 millirem of background radiation/year that the average person is subjected to from sources such as the radiation that is constantly raining down from outer space or seeping up from the earth's curst plus that emanating from manmade sources like X-rays, luminous watches, and smoke detectors.)

INDUSTRY RESPONDS: The Marble Institute of America now says it plans to develop a testing protocol for granite. "We want to reassure the public that their granite countertops are safe," Jim Hogan, the group's president, said. "We know the vast majority of granites are safe, but there are some new exotic varieties coming in now that we've never seen before, and we need to use sound science to evaluate them." (ACTS is always suspicious of trade associations that develop a testing protocol when their expressed purpose is to reassure the public that their products are safe.)

I should think that one could easily self-test suspect granite by purchasing a home radon test kit and placing the sampler under an inverted container on your favorite granite surface. Follow the directions for the amount of time of exposure and send it away. If anyone does this, please let me know your results.

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Sources:

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