ENVIRONMENTALLY SPEAKING

Peter Schwartzman

Radon: a common gas that can kill you

Part I

What if I told you that there is a gas that seeps out of the ground that has carcinogenic (i.e., cancerous) effects? Would you believe me? What if, in addition, I said that this gas is found in

all of our homes where, for those of us that don't smoke, it serves as the main contributor in the development of lung cancer? Would you be skeptical? Well, radon is such a gas. In fact, the Environmental Protection Agency (EPA) currently estimates that as many as 8,000,000 houses in the United States have elevated levels of radon. While many of you have likely heard of this health threat by now, there is a great deal of complexity and confusion concerning this mysterious gas. Recognizing this confusion, I have prepared a two-part essay on this important subject. Part I will focus on basic information about radon including its physical properties, its geographic distribution and origin, its health impacts and social costs, as well as directions for taking radon measurements. Part II, to be published next month, will focus on empirical research conducted by a Knox summer research fellow on local radon levels as well as summarize a radon report issued by an Illinois government agency. It will also provide suggestions to abate radon exposure in homes. Upon reading this first installment, you may wish to measure the radon levels in your home to determine if mitigation steps are necessary.

Where does radon come from? Radon gas forms when radium-226 (the number refers to the atomic mass of this particular form of radium) in soil and rocks decays radioactively. When an element, such as radium, decays it changes form, i.e., becomes a new atom, and releases energy in the form of light or fast moving particles which can be harmful to life. In the case of the decay of radium-226, the released alpha particles consist of large subatomic fragments consisting of 2 protons and 2 neutrons. Yet since this radium decay occurs underground, the resulting radiation is shielded by the surrounding rock and thus isn't a threat to humans. The interesting and significant aspect of the decay of radium-226 is that it is a solid (at temperatures and pressures generally found in the upper reaches of the Earth's crust) while radon, its "daughter" in the decay, is a gas. Thus, in gaseous form, radon can leave the surrounding rock and move through the soil where it can be released into the open atmosphere. Once radon finds its way into the atmosphere, it can be readily inhaled.

Once inside the body, radon begins to show its damaging character. Since radon is itself radioactive it decays as well. Its daughter, polonium-218, forms during this decay and alpha particles are released. Radon-222 has a half-life of 3.8 days, and so, statistically speaking, half of any radon forming underground decays to polonium in about four days; in eight days, another half of the radon will decay, leaving only 25% of radioactive radon remaining. Thus, ingested radon will release radiation within the body fairly quickly. In the world of high-speed physics, alpha particles are relatively large and "slow," moving at only one-twentieth the speed of light, meaning that it doesn't take much for them to come to a halt. If we are exposed to alpha particles externally, our skin usually provides a sufficient barrier to protect us from damage. But if alpha particles are released inside the body, say within the lungs, major cellular damage can occur.

However, polonium-218 isn't the only relative of radon that causes problems. In fact it is the granddaughters, great-granddaughters, and more distant progeny that make radon ingestion so troublesome. Polonium-218, with a half-life of only 3 minutes, decays very quickly to lead-214, a granddaughter of radon or great-granddaughter of radium, releasing additional alpha particles. Lead-214 decays to bismuth-214 releasing a beta particle (a fast moving electron). This process of decay and release of radioactive materials continues for 6 more generations until lead-206, a stable material, forms. Thus, for each radon atom absorbed by the body, there will be up to 8 radioactive particles emitted into the body. In this way, radon and its descendents can greatly alter and damage cells within the body.

Geographically, radium-226 and its great-great-great grandparent uranium-238 are found virtually everywhere and, therefore, radon gas forms in soils and rocks throughout the world. Most rocks and soils contain between 1 and 3 parts-per-million (ppm) of uranium. (To convert this into more recognizable form, one part per million is unit that is equivalent to one drop of dye in a tub consisting of 55 gallons of water.) Yet the emission of radon by soil varies considerably from place to place. How so? The answer is complicated but it reveals much about whether you personally need to be concerned about such a phenomenon. First, uranium deposits aren't distributed evenly. Larger concentrations are found in specific rock forms, particularly certain igneous rocks (i.e., rocks that are volcanic in origin) and sedimentary rocks that contain high levels of phosphate. The chemical properties of uranium, including, for instance, its "tendency" to avoid entering into crystal lattices, dictates which rocks and soils will have the highest levels of uranium. The areas in the U.S. where underlying rocks and soils are supportive of relatively large levels of radon production, where uranium concentrations can reach 100 ppm, include northern Illinois and southern Wisconsin and the majority of the following states (roughly organized from east to west): Pennsylvania, Ohio, Indiana, Minnesota, Kansas, South Dakota, North Dakota, Colorado, Wyoming Montana. States noted for their lack of radon emissions include: Florida, Mississippi, Louisiana, Arkansas, Oklahoma and Texas. Yet, given the variability in rock and soil type, no location can be said to be radon-free. Second, the underlying soil characteristics are very important to the levels of radon emitted. Since radon is a gas, it can more readily seep through soil that is permeable, i.e., having lots of channels. And third, the specific structural characteristics of one's household can have a great deal to do with the radon levels found inside. Outdoor radon levels, even in areas with large uranium deposits and permeable soil, do not reach hazardous levels because the atmosphere does a wonderful job of circulating radon through its immense volume. But inside homes that are poorly ventilated and have a sufficient number of entry points (such as porous cinderblocks, cracks in foundation, floor drains, or sump pumps) radon levels can reach magnitudes worthy of attention. A house provides a happy resting place for radon, and if a home's characteristics are favorable (tightly-secured for heating or efficiency, built directly on the soil, or full of cracks), radon concentrations gradually increase, potentially to harmful levels. So, both geology and home construction and utilization contribute greatly to one's potential radon exposure. Since permeability and the uranium richness of underlying rock and soil can vary greatly over a short distance predicting one's radon level is quite difficult. Yet, as suggested before, Knox and surrounding counties consist of soils and rocks that release radon in abundance and, thus, people living within shouting distance of *The Zephyr* should be particularly cognizant of the threat.

The individual radon exposure one receives is further complicated by several additional factors. First and foremost, radon is a soluble gas and it readily dissolves in water. Thus, water coming into contact with radon gas will bear higher levels of this radioactive substance. Radon contamination can be particularly problematic in well water because it usually goes untreated for the gas. Also, the duration of time between extraction and consumption for well water is much shorter than municipal sources which increases the likelihood that radon will not decay and precipitate out (in the form of polonium) before it is quenches one's thirst. Currently, the water provided by the Galesburg Water Department takes about three days to get the aquifer underneath the Mississippi river to residential faucets. Some municipal sources of water are aerated allowing most of the radon present to escape into the atmosphere and, thus, greatly reducing radon levels. While drinking water may be a source of radon, it is generally believed to be a minor source in comparison to the radon that comes directly into buildings via the soil and rock. Second, one's workplace (or school) can be a major source of radon accumulation. Thus, not only must someone know the radon levels at home but also at all other indoor facilities where they spend significant amounts of time. Yet, few business offices are tested for radon. Third, since radon enters the home from the ground and ventilation is often poor in basement areas, radon levels are often twice as high in basements as compared to first floors. Thus, people who spend large amounts of time in basements (perhaps in bedrooms located there) would be expected to have greater exposure to radon. And finally, since most of us move one or more times during our lifetime, our radon exposure can change dramatically through time. This last factor has made it more difficult for scientists to evaluate radon's health effects.

Now that you hopefully have a good sense of where radon comes from and how it manages to find its way into your body, it is time to consider some of the physical and social impacts of radon's presence. First, let's focus on the health impacts. Before 1900, scholars recognized that miners had elevated mortality but the reason wasn't clear. During the 20th century, evidence mounted that radon was a major culprit. Not to be confused with black lung which is primarily a fatal disorder brought about by the inhalation of excessive dust in coal mines, exposure to radon has been shown to be a major source of lung cancer in epidemiological studies. While smoking is a much more threatening factor in the development of lung cancer, occupational studies suggest that somewhere between 15,000 and 22,000 people in the United States perish because of radon-induced lung cancer (Frumkin & Samet). This is an extremely large number of people especially considering that it is greater than the number of people that die from homicides. Clearly, radon represents a major public health concern. Yet despite the apparent seriousness of the matter, radon doesn't get nearly the attention it deserves.

As with many other environmental contaminants, radon produces a string of social and economic costs in addition to those directly related to its health effects. Many of these costs go underappreciated because radon's specific impact has been poorly understood until recently and because radon is a very unique environmental hazard. Though radon had been examined previously, it didn't hit the national scene until the infamous Watras case. This case involved an employee of a nuclear plant in Pottstown, Pennsylvania who, in December, 1984, unexplainably set off radiation detection alarms upon entering his worksite. When it was determined a few months later that Mr. Watras had absorbed incredible amounts of radon from his residence (which measured an unprecedented 2,700 pCi/L) not from the plant, the gas finally captured a national audience. This attention brought about several changes in society. For instance, several radon-related industries subsequently formed, including companies that test for radon as well as those that attempt to reduce radon levels. In addition, radon testing became much more common during real estate transactions, making property owners responsible for the presence of radon. Wary citizens began questioning the healthy atmosphere of their own homes. Traditionally a place embodied by tranquility and security, some domestic dwellings, especially those located in radon "hot spots," were considered toxic quarters.

In response these economic and psychological changes, agencies at all levels of government have had difficulty determining how to proceed with the radon problem. Many of the estimates of the capital required to properly abate domestic radon concentrations to "safe" levels are astronomical; 8,000,000 homes at an average of $1,200 per would cost $9.6 billion, which isn't chicken feed. Yet, as with any known disease factor, if no remediation takes place, evidence strongly suggests that more deaths will occur and these have monetary and social costs of their own too. Responsible government leaders understandably want to avoid creating panic but at the same time they have an obligation to protect their constituencies. This dilemma is taxing because it is legally and morally difficult to assert who is to blame for elevated levels of radon since it is naturally produced and distributed, unlike many other environmental contaminants, and it has only just begun basic monitoring. According to some experts, since the government reluctantly provides a clear message, as they "hide" behind scientific and experimental uncertainty, the media cannot properly convey the "facts" to the public (Makofske and Edelstein). In the end, we have reached a point where only those that have combed their way through the scientific findings and have the financial resources to individually pay for the implementation of mitigation have the ability reduce their risk to radon-induced health problems. Currently, the rest of society relies on the luck of the draw. Undoubtedly, an informed public would demand that more be done to protect citizens from unnecessary exposure to this, and other, carcinogenic substances.

Despite the apparent governmental hand-tying that exists on the issue, there is no reason why you shouldn't be proactive and seek out information about your personal radon exposure. The best way to do this is to start with the home. While radon exposure for miners far exceeds the average for homeowners, remarkably, some homes actually have equivalently high levels of radon. Radon levels are often measured in picocuries per liter, written pCi/L. And while background outdoor radon levels generally range from 0-2 pCi/L, some homes have been found to have levels exceeding 100 pCi/L. The EPA recommends that homes exceeding 4 pCi/L should seek mitigation. But how might you know if your home has elevated levels of radon? Unfortunately, since radon is odorless and tasteless, you won't be able to detect it without specialized equipment. The quickest, surefire way to test a facility involves acquiring a test kit from your county Health Department, setting up and conducting the test over three to five days, and mailing your testing equipment to the appropriate analyzers. (For Knox County, the number for the Health Department is 344-2224.) The entire test, which can be conducted at little cost (usually below $10), is simple and requires very little of your time — perhaps 15 minutes which largely involves filling out the paperwork on the test kit. Once test kits are sent in, mailed results are sent within a week or two. Additionally, if you drink well water regularly, you can call the Safe Drinking Water Hotline at (800) 426-4791 to find out more about testing it for radon contamination as well. So, until next month when more of the radon story will be disclosed, happy radon testing.

Works Cited:

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Peter Schwartzman, a resident of Galesburg since 1998, is chair of the Environmental Studies Program at Knox College. He is a research climatologist with several peer-reviewed publications in the area of climate change and human population growth and he is currently writing two environmental books focused on bringing environmental understanding to a wider audience. He encourages responses to his writings.