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Radon Levels in Combustion Stream of a Natural Gas Incinerator Power Plant

J. E. Ericson, P. G. Pham

Department of Environmental Analysis and Design, School of Social Ecology, University of California, Irvine, Irvine, CA 92697-7070, USA

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Preliminary investigation has measured radon in the combustion stream of a natural gas incinerator power plant at an average concentration of 370 picocuries per liter (pCi/L) (13,700 Bq/m3), over 90 times the EPA household action level. Without scrubbing, radon, carried in the combustion stream is released into the local environment. Currently, Federal and State of California regulations do not control these "natural" radioactive emissions. Research underway will attempt to characterize the environmental exposure to radon and radon progeny at this location using analyses of air, soil, and vegetation.

Natural gas is widely considered as the fuel of choice for power production, because it burns cleaner, economical, and is associated with fewer environmental impacts than oil and coal use. Natural gas comes from the decomposition of organic matter; if the supply of natural gas is taken from an area rich in uranium then the natural gas potentially will contain high levels of radon. Radon from natural gas collected from recovery systems of landfills and underground wells may be pumped at rates that far exceed natural background levels of radon. Once in the incinerator, radon follows the combustion stream with methane and the other natural gases. Effluent coming out of the smokestack is therefore a potential health threat because scrubbers are not designed to minimize radon, an inert gas.

In its raw state, natural gas has a chemical profile of 50-85% methane, 10-30% ethane, 3-7% propane, 1-5% butane, 1-30% hydrogen sulfide, and 1-5% carbon (Van Netten et al. 1998). After processing it is refined into mostly methane (90-95%) and ethane (0.1-7%). The finished gas is then transported to different distribution centers where it will be stored and sold. Unfortunately, in the refinement process radionuclides which may be low initially can become concentrated (Drummond et al. 1990). A number of studies have examined the occurrence of Rn^{222} and its progeny in the collection, processing, and transmission of natural gas (Gesell 1975). These studies found high levels of radon in the main pipeline and in the distribution lines leaving the processing plant. Van Netten et al. (1998) did measure ambient air radon concentrations from fossil fuel power plants and found them to corrrespond to background radon levels. However the investigators did not specify the study area, direction, or distance they examined. Gesell's 1975 study (Wojcik 1989) in the United States

Correspondence to: J. E. Ericson

measured significantly higher radon levels in the gas systems than other studies conducted in Canada and Poland. The highest recorded radon concentration by Gesell (1975) was 1120 pCi/L while the Canadian studies recorded a high of 21 pCi/L and the Polish study recorded a maximum level of 9.8 pCi/L. The fate of radon and its progeny after combustion of natural gas and release into the atmosphere has not been studied.

Radon is the result of uranium and thorium decay in soil and rocks. Radon is transported by diffusion through fractures and pores in the rock and soil, which gets released into the atmosphere (Otton 1992). Therefore, radon concentrations released into the environment are directly proportional to the amount of uranium content in the rock and minerals and the dynamics of transport in the local environment. Different rock formations will have different ambient radon concentrations depending on their uranium content (Faure 1986).

Controlling radon emission from power plants has not been a major topic of research, since it is considered a "natural combustion product." There are no U.S. federal or State of California regulations governing radon emission from these "natural sources." As a consequence these releases are neither controlled or monitored. The EPA sets its action level to radon at 4 pCi/L. Based on a national residential radon survey in 1991, the average indoor radon concentration is 1.3 pCi/L, while the average outdoor level is about 0.4 pCi/L. However, underground water wells in the United States range from one to 1,450 pCi/L and in California some wells have concentrations up to 120 pCi/L. A number of studies have been done on well and ground water as a potential source of radon intoxication because it is often used for drinking water, but EPA does not consider well water a significant problem. According to the EPA website, the risk of radon entering homes through water is small compared to radon entering through the soil, in fact only about 5% of indoor radon is attributed to well water. Exposure studies of radon and radon progeny in natural gas have focused on occupational exposure levels of 120 pCi/L (Cothren & Smith 1987) in processing plant or distribution lines. However, retailers selling natural gas from such radioactive sites can have radon and progeny in their liquefied natural gas products.

Chronic exposure to radon is a major health hazard linked to an increased cancer risk with an expectable risk, which is 10,000 times higher than most carcinogens. The public and scientific community tends to believe radon is only hazardous to those occupationally exposed, underground miners (Yener & Kucuktas 1998) or nuclear plant technicians, and those exposed to radon in their homes. Health guidelines are in effect for occupational exposure, drinking water and indoor radon concentrations. These exposure pathways are the predominant area of radon research and monitoring efforts. Risk assessment estimates of lung cancer linked to radon exposure are based on studies of underground uranium miners exposed to radon (NIH 1994). According to the U.S. Surgeon General, radon only trails cigarette smoking as the leading cause for lung cancer (EPA 1992). In general, radon is not the major culprit but its energetic progeny of polonium, bismuth, and lead can wreak havoc on the tissue of the bronchial epithelium

inside the human body after radon is deposited into the bronchial airway (Harley 1996). After settling onto bronchial or lung tissue, radon-222 decays with a half-life of 3.82 days via alpha emission to polonium, which undergoes further alpha and beta emissions until it finally ends up as lead-206. Inside the body, the release radiation is energetic enough to penetrate the epithelium lining of the tissue and transfer a significant amount of energy to the cells. EPA estimates the risk of dying from cancer due to radon exposure of 4 pCi/L (150 Bq/m^3) over a lifetime to be a 3/100. The BIEV IV report conducted by the National Academy of Sciences estimates the risk to be approximately 1.5/100 (NAS 1988). In either case, these rates are 10,000 times higher than the standard expectable risk for most carcinogens which is $1/10^6$.

We became concerned that a local incinerator power plant using natural gas derived from a gas recovery system of a municipal landfill located in the middle Miocene Topanga Formation. The Topanga Formation is a 7,000 foot thick dominantly sandstone deposit (Vedder 1979). The reworked sandstone deposits contain zircon (Zr(U)SiO4) with uranium as a solid substitution product for zirconium. The uranium trapped in zircon provides a source of radon in this formation. We reasoned that radon, rather than undergoing natural decay in the ground, would be pumped to the surface at an accelerated rate with natural gas by the gas recovery system. We expect that a number of recovery power plants utilizing natural gas as a fuel may unknowingly be releasing large amounts of radon and progeny into the environment, particularly in areas with high uranium and thorium.

MATERIALS AND METHODS

Gas samples collected on different sampling days were collected from the combustion stream of a local natural gas recovery power plant using Tedlar bags. The samples were shipped immediately on July 12 and August 5, 1994 to TCS Industries, Inc. (Harrisburg, Pennsylvania) to analyze the radon concentration in the combusted effluent.

The samples were split into two sub samples and aspirated into evacuated Model 300A Lucas cells manufactured by Pylon Electronics Inc. of Canada. The oil lubricated pump was rated for 10-micron vacuum. The Lucas cells were counted in a Pylon Model Ab-5 monitor which was normalized with a radium-226 doped-Lucas cell, Pylon Model 3150A, Serial #177. TCS participated in a program of interlaboratory comparisons of radon gas measurements of companies and government agencies through the Environmental Measurement Laboratory (EML), Department of Energy and reported in the EML Reports. The TCS Lucas cells assigned EML code number 16 (April 1994) and 4 (October 1994) reported for unknown EML gas samples to be 5% low and 4% low, respectively (USDOE 1994).

RESULTS AND DISCUSSION

The analysis reported concentrations of 276, 312, 443, and 471 pCi/L for the July and August samples, respectively. These concentrations far exceed the residential action limit of 4 pCi/L. Since collection of these samples, there are now new homes within 200 meters of the incinerator stack.

Future research to be conducted will determine the amount of radon and progeny (particularly lead 210, $t_{1/2}$=22 years) emitted from this power plant by measuring concentrations in air, soil air, and vegetation in the local environment. We will use the Gaussian Plume Model for a known ground level to estimate the radioactivity of the plume released from the stack.

If we find that radon and progeny levels to be above the action limit in the environment under the proposed mechanisms, natural gas extraction and incinerator technologies may have to be modified. The solution may be as simple as reducing the rate of extraction and/or storage of fuel gas for a period of time before combustion. In addition, suppliers and retailers of natural gas could determine radon levels and date their supplies so end-users can estimate how much of the original radon has decayed.

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