Health Consultation

BIG BONE CAVE STATE NATURAL AREA

VAN BUREN COUNTY, TENNESSEE

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
The Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Background and Statement of Issues

The Tennessee Department of Environment and Conservation (TDEC), Bureau of Conservation asked Environmental Epidemiology (EEP), Communicable and Environmental Disease Services Section, Tennessee Department of Health to look at historical radon data for Big Bone Cave and to determine if Rock Island State Park Rangers and Naturalists who work in the cave are at increased risk from occupational exposure to radon.

Big Bone Cave is a 400-acre natural area located in Van Buren County on the Eastern Highland Rim. It is named for the discovery of giant ground sloth bones (*Megalonyx lacquetus* Harlan) in 1811. The cave also has historical significance as a salt peter mine during the War of 1812 and the Civil War. The cave has limited public access; however, special tours of the cave are led by Rock Island State Park rangers and naturalists. Groups, such as the Boy Scouts, made overnight camping trips in the past, and naturalists conduct research in Big Bone Cave.

The land above the cave is a mixture of areas of natural woodland, past farming, and evidence of past grazing activities. With 9.62 miles of passage, Big Bone Cave is the second longest mapped cave in Tennessee. Much of the cave's geology is Monteagle limestone formation that is approximately 380 feet thick. The ridge above the cave is capped by Hartselle sandstone with various strata of formations beneath it. Although Big Bone Cave is technically located on the eastern Highland Rim, it is considered an outlier of the Cumberland Plateau because of these formations.

Radon levels have been measured periodically in Big Bone Cave since 1980. See Table 1 for data.

Discussion

Radon is a naturally occurring colorless, odorless, tasteless radioactive gas that is formed from the normal radioactive decay of uranium. Radon has been causally linked to lung cancer in uranium miners; the risk of lung cancer increases with smoking. Radon is a noble gas and will not attach to dust or other particles in the air. Radon will be breathed in and out, without remaining in the lungs. Radon decays, releasing gamma radiation and an unstable daughter product. Breathing radon itself does not lead to increased risk of lung cancer, unless the amount of radon in the air is very high. Breathing radon does not cause other respiratory problems, such as asthma; there are no immediate effects from breathing radon.

The unstable daughter product of radon decays or disintegrates, again releasing radiation and another daughter product. The process continues until a stable, nonradioactive daughter product is formed. Radiation is released in the form of alpha and beta particles and gamma rays. The final stable product is lead. The daughter products are charged and easily attach to dust particles in the air. Dust particles can be trapped in the lungs, along

with the radioactive daughter products, resulting in an internal exposure to the lungs, especially from alpha radiation (ATSDR 1990).

The unit of activity for radioactive chemicals is the curie, defined as $3.7x10^{10}$ disintegrations per second. A picocurie is one trillionth of a curie. Radon measurements at Big Bone Cave were taken in units of picocuries per liter of air (pCi/L). The measurements ranged from a low of 0.3 pCi/L to a high of 2,221 pCi/L. The risks from breathing radon are controlled by a number of factors, including the dose, the duration of exposure, and the frequency of exposure.

The maximum concentrations in all areas of the cave occurred in June 1986. These maximum measurements are much higher than other measurements, three to four times the concentrations measured in May 1983 and July 1986. It is unknown if the June 1986 measurements are accurate. Variation in radon concentration is expected and is dependent upon physical factors such as barometric pressure and temperature.

Risk for occupational exposures to radon and its daughter products is usually determined using the concept of working levels (WL). Working level units describe the radon decay-product activities in air in terms of potential alpha energy. A WL is approximately the total amount of energy released by short-lived daughter products in equilibrium with 100 pCi of radon (BEIR VI). Because equilibrium is seldom reached, the pCi equivalent for WL is adjusted by the percent radon daughter equilibrium. This is usually assumed to be 50% for homes (Turner; Brian A. Thomas, SENES Oak Ridge, Center for Risk Analysis, July 28, 2004, personal communication). The radon exposure, based on the geometric mean of measurements, is estimated to be 0.4 WL if 82 pCi/L (geometric mean) and 50% equilibrium are assumed.

The annual occupational level should be below 4 working level months (WLM). A WLM is the cumulative exposure equivalent to one working level for a working month of 170 hours. If the maximum exposure for a park ranger is 2 hours per trip with 1 trip per week for 3 months (Joe Moore, Rock Island State Park Manager, July 21, 2004, personal communication), and if he were exposed to the geometric mean of all radon concentration measurements, he would be exposed to approximately 0.06 WLM annually.

Children's Health Considerations

In the preparation of this health document, the health of children was thoughtfully considered. Children sometimes tour the cave and even camp overnight in it. According to park rangers, most visitors take one to three trips to the cave per year. There is no clear indication that risk is different for exposures to radon received during childhood, adolescence, and during adulthood (BEIR VI).

If a child camps overnight in the Monster Room (12 hours in the cave per camping trip) 3 times each year, and if he were exposed to the average concentration of radon in the Monster Room each time, his annual exposure to radon would be about 0.11 WLM. Using an average radon value is appropriate because it is highly unlikely that a camper

would be exposed to the maximum concentration during each camping trip. The average, rather than the geometric mean, was used because there were only five data points for the Monster Room with concentrations ranging between 2.8 pCi/L and 159 pCi/L.

An annual whole body dose in millirems can be estimated from WLMs by assuming a quality factor for alpha particles of 20, a weighting factor of 0.12 for conversion of lung dose to effective whole-body dose, and 0.16 rad per WLM. The dose is approximately 42 millirem, which is well below the International Commission on Radiological Protection (ICRP) recommended limit of 100 millirem annually to members of the public (Michael Brooks, Health Physicist, ATSDR, August 6, 2004, personal communication).

Conclusions

1. No apparent public health hazard currently exists for workers from radon exposure in Big Bone Cave, Warren County, Tennessee.
2. No apparent public health hazard exists for child or adult day visitors to Big Bone Cave, Warren County, Tennessee.
3. No public health hazard exists for children or adults camping infrequently in Big Bone Cave, Warren County.
4. Measurements in picocuries per liter (pCi/L) are not the best measure for determining health risk from inhalation of unstable radon daughter products.

Recommendations

As routine measurements for radon continue, obtain working level measurements in Big Bone Cave rather than pCi/L measurements so that direct comparisons can be made to OSHA standards and ICRP recommendations without doing imprecise calculations of pCi/L to WLM, with their concomitant assumptions.

Public Health Action Plan

1. TDH EEP will meet with state personnel who work or have worked in Big Bone Cave, at their request or at the request of TDEC management.
2. TDH EEP will provide copies of this health consultation to the state personnel who work or have worked in Big Bone Cave.
3. TDH EEP is available to review additional data or provide additional assistance.

References

[ATSDR] Agency for Toxic Substances and Disease Registry. 1995. Toxicological profile for radon 1990. Atlanta: US Department of Health and Human Services.

[BEIR VI] Health effects of exposure to radon: BEIR VI. 1999. Committee on Health Risks of Exposure to Radon (BEIR VI), Board on Radiation Effects Research, Commission on Life Science, National Research Council. Washington, D.C.: National Academy Press.

[Turner et. al] Turner JE, Bogard JS, Hunt JB, Rhea TA, Problems and solutions in radiation protection. McGraw-Hill, Inc., Health Professions Division, New York. 1992.

Table 1. Radon measurements in Big Bone Cave, Van Buren County, Tennessee.

Location	Month	Year	Concentration (pCi/L)	Average (pCi/L)
Skyway	May	1980	256	368
	May	1983	371	
	June	1986	1,223	
	July	1986	366	
	July	1986	375	
	July	1986	351	
	Feb	2004	2	
	Feb	2004	2.3	
Muster Ground/5 Vats	May	1980	106	143
	Nov	1983	135	
	June	1986	433	
	July	1986	157	
	July	1986	137	
	July	1986	139	
	Feb	2004	22.8	
	Feb	2004	16.1	
Muster Ground	Nov	1983	228	120
(Needles Eye)	Feb	2004	12.3	
Entrance Room	May	1980	245	364
	June	1986	1,278	
	July	1986	351	
	July	1986	300	
	July	1986	370	
	Feb	2004	0.3	
	Feb	2004	0.3	
1812 Passage	May	1983	558	612
(At Peace Sign)	June	1986	2,221	
	July	1986	458	
	July	1986	539	
	July	1986	497	
	Feb	2004	3.7	
	Feb	2004	4.7	
Monster Room	July	1986	159	104
	July	1986	180	
	July	1986	174	
	Feb	2004	3.7	
	Feb	2004	2.8	
			Geometric Mean = 82 pCi/L	

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CERTIFICATION

This Big Bone Cave Health Consultation was prepared by the Tennessee Department of Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was begun.

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The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health consultation and concurs with the findings.

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