

Radon and its Effect on Den Dwelling Wildlife

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Abstract

Triggered by the observation of obviously healthy rodents and other mammals living in dens and tunnels in highly radon bearing soils and strata, the paper seeks observations and information from anyone who knows about wildlife exposed to natural radiation over long times. The analogy of phase equilibria studies in petrology is used to demonstrate that short-term high dose exposures of a medium may produce different results from long-term exposures. In natural, environmental radon exposures of evolved species in their habitat hormetic effects may well take place, stimulatory and beneficial effects of an otherwise harmful agent. Since most animal studies are done with high short-term doses typical for atomic weaponry and nuclear technology, it is argued that hormesis will probably not hold for those Hiroshima-like tests. Recent correlation problems of cancer incidence and inverse radon concentrations should be explored using natural den dwellers, and the authors are offering their field and laboratory services and are looking for sponsors and collaborators for long-term information gathering and controlled exposures and clinical testing. Results of a pilot program that has been started to test Michigan bears is also presented.

Introduction

Soils are the source of soil gas, and the radon gas content typically ranges from 100 to over 1,000 pC/l. During a routine exposure of alpha track monitors for test purposes near Chicago, it was casually thought out loud why little chipmunks and other wildlife that live in dens and burrows in radon-bearing soil do not suffer from lung cancer. We could think of several alternative answers:

- 1) The average lifetime of wildlife could be too short to exceed the required latency period, which for man may be 10-20 years.
- 2) Cancer-stricken wildlife seeks a quiet, hidden death underground.

3) Evolutionary radon exposure has hardened wildlife, and it suffers no ill effects, indeed, it may benefit from the irradiation.

4) There is a threshold of radiation, not exceeded for most cases.

As we were aware of some past and present studies involving laboratory animals and mine dogs, we sent out a signal in the form of a letter to the editor of a radon journal, Radon Industry Review, asking for information from anybody knowledgeable on the topic. This letter brought together the two authors of this paper, as Prof. Hagler came forward as a Michigan bear hunter and approached The Michigan Dept. of Natural Resources who agreed to cooperate in an effort to use the 15,000 or so bear population of the state as a test base, of which some 700 to 1,000 have been harvested each year.

Evidence from other studies

Cross and Dagle of Pacific Northwest Laboratory¹ reported at the recent EPA/DOE radon conference in Philadelphia about lung cancer in rats exposed to radon. Unfortunately, the test animals are given equivalents of 10^6 WLM of irradiation in a matter of a few days. We do not believe that results produced by enormous rates of exposure can be applied to natural conditions, where the exposure time is considerably longer, yet the dose by comparison, considerably lower.

The Inhalation Toxicology Research Institute of the DOE in Albuquerque has been carrying out studies on irradiation induced lung cancer². To our knowledge, they have been using laboratory animals. Lastly, Professor Cohen has come forward with evidence that the lung cancer mortality rate vs. radon exposure shows a strong tendency to decrease with increasing exposure at low levels. Theories and policies would project an increase of mortality with increasing exposure.

In considering the chipmunks in our backyard and the bears in the Michigan peninsula, we remind ourselves that they are part of the natural habitat. In environmental radiation, we have had a consistent problem separating nuclear and atomic warfare technology from natural, environmental radiochemistry. For example, some of our state health departments require BA degrees in nuclear technology for people who want to be licensed radon tester.

Based on a total annual effective radiation dose equivalent of 360

Table 1:

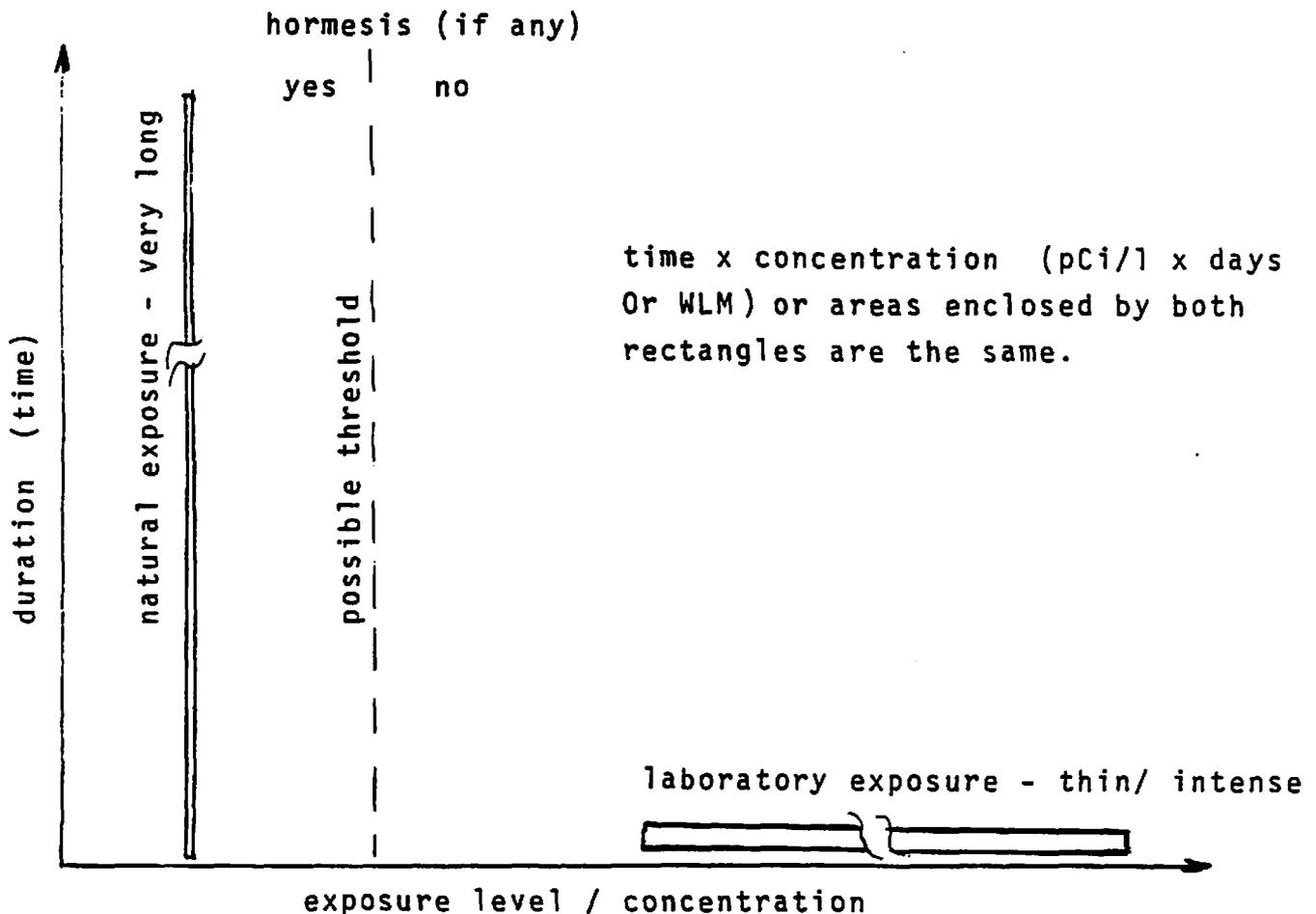
Average annual radiation dose to Members of the US Population:

(based on 360 mrem/ year Effective Dose Equivalent)
 Source: BEIR V Report)

radon	55 %
internal (K-40)	11 %
terrestrial	8 %
cosmic	8 %
medical x-rays	11 %
nuclear medicine	4 %
consumer products	3 %

Figure 1:

Natural (hormetic) and experimental exposure of subjects to radon



mrem/year, cosmic, terrestrial and internal radiation contribute about a quarter of the dose. On the Colorado Plateau, this share most likely is higher, more like 50% of the average population dose. (Table 1, p.3)

The other 50% of the dose about comparable in size, is from radon.

Environmental radiation is about one million millionth or 10^{-12} of the levels of nuclear, man-made radiation. This is what the word PICO stands for. PICO should signify to us the natural world of potassium 40 quietly ticking away in the muscles of mammals, of all the natural radioactive decay chains surrounding us in clays and rocks, and the cosmic showers coming in from space for billions of years.

It would make sense that evolution taking place in a naturally radioactive environment would adapt, and possibly utilize the radiation in a beneficial way. Native African bushmen and Australian aborigines have hardened skins and caloused soles on their feet, and they would be hard to compare with New Jersey housewives or other test subjects when it came to a survival test in the open.

To make up for infinitely long evolutionary, natural exposure of life by Hiroshima-like bursts of radiation and expect to be able to compare the results appears to be absurd. Evidence of the difficulty of unusual animal comparisons was presented at the 26th Hanford Life Sciences 1989 Symposium⁴

Beyond difficulty of man/animal comparisons lies the field of radiation hormesis. A conference on this topic was held in Oakland, CA, on 14-16 August, 1985. It's proceedings were published in Health Physics, 1987⁵. Hormesis may be characterized as a process whereby low doses of an otherwise harmful agent could result in stimulatory to beneficial effects. The phenomenon of hormesis is commonly found in nature in biological response to harmful chemical and physical agents.

Leonard Sagan of the Electric Power Research Institute, the guest editor of the conference proceedings, states that hormesis has previously received scant attention because it conflicts with the conventional radiation science paradigm.

Among the two dozen or so papers of the conference is the contribution by Bernard Cohen⁶ entitled "Tests of the linear, no-threshold dose response relationship for high-LET radiation. He states that failure of the linear, no-threshold theory is a necessary condition before hormesis can be accepted.

The issue of hormesis is a further case in point that natural participants, such as evolved wildlife, need to be examined in their habitat or a simulation thereof, and that man/animal analogues must be undertaken with great care and must be viewed with suspicion.

An Analogy from Petrology: Phase Equilibria Studies⁷

As another part of natural evolution, the Earth's crust contains minerals and rocks, that have formed in strict dependence on the temperature and pressure dominating at various depths. As crustal movement depresses or elevates a rock formation, its minerals adapt and change over long periods of time. The above mentioned soils on the Earth's surface are evidence of this change. The states of equilibrium between different minerals have been subject of arduous studies at many institutes and universities, and this matter deserves mention at this place, as the approach and the problem resemble the radon problem in several ways indeed.

In order to study the shift in mineral assemblages from, say, a one kilobar pressure environment going to a six kilobar level, the experimenter takes a rock sample from the original environment, a sandstone or a granite, and squeezes it in a high-pressure press with the pressure of the target environment, say, 6 kbar. The rock will then alter its configuration, and new minerals will form, to be identified and studied under petrographic microscopes after the test.

The crux of the matter is time, or the rate of change.

As most professors must publish, and most students must graduate, and most research contracts must be renewed annually or bi-annually, the duration of the typical pressure experiment is in the order of days. Imagine taking a sample out of nature that it took 100 million years or so to form, and then to change it within a few days! Professor Winkler of the Universities of Marburg and Goettingen pointed out to one of us some 30 years ago that he did not agree with imposing human habits upon natural ones. He laid out phase equilibrium tests designed for as long a time span as humanly possible. No, he could not wait one million years. Not even a thousand. But he could try for twenty, as he was a tenured professor. So he set up his experiments to simulate natural phase changes during a 20 year time span. From progress reports

received some time ago, we heard that his assemblages developed quite different from the short bang type experiments.

We are bringing forward this analogy as food for thought for the environmental radiation community. We are suggesting though, mathematically, the same dose equivalent can be produced in a very short time using a very large exposure, as can in a very long exposure with a very small dose rate - the result must not be the same.

This is why we are out to call for assistance from anyone. We are now going to talk about the Michigan project, and then to suggest a work program, which hopes to encompass government agencies, universities, naturalists, private industry, and anyone who has interest and sense and is willing to contribute.

Table 2 (to follow the text of page 7)

Preliminary radon results from Michigan bear dens

<u>Monitor #</u>	<u>Den #</u>	<u>Installed</u>	<u>Removed</u>	<u>pCi/l</u>	<u>Comments</u>
220 634	1	4/29/91	6/6/91	below 0.6	
220 579	2	"	"	0.8	
220 641	3	"	"	4.6	needs mitigation
220 640	4	"	"	1.6	
220 638	5	"	"	below 0.6	

The Michigan Bear Project

After reading the chipmunk letter in the radon journal, Russell Hagler contacted Bruno Sabels, and he brought the Michigan Dept. of Natural Resources and the ITRI institute in New Mexico into the picture, thereby turning a sigh into a project. REM, Inc. donated the alpha track monitors for the first phase of the study.

The chipmunk letter precipitated consideration of bears as animals exposed to probable high radon levels during hibernation that lasts from October to April during Michigan winters, and having a life span of forty or more years. With the cooperation of John Stuht, Statewide Coordinator of Programs, for the Michigan Dept. of Natural Resources, we ran a pilot program in which monitors were placed in bear dens that were known to have been used the previous winter. The five dens evaluated were all on Drummond Island just off the tip of Michigan's upper peninsula. The choice of location was due to the Wildlife Division of the DNR using this location for research purposes. On this island, bears are located during hibernation by searching out "blow holes", these are small openings in the snow surrounded by crusted ice, that are created by the escaping warm air from the bear's respiration and body heat. The bears are tranquilized, fitted with radio collars, and returned to their dens. This enables the DNR personnel to monitor movement of the population during the summer months. Eleven were available, at this time, but only five were suitable to be monitored. These were subterranean enclosures with little ventilation. Those considered unsuitable were under root structures that would be enclosed by heavy snow cover in the winter, but during the monitoring period the radon level would essentially be the average outdoor level. There are over one hundred known bear dens on the island that are accessible in the winter and the dry summer months.

Of the dens evaluated dens 1&2 were excavations under large rock formations. Den 3 was an excavated hole in the top of a small sandy knoll. Den 4 was a shallow hole under rocks. Den 5 was an enlarged hole under the roots of an uprooted tree. In each case, after placing the monitor, the entrance was covered with foliage in an attempt to simulate the sealed condition produced by deep winter snow.

The radon levels measured were : (see Table 2 on page 6)

This is to be considered as only a pilot program. The future intent is to have DNR personnel install small monitors on the radio collars to obtain more precise measurements of the radon level to which bears are actually exposed, as suggested by John Stuht. I have sought the advice of Dr. Bruce Muggenberg, Research Veterinarian, at the Inhalation Toxicology Research Institute, in New Mexico. I have been informed that examination of fresh, or preserved lung tissue is essential to determine if radiation damage, i.e. lung tumors, has occurred. John Stuht has offered to supply selected bear hunters with kits for the preservation of lung tissue from harvested bears in the fall 1991 hunting season. All hunter killed bears in Michigan must be taken to a DNR station where a tooth is extracted to keep track of the median age of the population. The hunters supplied with kits are expected to turn in lung tissue samples at these stations.

I am looking for funding for this project to help defray expenses for additional monitors, hiring someone to examine the tissue samples, and travel expenses. This is expected to be an ongoing project to continuously increase the data supply and hopefully help provide answers to some of the perplexing questions previously discussed in this paper.

Suggested effort

Cross and Dagle¹ suggested to the authors that a study of natural soil-dwellers was once attempted at Rocky Flats in Colorado. The objective was to find evidence of plutonium contamination in rodents. After futile efforts it was concluded the sick animals would hide and terminate out of reach, while only healthy animals were caught.

We are suggesting that natural, albeit healthy animals be used for longer term exposure studies than have been carried out so far. It has even been suggested that Bernie Cohen be given a sabbatical year from his professorship, to be spent buried in a prairie dog town in Nebraska, cohabitating with a natural population unlike any he has studied so far.

But yes, exposures of years should be anticipated, perhaps approaching or exceeding average, natural life spans.

We would urge DOE and EPA to consider modifications of some of their respiratory exposure studies, to de-Hiroshimize the dosage and to use natural, so to speak, radon-adapted species that can be managed over extended times. Unmanageable species, such as bears, may be studied in the open range.

Radon QC will make available radon chamber space for the foreseeable future, and is offering to house test animals in the chambers, preferably in cooperation with a biological or environmental sponsor.

It is hoped that we did not give the impression of having an axe to grind with anyone. We hope that our suggestions, and indeed this paper, will help adjust and re-direct our efforts, so as to come up with new evidence, being untapped around us for which we may continue matching the wrong answers with the wrong questions.

please read the following after observing page 10

Washington, Geophysical Laboratory, Proceedings in 1950's and
60's, pp.102-105, 224-226.

Acknowledgments

The idea for this effort originated with Judy B. Garcia, Laboratory Director, Radon QC. Mr. Robert Pollock of REM Inc. has contributed Health Physics references and suggestions in reviewing draft material. REM has also donated alpha track monitors for the first phase of the Michigan bear study.

References

- (1) F. T. Cross and G. E. Dagle, Lung Cancer in Rats Exposed to Radon/Radon Progeny.
paper II-4, 1991 Int. Symp. on Radon, USEPA, Phila. PA April 2-5, 1991, Proceedings.

Cross, F. T., Evidence of Lung Cancer Risk from Animal Studies, in: Proceedings of the 24th annual meeting of the National Council on Radiation Protection and Measurement, March 30-31, 1988, pp. 129-140.
- (2) ITRI Laboratory Studies Human Health Risk, in: Radon Research Notes, ORNL/Martin Marietta Energy Systems/USDOE, April 1991, No. 4, pp. 1-4.
- (3) Bernard L. Cohen, Expanded and Upgraded Tests of the Linear-No Threshold Theory for Radon-Induced Lung Cancer, paper II-7 in: 1991 Int. Symposium on Radon, USEPA, Phila. PA April 2-5, 1991 Proceedings.
- (4) Judith A. Mahaffey (ed, 26th Hanford Life Sciences Symposium, Modeling for Scaling to Man, Biology, Dosimetry, and Response, in: Health Physics, vol. 57
pp.1-471.
- (5) Leonard A. Sagan, (ed), Radiation Hormesis, proceedings of a conference, in: Health Physics, vol. 52, No. 5, May 1987, pp. 521-680.
- (6) Bernard L. Cohen, Tests of the Linear, No-Threshold Response Relationship for High-LET Radiation, in: Health Physics as under (5), pp.629-635.
- (7) Phase equilibria are discussed by Brian Mason, Principles of Geochemistry, J. Wiley & Sons, 1952, and in Carnegie Inst.

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