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Radioactive Hazard of Potable Water in Virginia and Maryland

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Only a few studies have examined instances of prolonged exposure to radionuclide concentrations found in natural settings. Radium in domestic water in Florida counties has been correlated with a higher than normal incidence of leukemia (Lyman et al 1985). A similar study in Iowa towns reported on a correlation between radium and increases in lung, bladder and breast cancer (Bean et al. 1982). Radium and radon in domestic water has been correlated with the development of lung cancer in a study of several Texas counties (Cech et al. 1987, 1988a-b). A correlation has been found between radon in home water supplies in Maine and the incidence of lung cancer (Hess et al. 1982).

MATERIALS AND METHODS

Starting in the winter of 1986-87, the Center of Basic and Applied Science conducted a study of indoor radon and soil radon. Most of the study homes are in Fairfax County in northern Virginia, and the immediately adjacent Montgomery County in southern Maryland. Both are located along the western margin of Washington, D.C. At the present time, over 1500 Virginia and Maryland homes have been examined in this indoor radon study, each over an entire year, using a series of three month exposures with four alpha-track indoor radon monitors (Mose and Mushrush 1988; Mushrush and Mose 1989). Since this group of homeowners developed a good record of punctual and complete reporting through questionnaires, and had generally been careful in placing and removing the radon monitors, it seemed reasonable to provide all the homeowners with an opportunity to obtain a measurement of radon in drinking water. Approximately 650 homeowners agreed to participate in the radon-in-water study. The study group now includes approximately 1400 people, over 1000 of whom have consumed their present water supply for 5 or more years, and over 700 of whom have consumed this water for 10 or more years.

Arrangements were made with the Waterborne Survey at Kutztown University in Pennsylvania for the radon analyses using liquid

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scintillation. Although only a single sample of drinking water was analyzed for its radon content from each home, the radon concentration in groundwater is thought to show variation below a factor of two (Prichard and Geselle 1981). Studies now in progress will serve to determine if this level of variation is found in the Virginia and Maryland study area, but preliminary data suggest that the variation is indeed below a factor of two.

In the introductory letter to all the participants, it was noted that sometimes drinking water provided by municipal water services contains radon and radium, and that private well water usually contains at least some radon and radium. About 35% of the participants currently use well water, and 65% use city water. Since there had been no testing of water for its radon concentration in the study area, and there had been almost no news media coverage about radon in water, the data shown later were not biased toward homes for which the homeowner had some prior data from their drinking water.

To gather the measurements of radon in drinking water, the homeowners were provided with an inexpensive syringe, a capped vial with 5 mL of toluene-based liquid scintillation fluid, along with directions about how to collect 10 mL of drinking water from a commonly used water tap. The homeowners filled out a pretest survey about their family health which asked, in part, the age of each home occupant, the length of time the person lived in the home, and a few questions about cancer (e.g., did any type develop, and if so, when was it discovered and what type) and smoking (e.g., did the person smoke, and if so, when, what, how long, and the average amount of smoking per day during the smoking interval). The data compiled in the following report comes from people who have not smoked, or who have smoked for less than 3 years. The radon in drinking water data reported in this study results from measurements that were accumulated between July of 1988 and March of 1989.

The homeowners who obtained the test kit also filled out a posttest questionnaire about the water supply to the home (e.g., from where is the water obtained, if from a well, how deep and how far away is the well, is the water treated, and if so, how, etc.). Several studies have noted that well water radioactivity increases with the depth of the well, and we anticipate commenting upon this observation using data from our study. However, the present report is confined to a comparison between radon and cancer, without reference to the well depth and to other physical and chemical properties.

RESULTS AND DISCUSSION

The following discussion will show that at the water radon concentrations examined in our study, there is a measurable increase in the rate of cancer with increasing water radon, and this rate increases as the exposure interval to the present water supply increases. In Table 1, a comparison is presented

between the incidence of several types of cancer and the source of the potable water. The data show that the incidence of cancer

Table 1. Comparison between cancer incidence and the source of the home water supply.*

	5 OR MORE YEARS IN HOME		10 OR MORE YEARS IN HOME	
	City Water	Well Water	City Water	Well Water
TYPE OF CANCER	(680 people)	(380 people)	(463 people)	(240 people)
Breast and Skin	0.8%	1.6%	1.1%	2.1%
Digestive System	0.7%	1.3%	0.6%	1.7%
Hormonal Glands	0.3%	1.3%	0.0%	1.3%

*The study population was divided into a subset that had lived in their present home with its present water supply for 5 or more years, and subset that had used its present water for at least 10 years. The study population was further divided into a group that used water provided by a municipal system, and a group that relied on a private well for the home potable water.

is about twice as great for the well water group, compared to the people who obtain municipal water. This observation is based on the incidence of breast and skin cancer, digestive system cancer (gastric, kidney, bladder and colon), and hormonal gland cancer (thyroid, prostrate). To determine if this difference could be related to the radon content of the potable water and the age of the people, the study group was divided into groups according to the radon level of the water and age.

In Tables 2 and 3, one of the water radon groups is identified as people who use city water. This group includes the people who have been consuming municipal water, and we found that this water did not contain radon. The other water radon groups refer to people who consume well water, and were selected as up to 2500 pCi/L and 2,500-25,000 pCi/L to divide the well water population into groups of approximately equal size. The groups of ages, at up to 29 years, 30 to 60 years, and over 60 years were selected to examine cancer incidence for people of similar age, drinking water with different levels of radon. Table 2 compiles the cancer percentages of people who have been drinking their present water for 5 or more years. The data show that people who consume water from a private well with less than 2500 pCi/l of dissolved radon have an incidence of cancer similar to people who consume city water, but both groups have a lower incidence of cancer than the people who consume water from a private well with more than 2500 pCi/l of dissolved radon. It is generally thought that an increase in the exposure interval to a carcinogen results in an increased incidence of cancer. It is also true that in the study area, rapid urbanization has resulted in the conversion of domestic supplies from private wells to municipal water much more frequently than the converse. To examine the effect of radon ingestion in a population with a

Table 2. Comparison between radon in drinking water and the cancer indicence (all types together) in a population that consumed its present water supply for 5 or more years.*

AGE OF PERSON (As of Spring 1989)	CANCER CASES	NUMBER OF PEOPLE	CANCER PERCENTAGE
PEOPLE WHO USE CITY WATER			
Up To 29 years of age	0	108	0 %
30 to 59 years of age	7	410	2 %
60 years and above	19	162	12 %
All ages	26	680	4 %
DRINKING WATER UP TO 2500 pCi/L			
Up to 29 years of age	1	61	2 %
30 to 59 years of age	6	111	5 %
60 years and above	0	32	0 %
All ages	7	204	3 %
DRINKING WATER OF 2,500-25,000 pCi/L			
Up to 29 years of age	1	60	2 %
30 to 59 years of age	4	88	5 %
60 years and above	5	28	20 %
All ages	10	176	6 %

*For people who have not developed cancer, the age of person is their age in the spring of 1989. For people who developed cancer, this age is the age at which the cancer was discovered.

measurably longer exposure to their present water supply, and to reduce the statistical effect of people in our study who have recently changed the source of their water supply, Table 3 was compiled to include only those people who have consumed their present water supply for 10 or more years. For people who have consumed their present water supply for 10 or more years, the city water population has the lowest incidence of cancer, and the well water population has a cancer incidence that is about twice as high. It is apparent that the effect of the transition group (people who have changed from well water to municipal water between 5 and 10 years ago) is significant. When this transition group is removed, the cancer rate for the city water group decreases, presumably because some of these people had previously consumed radon-enriched well water.

In order to examine the possible relationship between radon in water and cancer, we made the assumption that the body reaches an equilibrium with its normal level of radon (and its associated radionuclides radium and polonium) consumed by drinking water. We assumed, as have others (Hess et al., 1982, 1983), that radon and the other radionuclides act in concert with other carcinogens to produce the cancers. We assumed that radon and other dissolved radionuclides move throughout the body; and while it is perhaps not possible to know what fraction of these radionuclides decay before being removed from the body, this natural radiation could contribute in a measurable way to the

Table 3. Comparison similar to Table 1, but using home occupants that have consumed their present drinking water for 10 or more years.

AGE OF PERSON (As of Spring 1989)	CANCER CASES	NUMBER OF PEOPLE	CANCER PERCENTAGE
PEOPLE WHO USE CITY WATER			
Up to 29 years of age	0	76	0 %
30 to 59 years of age	3	243	1 %
60 years and above	8	144	6 %
All ages	11	463	2 %
DRINKING WATER UP TO 2500 pCi/L			
Up to 29 years of age	1	37	3 %
30 to 59 years of age	6	70	9 %
60 years and above	0	25	0 %
All ages	7	132	5 %
DRINKING WATER of 2,500-25,000 pCi/L			
Up to 29 years of age	0	28	0 %
30 to 59 years of age	2	57	4 %
60 years and above	4	23	17 %
All ages	6	108	6 %

development of cancer. This approach is similar to that used in a study in Maine (Prichard and Gesell 1983), where a significant correlation was found between all cancers together and county averages for radon in water. Our data point to a similar conclusion, using information from individual homes rather than county averages.

It now appears that the ingestion of radon enriched water is a health concern; because radon and its associated radionuclides can move throughout the body, to produce an effect at many cancer-prone sites. Since well water almost always carries some radon, we suggest that until additional data of the type compiled in this report are available, radon in both air and water should be of concern to public health officials.

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