

ALARA

There has been considerable concern lately about the amount of our daily exposure to radiation. The U.S. Nuclear Regulatory Commission has set up guidelines to determine the maximum allowable dose determined by “as low as reasonably achievable” (ALARA) criteria. Are you exposed to more or less radiation than the average American, for whom the annual dose calculated from this activity is 180–200 mrem? You will find out from this activity.

Exploration

Step 1 Fill in the appropriate amounts where indicated on the following table:

Common sources of radiation*#	Your annual exposure (mrem)	Additional considerations																				
cosmic radiation at sea level	26	—																				
elevation		If you live above sea level, add this number of mrem for the elevation at which you live: <table border="0"> <tr> <td>elevation</td> <td>mrem</td> </tr> <tr> <td>1000</td> <td>2</td> </tr> <tr> <td>2000</td> <td>5</td> </tr> <tr> <td>3000</td> <td>9</td> </tr> <tr> <td>4000</td> <td>15</td> </tr> <tr> <td>5000</td> <td>21</td> </tr> <tr> <td>6000</td> <td>29</td> </tr> <tr> <td>7000</td> <td>40</td> </tr> <tr> <td>8000</td> <td>53</td> </tr> <tr> <td>9000</td> <td>70</td> </tr> </table>	elevation	mrem	1000	2	2000	5	3000	9	4000	15	5000	21	6000	29	7000	40	8000	53	9000	70
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1000	2																					
2000	5																					
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5000	21																					
6000	29																					
7000	40																					
8000	53																					
9000	70																					
ground/soil	26	U.S. annual average																				
house construction		For stone, concrete, or masonry building, add 7 mrem																				
food, water, and air	24	U.S. annual average																				
weapons test fallout	24	U.S. annual average																				
x-rays and radiopharmaceutical exams ^v		number of chest x-rays * 10 mrem number of GI tract x-rays * 500 mrem number of radiopharmaceutical exams * 300 mrem																				

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Common sources of radiation ^{**}	Your annual exposure (mrem)	Additional considerations
jet plane travel		for each 2500 miles add 1 mrem
TV viewing		number of hours per day * 0.15 mrem
how close you live/work to a nuclear power plant		ave. number of hours per day at site boundary * 0.2 mrem ave. number of hours per day at 1 mile away * 0.02 mrem ave. number of hours per day 5 miles away * 0.002 mrem
TOTAL		—

* Other factors may affect your mrem exposure. The number given as the national average is just for this survey.

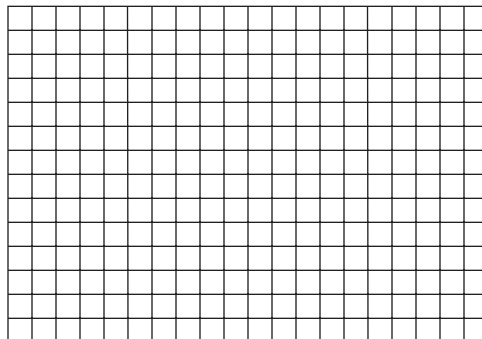
This chart was adapted from the "BEIR Report III"-National Academy of Sciences, Committee on Biological Effects of Ionizing Radiation, "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation," National Academy of Sciences, Washington, DC 1980.

∇ It is very important to note that the benefits of undergoing medical procedures generally outweigh any negative radiation consequences.

Step 2 What does the unit "mrem" signify? Why is this particular multiple of the unit used?

Step 3 Do you think your calculated annual exposure is "as low as reasonably achievable?" What are the most controllable ways to limit your ionizing radiation exposure if you continue to live where you do now?

Step 4 How much would your annual mrem exposure increase if you increased your diet by 4%? How much would it increase if you took a 5-day vacation in the Sierra Nevadas in California (elevation: 14,000 feet)? (The relationship between mrem and elevation is nonlinear, so must be graphed to extrapolate a value at 14,000 ft.) Are these two considerations serious health concerns with regard to radiation exposure?



Challenge

How is a person's exposure to ionizing radiation described, and how does your annual exposure compare with the national average?

ALARA

Concepts

ionizing radiation, radiation units

Expected Student Responses to Exploration

Step 1 All blanks in the table should be filled in.

Step 2 (a) A rem (roentgen equivalent for man) is a radiation unit that best indicates the biological effect of the actual radiation. It is obtained by multiplying a rad (radiation absorbed dose, the amount of radiation that results in the absorption of 1×10^{-5} J per gram of irradiated material) by the RBE factor (Relative Biological Effectiveness).

(b) The mrem, 1/1000 of a rem, is a more convenient unit for small quantities of radiation.

Step 3 (a) A student should comment about his or her own exposure.

(b) Little can be done about the mrems that we get from things like food and air. More controllable ways to limit radiation exposure are to watch less TV and limit air travel. However, the mrems avoided from these are minimal.

Step 4 (a) Increasing your diet by 4% would increase your annual ionizing radiation exposure by less than 1 mrem: $4\% \text{ of food} \times 24 \text{ mrem (which also includes air \& water)} = 1 \text{ mrem}$.

(b) Taking a 5-day vacation in the Sierra Nevadas:
 $5 \text{ day} \times (1 \text{ yr}/365 \text{ day}) \times 260 \text{ mrem/yr} = 4 \text{ mrem}$.

(c) In terms of radiation, neither activity is a serious health concern.

Expected Student Answer to Challenge

A person's exposure to ionizing radiation is described in terms of an annual dose in rem. Unless the student has had X-rays or radiopharmaceutical exams, the average student from this area probably calculates a value of about 100 mrem, a value considerably less than the national average.

Reference

Kotz, J.C.; Joesten, M.D.; Wood, J.L.; Moore, J.W.; *The Chemical World: Concepts and Applications*; Saunders College Publishers: Fort Worth, 1994; p 853.

Acknowledgment

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