Health Physics Society
Specialists in Radiation Safety

Radiation From Granite Countertops
Information Sheet


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Summary: Assuming a relatively tight house with an air change rate of 0.5 per hour (h^{-1}) and using average measured dose rates from granite countertop slabs, the estimated radon concentration in kitchen air would be 4.8 becquerels per cubic meter (*Bq m^{-3}). This concentration is less than one-eighth the average radon gas concentration in U.S. homes and is well below the Environmental Protection Agency (EPA) guideline of 4 picocuries per liter (pCi L^{-1}) (150 Bq m^{-3}).[1]**

It isn't a surprise that granite emits radiation. So do other items in our households. The amount of radiation emitted from granite can vary depending on the natural uranium and/or thorium concentration.

The surprise is that, in the *New York Times* article "What's Lurking in Your Countertop?" (Murphy 2008), a radon measurement contractor stated that exposure rates from granite countertops in the kitchen of a summer home in upstate New York were ten times higher than in other areas of the residence. He attributed the elevated exposure rate to uranium in the granite countertops. The article reports that radon levels in the kitchen (of this home) were reported to be 3,700 Bq m^{-3} compared to basement levels of about 200 Bq m^{-3}.

There are some alerting factors when we see measurements and statements like this. First, investigation determined that the measurement procedure was not valid. The procedure used by the contractor was not appropriate (as per EPA radon measurement methods) and did not provide a real idea of the amount of radon in the ambient kitchen air. Second, even if the measurement had been valid, one measurement result based on one type of granite countertop in one particular home is <u>not</u> an indication of radon exposure in any other kitchen with a granite countertop. What is needed is to measure many types of granite. So some members of the Health Physics Society did.

Our visit to a granite countertop distributor allowed measurements to be taken of various types of granite using a Ludlum *microR* meter. Background exposure rates outside the building and in most indoor areas ranged from 13 microroentgens per hour (μR h^{-1}) to 15 μR h^{-1}. All but one granite slab showed surface exposure rates in the range of background to approximately 1.5 times background (about 20 μR h^{-1}) (one slab was 80 μR h^{-1}, but was surrounded by other slabs, so the reading may have been influenced by that).

Based on the 20 μR h^{-1} reading and making some additional conservative assumptions (like no air flow mix from the kitchen to the rest of the house), we calculated an ambient radon concentration in a kitchen of 4.8 Bq m^{-3}. This is about one-eighth the average household indoor air concentration level and less than one-thirtieth the EPA recommended action limit. The calculations are shown in the next few pages for those who are interested.

The bottom line: No action needs to be taken to remove granite countertops in existing homes. If there are concerns by the homeowners, appropriate radon concentration monitoring should be conducted in the living areas of the home (per EPA protocols). If the granite countertop is determined to be a cause for concern, the most risk-reducing and cost-effective action to take would be to remove radon from the air throughout the home rather than remove the granite countertop.

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*Words in italics are defined in the Glossary on page 3.

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[1] The radon concentration units are given here in pCi L^{-1} (called traditional units) because that is the unit used by the EPA. However, the Health Physics Society has adopted the International System (SI) of units and these are given in parentheses.

Calculations

As indicated in the write-up, the average radiation exposure measurement from a granite slab was 20 μR h^{-1}. Based on field experience comparing the type of detector used to take the measurements and what is considered the "gold" standard (a pressurized ion chamber), the detector overresponds by as much as a factor of two where the uranium decay series is of concern.

Our starting factor is 20 μR h^{-1} divided by a factor of 2, so we start with 10 μR h^{-1}.

The exposure rate at the surface of an infinitely thick slab of soil with a uranium-238 concentration of 3.7×10^{-2} becquerel per gram (*Bq g^{-1}*) (with all decay products in equilibrium, i.e., radium-226 at 3.7×10^{-2} Bq g^{-1}) is 1.9 μR h^{-1} (Huffert 1995).

Conservatively assuming a true exposure rate at the surface of the granite slab of approximately 75% of the measured exposure rate and an upward adjustment factor of two to account for the fact that the granite slab is not infinitely thick, the estimated radium-226 concentration in the granite would be as follows:

Concentration of radon within a granite slab = (10 μR h^{-1} × 0.75 × 20)/(1.9 μR h^{-1}/3.7×10^{-2} Bq g^{-1}) = 0.29 Bq g^{-1}

The number of radon atoms produced each hour in the granite is:

Number of atoms of radon-222 in an hour = 0.29 Bq g^{-1} radon × 60 disintegrations per minute (dpm) Bq^{-1} × 60 minutes (min) h^{-1} = **1,044 atoms each hour in each gram**

Assume:

- density of granite is 2.75 g per cubic centimeter (cm^{-3})
- countertop area = 5 square meters (m^2)
- countertop thickness = 3 cm
- countertop volume = 3 cm × 5 m^2 × 10^4 cm^2 m^{-2} = 1.5×10^5 cm^3

Total number of radon atoms produced in an hour = 1,044 atoms h^{-1} g^{-1} × 2.75 g cm^{-3} × 1.5×10^5 cm^3 = 4.3×10^8 atoms h^{-1}

Total radon-222 activity produced in an hour = 0.693 N/$T_{1/2}$

Where: N = number of atoms produced per hour; $T_{1/2}$ = radon-222 half-life = 3.8 days (d)

Radon-222 activity = (0.693 × 4.3×10^8 atoms h^{-1})/(3.8 d × 24 h d^{-1} × 60 min h^{-1} × 60 dpm Bq^{-1}) = 910 Bq h^{-1}

Assuming that 10% actually gets out into the air (probably a lot less, but to be conservative), then **91 Bq of radon-222 would be released into the air each hour.**

Note: The emanation fraction for uranium mill tailings is nominally assumed to be approximately 0.2 (NRC 1980). Granite is more like a relatively tight rock. The emanation fraction for two different types of granite was estimated to be between 0.03 and 0.28 (Sakoda et al. 2008). In addition, the countertop material is typically sealed (at least on one side), further reducing the escape of radon into the air. Therefore the assumption of an emanation fraction of 0.1 is conservative.

The equilibrium concentration in a typical kitchen can be calculated as follows:

C_{eq} = I/(ach × V)

Where: Ceq = equilibrium concentration
ach = number of air changes per hour
V = volume of the room
I = influx of radon-222 per unit time = 91 Bq h^{-1} radon-222.

- Assuming a kitchen area 4.6 m × 4.6 m with 2.4 m ceilings, the total volume would be 51 m^3
- Assuming 75% of the total room volume is air, with the remainder occupied by cabinets and furniture.

Assuming a relatively tight house with an air change rate of 0.5 times per hour, the estimated radon concentration in kitchen air would be as follows:

$$\mathbf{C = 91\ Bq\ h^{-1}/(0.5\ h^{-1} \times 51\ m^3 \times 0.75) = 4.8\ Bq\ m^{-3}}$$

This concentration is approximately one-eighth the average radon gas concentration in U.S. homes (37 Bq m^{-3}) and is well below the EPA guideline of 4 pCi L^{-1} (150 Bq m^{-3}).

This calculation is very conservative in that it assumes that there is no mixing of air between the kitchen and other rooms in the home. If air in the kitchen of the house flows easily into other rooms, then the radon-222 concentration would likely be lower than the above calculation indicates.

The kitchen area is assumed to be relatively large, as is the countertop area. In addition, the true emanation fraction for a solid granite slab is likely to be lower than the value of 0.1 used in the equation.

Kitto and Green (2005) estimated the contribution from granite countertops to indoor air to be approximately 20 Bq m^{-3} based on a similar-type calculation using measured radon flux. Other measurements indicated a range of <4 to 85 Bq m^{-3} (Kitto 2005). Given these calculations and measurements, it would have been highly improbable, if not impossible, for the home cited in the *New York Times* article to have a radon concentration in room air of 3,700 Bq m^{-3} attributable to the granite countertops.

Glossary

Bq g^{-1}

This is an SI unit used to describe the amount of radioactivity measured in a certain solid volume. This particular term, becquerels per gram, describes a certain number of radioactivity disintegrations detectable in one gram of a substance, in this case, granite or soil. A becquerel is one disintegration of radiation per second.

Bq m^{-3}

This is an SI unit used to describe the amount of radioactivity measured in a certain liquid or gas volume. This particular term, becquerels per cubic meter, describes a certain number of radioactivity disintegrations detectable in one cubic meter of air. A becquerel is one disintegration of radiation per second.

microR

This is a traditional unit used to describe radiation exposure in air. This particular term, microR or μR, describes a certain amount of radiation energy being deposited in a certain amount of air. A microR is one-millionth of a roentgen (R). In SI units, 1 μR = 2.58 microcoulombs per kg (μC kg^{-1}) in air.

$T_{1/2}$

This refers to half-life. It is the amount of time it takes for half of the radioactivity in a material to be gone or to decay. The half-life of a radionuclide can be fractions of a second or up to millions of years. As an example, the half-life of radon-222 is 3.8 days. If we start with 10 radioactivity units of radon-222, after 3.8 days we have 5 radioactivity units or half the amount we started with. After 3.8 more days (7.6 total), we would have 2.5 radioactivity units left or a fourth of what we started with.

References

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