Obtaining and Investigating Unconventional Sources of Radioactivity

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This paper provides examples of naturally radioactive items that are likely to be found in most communities. Additionally, there is information provided on how to acquire many of these items inexpensively. I have found that the presence of these materials in the classroom is not only useful for teaching about nuclear radiation and debunking the "nuclear free" myth, but also for helping students to understand the history of some of the commercial uses of radioactive materials since the early 20th century. Finally, the activity of each source (relative to background radiation) is provided.

Sausalito, CA, the city bordering the one I teach in, has a "Nuclear Free Zone" sign (Fig. 1). I often wonder how many readers of the sign actually believe it's possible to live in such a place. I know the intent is to protest nuclear power or weapons, but I have a feeling that many of the promoters and readers of those signs feel as though it is possible to find a spot somewhere where they could actually be free of nuclear radiation. Physics teachers know that barring nuclear weapons and nuclear power plants from a community doesn't come close to removing sources of nuclear radiation. In fact, we know that, although generally small in activity, radiation is pervasive.

Over the last century, the popular view of nuclear radiation has evolved from a cavalier excitement that led to such careless practices as injecting and ingesting radium as a medicine and elixir to a near hysteria that considers any radiation exposure to be unacceptably dangerous. My approach to teaching nuclear radiation always begins with exploring this dichotomy. When introducing nuclear radiation, I have students gather closely around a large lab table containing, unbeknownst to them, a number of radioactive materials. A Geiger counter on another table chirps intermittently, indicating the presence of background radiation. The class is generally surprised to learn their bodies are constantly penetrated by naturally occurring radiation as well as high-energy cosmic rays. It's the first clue to most students that radiation is pervasive. Next I use the Geiger counter to check a commercially available radioactive source. The obviously higher activity from the small speck of radioactive material typically evokes two responses. First, most are relieved that background radiation is small compared to the radioactive source (Table I). Second, they wonder if it is safe to be near the commercial source. I assure them that, while the Geiger counter indicates a much higher activity for the commercial source, compared to background, the actual amount of radiation from the source is deemed to pose no danger to those nearby.

It is especially surprising to students to learn about the many things and places in their environment where they will routinely find radioactive materials. I use the Geiger counter to check for radioactivity in things they might reasonably find in their homes (or at least in their communities). The first item we check is an ionizing smoke detector (Fig. 2). Commonly found in most homes, the radioactive isotope americium-241 within the detector produces alpha particles that are used to produce a small electric current in a circuit within the detector. However, if smoke is present, the alpha particles will attach to the smoke particles, reducing the current in the detector and causing an alarm to sound. The americium source can easily be removed from its protective metal housing, and the Geiger counter indicates an activity similar to a commercially available polonium-210 source (Table I). New ionization smoke detectors can be obtained from home improvement stores for less than \$20 and closer to \$10 online.[1] Not only are they less expensive than the commercially available alpha sources, but they last far longer. The polonium-210 in the commercially available alpha source has a half-life of 138 days, making it virtually useless after two years; however, the 433-year half-life of the americium-241 in smoke detectors makes it a "one time" buy.

Table I. Various Radioactive Sources and Activities

Radioactive Source	Detected Activity (Bq)
Revigator (inside)	6648
Revigator (inside, alpha blocked)	4001
Cobalt-60 (commercial source)	1532
New Polonium-210 (commercial source)	615
Americium-241 (smoke alarm)	692
Fiesta® Ware	568
Thorium Lantern Mantle	174 (with alpha radiation blocked)
Radium Painted Watch Hands	58
Vaseline Glass	39
Background	16

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Fig. 1. A Nuclear Free Zone sign in Sausalito, CA.

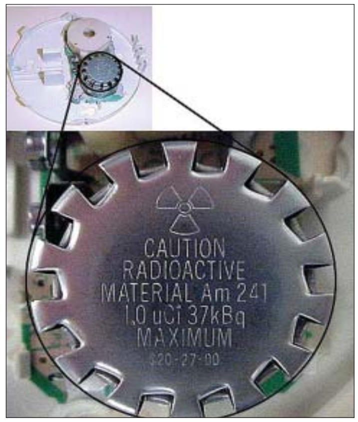

Fig. 2. An ionizing smoke alarm showing the presence of the isotope americium-241.

Fig. 3. Radioactive lantern mantles containing thorium nitrate.

Fig. 4. Vintage Fiesta® Ware used uranium in the glaze in order to achieve this particular shade of orange.

Fig. 5. Vintage Vaseline glass used uranium to achieve its yellow hue.

Fig. 6. The uranium content of the Vaseline glass causes it to fluoresce under ultraviolet light.

The next item we look at is a radioactive lantern mantle (Fig. 3). Lantern mantle companies no longer manufacture these with radioactive thorium nitrate, but they can be found occasionally on eBay. High bidders usually spend $5-10 for these. A search for "radioactive lantern mantles" will lead to auctions for these. I also found a pair recently in a thrift store for less than $2. They emit alpha, beta, and gamma radiation. With the alpha particles blocked and the detector about 1.0 cm from the mantle, the activity is about 10 times background radiation.

I next direct students' attention to a collection of Fiesta® Ware dishes (Fig. 4). Although new Fiesta® Ware can still be purchased, the vintage pieces with their characteristic orange color are radioactive. To achieve the particular shade of orange in these dishes (known as Fiesta red), a uranium oxide was used in the glaze. Natural uranium was used from 1936–1943 and depleted uranium was used from 1959–1969.[2] The uranium decay series provides an abundance of alpha, beta, and gamma radiations. However, using an old civil defense Geiger counter, the vintage Fiesta® Ware acts as though it were only a beta source. These Geiger counters are designed to detect gamma rays, but there is a window on the detector that can be rotated to allow the detection of beta particles. With the window open and the detector held 1.0 cm from the Fiesta® Ware plate, the activity was over 35 times greater than background. Placing several pieces of paper between the detector and the plate does not reduce the activity, indicating no detection of alpha particles. However, closing the window on the detector reduces the activity to background, indicating no detection of gamma rays with this particular detector. Vintage radioactive Fiesta® Ware is very easy to acquire. Most antique stores will have some pieces. They can also be found occasionally in thrift stores and antique fairs. The best source is probably eBay. Simple pieces that have scratches or chips can be obtained for as little as $10. Students always ask about the safety of using these dishes. My response is that since the activity of the dishes is so far less than that of commercially available lab sources, the danger of being near them is negligible. However, I am quick to caution that eating off the dishes could possibly scratch off some of the glaze and result in the possibility of ingesting some radioactive material. In addition to the possibility of the glaze being physically scratched off, it has also been reported[3] that leaching has been observed, especially in acidic solutions. Therefore, the same caution used in handling ceramics with lead-containing glazes should be observed when handling Fiesta® Ware, with its uranium-containing glaze.

Another vintage type of radioactive dishware is Vaseline

Fig. 7. The Revigator, a radium-lined water crock that produced radon gas, which was absorbed by water stored inside, making the water slightly radioactive.

glass (also known as uranium glass or canary glass, Fig. 5). As with Fiesta® Ware, this glass contains uranium. However, the radioactivity is much less than Fiesta® Ware (only about twice background). But there is a bonus. The uranium in the Vaseline glass causes it to be fluorescent. Under ultraviolet light, Vaseline glass glows a spectacular yellow-green (Fig. 6). It can be found in all the places that Fiesta® Ware is found, and sometimes cheaper prices can be found doing eBay searches for misspelled "Vasoline" or "Vasaline" glass—cheaper because not as many people find the auctions, potentially making you the only bidder. A recent search for Vaseline, Vasaline, and Vasoline glass on eBay resulted in 1105, two, and three auctions, respectively.

Another radioactive item that is not too hard to find is the vintage glow-in-the-dark clock or watch, which uses radium-painted hands and dials to produce the glow. These can be found in antique stores and on eBay. The prices are dramatically lower if the clock or watch no longer works, which is probably not an issue for physics teachers. Along the lines of this type of radioactive item, there are frequent eBay auctions for individual lots of dozens of radium-painted replacement watch hands. These are usually very inexpensive (several watch hands per dollar). With the Geiger tube held 1.0 cm from a set of watch hands, the detected activity was over three times background.

The last item I show students is a more expensive source of radiation that comes up for auction occasionally on eBay. The Revigator[4] (emphasis on the syllable "vig" to imply vigor) is a crock that was widely used in the 1920s and 1930s to irradiate drinking water (Fig. 7). Radium, which was believed to have healthful effects on the body, lined the inner wall of the crock. However, the radium didn't directly affect the water placed in the crock. And it wasn't due to the alpha or gamma emissions that resulted from the radium's radioactive transmutations. Rather, it was due to the radon gas produced when the radium transmuted. The only long-lived isotope of radium (radium-226, with a half-life of 1600 years) transmutes to radon-222 (with a half-life of 3.8 days). The alpha-emitting radon is absorbed by the water, making the drinking water mildly radioactive. I have purchased two, one for $100 and another for $135, and seen a dozen or so go for similar and somewhat higher prices. A test of water stored overnight in one Revigator indicated an activity that was twice the background radiation. However, this activity was only that of the surface of the water sample. Any alpha emissions below the surface of the water would have been absorbed by the water.

Finally, the most prevalent source of radiation, which negates every "radiation free zone," is naturally occurring radon. An active sample may be obtained by simply exposing an electrostatically charged inflated balloon to air, as explained in a paper[5] published in 1995 in *The Physics Teacher*.

Using unconventional sources of radioactivity in the introduction of nuclear radiation has had a positive impact on my students. They are more interested in the study of radioactivity when they see the abundance of sources that have been used historically and that are commonly available. Additionally, they are better able to objectively consider the issues around nuclear radiation than either the misguided citizens of nearly a century ago who wholeheartedly embraced radioactivity as an absolute good or the general public of today that rejects anything about radioactivity as an absolute evil.

References

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