Radiological Levels in North Pacific Seafood Consumption

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Introduction

Concerns over the effect of bioaccumulation of toxins in our food webs have been voiced for decades, and the recent release of dangerous nuclear decay products from the Fukushima Daiichi nuclear accident into the northern Pacific ocean only amplifies the threat. Many communities around the northern Pacific rim express the reasonable fear that both coastal and deep-sea fisheries may now be contaminated. This is especially true of radioactivity, with a host of other radionuclides that have half-lives long enough to be taken in by a variety of marine organisms, including those we eat ourselves. Determining the measurable levels of ionizing radiation in the seafood we buy in Pacific supermarkets is essential to determining whether measures to prevent consumer exposure need to be addressed.

What is Radioactive?

All atoms possess unstable isotopes, most being exotic and rare, decaying within a matter of seconds or less. Certain isotopes, however, are more common with longer half-lives. In the atmosphere, 40K, in living tissue, and 238U and 232Th (along with its decay chain daughters like 226Ra) commonly found in terrestrial rocks, are particularly abundant and pose a threat to public health if not managed properly. In addition, many manufactured products like smoke detectors with 90Sr and (more outlawed) glow-in-the-dark watch dials with 210Po are common in our modern, post-atomic-age world.

In nuclear fission processes that occur in reactors, there are additional radionuclides that may have shorter half-lives, but higher decay energy, and hence a more damaging effect on living tissue. The Fukushima accident released large amounts of volatile isotopes like 60Co, 65Zn, 131I, 140Ce, 144Ce, and 137Cs into the Pacific ocean currents and airstreams, that were subsequently distributed all over the northern Pacific Ocean from these range in half-life from 2.3 hours to 30.2 years, with some gamma ray energies of over 800 keV, certainly enough to damage tissues.

Methods

We assembled a MightyOhm Geiger Counter from a kit and maintained a 340V operating voltage. We used a TL-232R05-8 pin serial to USB cable to record count and dosage data in RealTerm for Windows. A total of 45 g sample of each seafood product was measured 1 mm from our Geiger tube for between 300 and 400 seconds, then the averaged count-per-minute (CPM) rates and computed errors were plotted as demonstrated below.

Results

The average count per minute (CPM) rate is shown below. Since radioactive decay counts independent events with only elapsed time determining probability, it can be modelled as a Poisson process, allowing us to calculate the error in our average, $\sigma/\sqrt{N}$, in terms of the standard deviation $\sigma$ and the total number of counts $N$.

$$\sigma/\sqrt{N}$$

A closer look at the expected distribution of counts in our measured background shows excellent agreement with a Poisson distribution.

Seafood Radioactivity

Background CPM Frequency

Background

Analysis

We can see from our data that the radiological measurements of all the tested marine seafoods are nearly indistinguishable from the background. Curiously, all measurements indicate a lower level of measurable radiation than the ambient atmosphere of my home, suggesting that in fact these samples actually act as partial shielding from the natural radionuclides. Additionally, a comparison of radioactivity and trophic level shown in the following plot corroborates the near identical levels in both contexts, but suggests a slight negative correlation between radioactivity and trophic level.

Conclusion

Aside from the background radiometric levels of my house and the inherent triggering energy limitation of our Geiger counter, there were few sources of intrinsic error to consider. One consideration is how fresh the seafood was; this information was nearly impossible to determine, but could have had a huge effect on measurable radiation (indeed, the time since death is the determining factor in $^{14}C$ dating, where the half-life is in thousands of years, not around 30 as for $^{137}Cs$).

Acknowledgements

I chose this project because it is a direct application of nuclear phenomena in the environment. The omnipresent and fundamental nature of physics fascinates me. This project was an exciting and engaging opportunity to explore the subatomic phenomena constantly in play around us as we add a real environmental concern that affects non-scientist consumers every day. Thank you to MightyOhm for the counter we used in the experiment, to Nugget Market for providing the seafood samples, and to Paul van Berchem and the AggieMentors program for the opportunity to conduct this research.

Sources


