BLBF
LBNL γ SURF

Berkeley Low Background Facility
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Naturespirit Herbs LLC Summer 2014 Samples

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1. Introduction and Method

Six samples of dried seaweed collected by Naturespirit Herbs LLC were analyzed at the Berkeley Low Background Facility (BLBF) at Lawrence Berkeley National Laboratory (LBNL). By analyzing them at the BLBF, we were able to analyze them with greater sensitivity than the samples previously analyzed a year ago, as well as provide additional information about natural radioactivity existing in the uranium and thorium series. Each of the six samples were counted for approximately 24 hours using a detector named MERLIN– a high purity germanium detector rated at 115% relative efficiency. The detector is located within a specially constructed, low background laboratory and low activity Pb shielding equipped with an external active muon veto system for further reducing cosmic ray related backgrounds. The samples of dried seaweed arrived as 'flakes,' with analyzed masses ranging from 176 to 468 grams. Note: for future samples, we would be able to obtain improved sensitivity when testing the samples if they were provided as a milled powder, which would allow for more of the sample to be packed into our standard Marinelli beakers used in analysis (which would create a higher density of sample material around the detector).

The samples analyzed included:

Table 1: List of samples and collection information provided by James Jungwirth of Naturespirit Herbs LLC.

Type	species	collection location	collection date
Kombu	Laminaria setchellii	Del Norte County, CA	6/16/14
Sea Fern	Cystoceira osmundacea	Del Norte County, CA	6/18/14
Gigartina	Gigartina papillata	Humboldt County, CA	7/16/14
Wakame	Alaria marginata	Humboldt County, CA	7/16/14
Bladderwrack	Fucus gardneri	Humboldt County, CA	7/17/14
Bull Kelp Fronds	Nereocystis luetkeana	Humboldt County, CA	7/17/14

2. Results and Discussion

The results of the gamma spectroscopy measurements are presented below in Table 2.

Table 2: Gamma spectroscopy results from the samples provided by James Jungwirth of Naturespirit Herbs LLC. The mass analyzed is provided in grams, along with the activity per unit mass (dry weight) for various isotopes of interest in becquerels per kilogram. For isotopes not detected (nd), a one sigma upper limit is provided.

sample	mass	K	^{40}K	U_e	U_l	Th_e	Th_l	^{137}Cs	^{134}Cs
	g	%	Bq/kg	Bq/kg	Bq/kg	Bq/kg	Bq/kg	Bq/kg	Bq/kg
Kombu	422	8.61(2)	2665 ± 6	315 ± 84	2.78 ± 0.07	0.86 ± 0.14	0.08 ± 0.01	0.36 ± 0.05	< 0.05
Sea Fern	463	14.44(3)	4470 ± 8	471 ± 86	1.05 ± 0.06	0.82 ± 0.18	0.06 ± 0.01	< 0.07	< 0.06
Gigartina	252	1.26(1)	390 ± 3	42 ± 13	0.11 ± 0.02	0.15 ± 0.06	0.14 ± 0.02	0.08 ± 0.02	< 0.02
Wakame	176	4.55(2)	1409 ± 5	164 ± 28	1.47 ± 0.06	0.75 ± 0.13	0.12 ± 0.02	0.13 ± 0.04	< 0.04
Bladderwrack	468	4.56(1)	1412 ± 4	755 ± 31	0.87 ± 0.04	0.50 ± 0.08	0.23 ± 0.03	0.30 ± 0.04	< 0.03
Bull Kelp Fronds	343	14.82(3)	4588 ± 9	207 ± 44	1.09 ± 0.07	1.13 ± 0.26	0.03 ± 0.01	0.29 ± 0.11	< 0.07

None of the samples showed explicit evidence for containing radioisotopes sourced from the damaged Fukushima power plant. This is based upon no ^{134}Cs being detected in any of the samples, which has a 2.06 year half life and was widely released following the reactor accident in March of 2011. Some of the samples did, however, have detectable amounts of ^{137}Cs, which has a 30 year half life. Although ^{137}Cs was also released from the Fukushima accident, we do not believe this is the source of it as there was already widespread, low-level contamination of ^{137}Cs all over the northern hemisphere leftover from the atmospheric nuclear weapons testing that took place in the 1950's and 1960's. Since this ^{137}Cs was largely present in the environment prior to Fukushima, detection of ^{134}Cs is the remaining true 'smoking gun' for radioactivity directly attributable to the Fukushima accident.

Regardless, this amount of ^{137}Cs is not unique to these kelp or alarming in anyway as most samples of biota will show some small level of it depending upon the sensitivity of the detector system characterizing the sample. (In fact, gamma spectroscopy has found some application in the wine industry, for verifying the age of certain wines by looking for small signatures of ^{137}Cs as a tracer!) As a benchmark for radioactivity and perceived risk, the Derived Intervention Level (DIL) established by the U.S. Food and Drug Administration (FDA) for $^{134+137}$Cs in food is set at 1200 Bq/kg [1]. The Kombu sample, which had the highest level of ^{137}Cs, the activity of ^{137}Cs was over 3,300 times less than this DIL from the FDA. Although it is man-made, the level of ^{137}Cs found in these samples does not in our opinion produce any health concerns since it is far below the official FDA DIL and it pales in comparison to the magnitude of the natural radioactivity present in the samples as well. (A good analogy would be that the activity from cesium in these samples would be like a single person cheering in a crowded football stadium compared to the total sum of everyone cheering– its absolutely dwarfed in the noise of the natural radiation present.) It may also be of interest to know that the levels of ^{137}Cs (and lack of ^{134}Cs) are quite consistent with the results of our analysis of the 2013 Naturespirit samples we provided as well as KelpWatch 2014, for which the BLBF has been screening large amounts of kelp throughout 2014. The results of the project are available online at http://kelpwatch.berkeley.edu.

In terms of natural radioactivity, the dominant source of gamma rays from all samples was from natural potassium (from ^{40}K), which makes up a significant amount of the mass of the samples (1-14% of the dry weight). Potassium is a primordial radioisotope with a half life of 1.27 billion years. Other detectable radioisotopes from the uranium and thorium series were also present. ^{238}U and ^{232}Th, with respective half lives of 4.47 and 14 billion years, are also common primordial radioisotopes with large decay chains containing many other daughter isotopes. Some of the more prominent gamma emitters in these samples from them include ^{226}Ra, ^{214}Bi, ^{214}Pb, ^{210}Pb from the ^{238}U series; and ^{228}Ra, ^{228}Ac, ^{212}Pb, ^{212}Bi, and ^{208}Tl from the ^{232}Th series.

Since measurement of isotopes in the uranium and thorium chains also imply the presence of other isotopes in the chain as well, we often refer their activity to the parent activity of U or Th that would

be sourcing them. Due to disequilibrium that can arise, we often break the chain into early and late series values while reporting activity. The early uranium series, or U_e in the seaweed is generally measured by ^{234}Th, while the late uranium series (U_l) refers to ^{226}Ra and below. For the thorium series, Th_e and Th_l refer to the chain above and below ^{228}Th.

Note that in this report, we are only reporting the approximate activities contained within the chains of these isotopes, and that if one was to do a completely proper evaluation of the radiation dose of these isotopes to the man made isotopes (such as ^{137}Cs) one would also have to factor in other effects relevant to dose such as particle type, energy, and tissue receiving the dose – which is beyond the scope of this work. However, it is also worth noting that the dose one would receive from the alpha-emitters present in the U and Th series from ingesting the kelp would far outweigh the dose from ^{137}Cs by many orders of magnitude. A good report of comparative dose related to these isotopes is presented in the article by Fisher, et. al. [2] where they evaluated the dose one would receive from ingesting tuna that contained ^{134,137}Cs from Fukushima. (They used the isotopes to study migration of pacific bluefin tuna [3, 4].)

3. Conclusion

From those samples of seaweed provided by Naturespirit Herbs LLC, sampled in June and July of 2014 from Humboldt and Del Norte County in California, there was no detectable radioactivity directly attributable to the Fukushima nuclear reactor accident since no detectable ^{134}Cs was found in the samples. Although small amounts of legacy ^{137}Cs were present in most of the samples, normal levels of natural radioactivity from uranium, thorium, and potassium were the dominant source of radiation in the various seaweeds.

4. Acknowledgements

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5. References

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