Beta Radiation in the United States Following the Fukushima Disaster

by Bobby1

This is a statistical study of beta radiation in the United States following the Fukushima nuclear disaster. Its purpose is to assess the levels of beta radiation compared to an average background level, and its change over time. The data was obtained from the US Environmental Protection Agency (EPA) Radnet customized search.

Health risks from beta radiation are due primarily through internal exposure to beta particles. "Beta particles cause biological damage when they enter the body through inhalation, ingestion, absorption though the skin, or through a cut in the skin." (http://www.psr.org/resources/**health**-**risks**-releases-radioactivity.pdf) Some of the radioactive isotopes which comprise beta particles, which may currently be found in the US, include:

Isotope	**Half-life**
Iodine-131	8 days
Barium-140	12.7 days
Strontium-89	5.5 days
Strontium-90	29.1 years
Tellurium-129m	33.6 days
Cesium-134	2.1 years
Cesium-137	30 years

The data presented below involve concentrations of radioactive particles in air. The accumulation in soil and water is cumulative. Bioaccumulation in milk, meats, plants and human beings create increasing nonlinear effects. On the other hand, the relatively short half-lives of the isotopes involved (with the exception of Strontium-90 and the Cesium isotopes) lead to the decay, over time, in the intensity and health effects of these beta particles.

The levels of Gross Beta radiation (from air filters, expressed in pCi/m^3) for the period March 15-May 23 were obtained for each of the years 2010 and 2011. The 2010 values for the corresponding month were considered to be background levels of beta radiation in the context of this study. The latest value for collection end date that was available at the time of this study was May 23, 2011. Tests of statistical significance were performed for the time periods March 15-31, April 1-30, and May 1-23. The null hypothesis (which was rejected in all cases) was that the values of gross beta radiation in 2011 did not increase over background. Each observation was weighted by the reciprocal of the number of observations for each city. The significance levels were obtained from optimal discriminant analysis.

Time period	US beta radiation level	N	$p <$
March 15-31	5.09x background	1093	.001
April 1-30	2.01x background	1877	.001
May 1-23	1.15x background	1173	.011

Levels of beta radiation were also studied for selected individual locations in the US. This table represents the multiplier over background level for each city and month.

City	March multiplier	April multiplier	May multiplier
Anchorage AK	4.17x	3.32x	1.23x
Fairbanks AK	2.06x	3.37x	1.14x
Birmingham AL	1.69x	1.20x	.86x
Little Rock AR	1.95x	1.16x	1.02x
Phoenix AZ	9.81x	3.31x	.63x
Tucson AZ	18.20x	3.07x	1.92x
Eureka CA	53.05x	19.82x	6.46x
Los Angeles CA	5.23x	2.19x	1.11x
Sacramento CA	6.83x	2.45x	1.24x

San Diego CA	11.42x	2.59x	1.53x
Riverside CA	6.91x	2.94x	1.09x
San Francisco CA	1.48x	2.43x	.85x
Denver CO	3.96x	1.29x	1.42x
Hartford CT	2.07x	2.96x	.82x
Jacksonville FL	6.38x	.82x	.93x
Orlando FL	8.13x	1.07x	.77x
Honolulu HI	23.98x	1.38x	.94x
Hilo HI	12.49x	1.23x	1.10x
Des Moines IA	5.35x	3.09x	1.96x
Idaho Falls ID	8.15x	3.53x	.95x
Aurora IL	2.27x	3.06x	1.10x
Indianapolis IN	4.49x	1.80x	1.47x
Topeka KS	2.09x	1.27x	1.33x
Lexington KY	2.90x	.92x	.77x
Baton Rouge LA	2.68x	.77x	.80x
Worcester MA	1.77x	2.12x	.79x
Baltimore MD	2.06x	1.85x	.76x
Portland ME	1.23x	1.76x	.39x
Detroit MI	2.27x	1.99x	1.00x
Duluth MN	1.07x	1.78x	.86x
Jefferson City MO	2.18x	1.41x	1.04x
Jackson MS	3.16x	1.07x	.92x
Billings MT	1.82x	1.04x	.58x
Charlotte NC	1.82x	1.10x	.81x
Bismarck ND	1.53x	1.33x	1.23x
Omaha NE	4.82x	3.52x	1.38x
Trenton NJ	1.61x	2.17x	.61x
Santa Fe NM	1.12x	2.37x	1.39x
Las Vegas NV	6.20x	2.40x	1.12x
Albany NY	2.01x	2.11x	.79x
Cincinnati OH	2.35x	1.89x	1.42x
Cleveland OH	1.91x	1.62x	1.28x
Portland OR	2.16x	.64x	.32x
Pittsburgh PA	1.59x	2.01x	1.21x
Columbia SC	2.64x	1.35x	1.02x

Pierre SD	2.13x	1.70x	1.42x
Dallas TX	2.29x	1.78x	.74x
Houston TX	2.03x	1.77x	.44x
San Angelo TX	1.97x	1.54x	1.61x
Salt Lake City UT	16.77x	3.61x	1.94x
Lynchburg VA	4.33x	1.56x	.82x
Virginia Beach VA	2.90x	1.34x	.66x
Olympia WA	1.28x	1.75x	.87x
Charleston WV	1.88x	1.10x	1.39x

It is also of interest to see the increase over the 2010 "background" level in absolute terms. The following table represents the absolute increase in 2011 gross beta (measured in pCi/m^3) over background for each city.

City	March increase	April increase	May increase
Anchorage AK	.0135	.0051	.0005
Fairbanks AK	.0105	.0104	.0006
Birmingham AL	.0053	.0030	-.0017
Little Rock AR	.0069	.0017	.0002
Phoenix AZ	.1521	.0337	-.0055
Tucson AZ	.1034	.0136	.0053
Eureka CA	.0209	.0056	.0017
Los Angeles CA	.0356	.0067	.0006
Sacramento CA	.0327	.0058	.0010
San Diego CA	.0779	.0078	.0026
Riverside CA	.0490	.0111	.0006
San Francisco CA	.0395	.0042	-.0004
Denver CO	.0255	.0021	.0024
Hartford CT	.0071	.0110	-.0009
Jacksonville FL	.0327	-.0016	-.0005
Orlando FL	.0455	.0006	-.0023
Honolulu HI	.0559	.0011	-.0002
Hilo HI	.0445	.0009	.0004
Des Moines IA	.0298	.0162	.0044

Idaho Falls ID	.0325	.0144	-.0003
Aurora IL	.0131	.0229	.0009
Indianapolis IN	.0255	.0071	.0026
Topeka KS	.0123	.0031	.0022
Lexington KY	.0111	-.0007	-.0016
Baton Rouge LA	.0088	-.0019	-.0013
Worcester MA	.0054	.0083	-.0014
Baltimore MD	.0100	.0067	-.0019
Portland ME	.0015	.0047	-.0041
Detroit MI	.0097	.0080	.0000
Duluth MN	.0006	.0045	-.0008
Jefferson City MO	.0098	.0045	.0003
Jackson MS	.0141	.0007	-.0007
Billings MT	.0144	.0004	-.0045
Charlotte NC	.0052	.0009	-.0016
Bismarck ND	.0051	.0023	.0009
Omaha NE	.0347	.0271	.0022
Trenton NJ	.0065	.0095	-.0034
Santa Fe NM	.0012	.0112	.0025
Las Vegas NV	.0433	.0094	.0007
Albany NY	.0094	.0097	-.0015
Cincinnati OH	.0107	.0079	.0024
Cleveland OH	.0069	.0043	.0012
Portland OR	.0075	-.0027	-.0058
Pittsburgh PA	.0056	.0076	.0012
Columbia SC	.0143	.0047	.0003
Pierre SD	.0093	.0047	.0018
Dallas TX	.0112	.0077	-.0020
Houston TX	.0080	.0072	-.0056
San Angelo TX	.0078	.0043	.0047
Salt Lake City UT	.1119	.0230	.0066
Lynchburg VA	.0268	.0063	-.0017
Virginia Beach VA	.0093	.0024	-.0034
Olympia WA	.0228	.0024	-.0005
Charleston WV	.0067	.0009	.0028

The top 15 increases in gross beta radiation for the selected cities are shown below. This will provide an index of the highest amounts of beta radiation caused by emissions from the Fukushima plant.

City	March beta level increase
Phoenix AZ	.1521
Salt Lake City UT	.1119
Tucson AZ	.1034
San Diego CA	.0779
Honolulu HI	.0559
Riverside CA	.0490
Orlando FL	.0455
Hilo HI	.0445
Las Vegas NV	.0433
San Francisco CA	.0395
Los Angeles CA	.0356
Omaha NE	.0347
Sacramento CA	.0327
Jacksonville FL	.0327
Idaho Falls ID	.0325

Arizona, Utah, and California had the highest amounts of airborne beta radiation. But Hawaii and, surprisingly, Florida also had high readings.

These figures will be assumed to be proportional to the *dry deposition* of radioactive particles. Additionally, rain and snow also contribute greatly to the amount of radiation deposited on soil. This is called *wet deposition*. The following table summarizes the total March rainfall for cities in Florida and west of the Rockies:

City	March 15-31 Rainfall (inches)
Phoenix AZ	0.06
Tucson AZ	0.02
Eureka CA	8.02
Los Angeles CA	3.80
Sacramento CA	4.10
San Diego CA	1.32
Riverside CA	1.41
San Francisco CA	4.72
Jacksonville FL	1.84
Orlando FL	4.02
Honolulu HI	0.17
Hilo HI	6.53
Idaho Falls ID	0.74
Las Vegas NV	0.17
Portland OR	3.83
Salt Lake City UT	0.99
Olympia WA	3.58

Summarizing the March deposition of beta particles, we have the following states ranked in decreasing order of dry deposition:

1. Arizona
2. Utah
3. California
4. Hawaii
5. Florida

The following states are estimated to have the highest amount of March wet deposition:

1. California
2. Hawaii
3. Florida
4. Washington

5. Oregon

The areas with higher amounts of dry deposition of beta particles are likely to suffer relatively higher amounts of contamination in topsoil and vegetation. Radioactive particles would tend to collect on the surfaces of green leafy vegetables. Areas with high amounts of wet deposition would have higher amounts of beta particles deposited from rain, and especially snow. This would find its way into groundwater, and drinking water supplies for cities. The contamination levels are likely to be greater in areas with high elevations.

April saw a sharp dropoff in beta radiation in Florida and some other areas. The highest amounts were located in the following cities:

City	April beta level increase
Phoenix AZ	.0337
Omaha NE	.0271
Salt Lake City UT	.0230
Aurora IL	.0229
Des Moines IA	.0162
Idaho Falls ID	.0144
Tucson AZ	.0136
Santa Fe NM	.0112
Riverside CA	.0111
Hartford CT	.0110

May had a further dropoff, with many areas indistingishable from background. Some areas, especially in the west and Midwest, were elevated, and the beta radiation increases over the whole US were still statistically significant.

City	May beta level increase
Salt Lake City UT	.0066
Tucson AZ	.0053
San Angelo TX	.0047
Des Moines IA	.0044
Charleston WV	.0028
Indianapolis IN	.0026
San Diego CA	.0026
Santa Fe NM	.0025
Cincinnati OH	.0024

The reduction in levels of beta radiation should not be assumed to continue in the future, as long as the Fukushima nuclear power plant emits radioactive substances into the atmosphere. A large Iodine-131 release occurred on May 22-23 (which did not enter into this analysis), and the Wallow fire in Arizona has increased beta levels for many areas of the country.