Radioactivity in South Dakota Resulting from the Chernobyl Nuclear Power Plant Accident

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At 1:23 am on April 26, 1986, an explosion occurred at the Chernobyl nuclear power plant 80 miles north of Kiev in the Soviet Union. Over the next week to 10 days, the largest quantity of radioactive material ever freed in one technological accident was released. The initial radioactive plume traveled in a northwesterly direction toward Scandinavia, then in an easterly direction, over the Asian Continent, Pacific Ocean, and eventually to the North American Continent.

While not receiving the high levels of radioactivity measured in Europe, South Dakota did receive some measurable levels of the radioactivity released by the explosion. In the days following the Chernobyl accident, sampling was conducted at two locations in the state:

Pierre - air particulates and precipitation
Rapid City - air particulates and milk

The air particulate and precipitation sampling in Pierre and the milk sampling in Rapid City were all conducted as part of the Environmental Radiation Monitoring System (ERAMS) which is EPA's nationwide network of environmental radiation monitoring stations. ERAMS is a cooperative program among the state and local governments which conduct the samples and the EPA which performs the analyses using verified analytical and quality assurance procedures. ERAMS consists of 268 sampling locations which routinely collect environmental data on air particulates, precipitation, milk, drinking water, surface water and external gamma.

The ERAMS air particulate sampling and precipitation sampling in Pierre are conducted by the South Dakota Department of Water and Natural Resources on the roof of the Sigurd Anderson Building. The particulate sampler is comprised of a shelter housing a vacuum motor which draws air through a 4-inch round filter. A magnehelic gauge is used for determining air flow. During routine sampling conditions, the sampler runs constantly with the filters being changed twice per week. Five hours after the filter is removed from the sampler, a gross beta field count is taken using a field meter and then the filter is sent to Montgomery, Alabama for further analyses. These analyses include gross alpha and gross beta levels, gamma analyses for fission products and specific analyses for uranium, plutonium, strotium, iodine, radium, krypton and tritium. The precipitation sampler is a fiberglass catch device with a 0.5 m^2 collection area. During routine sampling conditions, samples are collected monthly. The precipitation samples are sent to Montgomery, Alabama for analyses. In the days following the Chernobyl accident, sample collection frequency for both particulate and precipitation was increased to daily.

During routine sampling, milk samples are collected monthly in cooperation with the Pennington County Health Department in Rapid City. Like the precipitation samples, the milk samples are sent to Montgomery, Alabama for analyses. After the Chernobyl accident, the sampling frequency was increased to twice weekly.

Air particulate samples in Rapid City are also collected by the Pennington County Health Department. This low-volume air sampler is equipped with two filters--a charcoal filter and then a particulate filter which is sent to EMSL-Las Vegas for analyses. This sampler is run once a quarter and is then run during special circumstances such as the Chernobyl accident.

Three days following the explosion at Chernobyl, EPA increased its sampling frequency for airborne radiation to daily. It was not until May 4, however, than any increase of radiation was first measured on groundlevel in the U.S. A rain sample collected on May 4 from Portland, Oregon showed the first increase with a concentration of 130 pCi/l of iodine-131.

Iodine-131 (I-131) has special significance because it is one of the most copiously-emitted radionuclides in an accident of this nature. It is the product of fresh fissionable materials (bombs or nuclear power production) and because of its short half-life (8 days), the normal background level is zero. It is readily taken into the body from food, milk and water. Once in the body it tends to concentrate in the thyroid. Large amounts of I-131 (or radioiodine) can damage or destroy the thyroid while at lower levels of exposure, smaller doses of radioiodine may, over a long period of time, produce cancer of the thyroid.

In 1982, the Food and Drug Administration established what are known as recommended Protective Action Guides for several radionuclides, including I-131. Public health officials are required to take action to prevent foodstuffs from entering commerce if the PAG is exceeded. These PAG's offer a basis for comparing readings in rainwater and milk samples that were found as a result of radiation contamination from the Chernobyl incident. The PAGs for I-131 are 130,000 picocuries per square meter (pCi/m^2) for rainwater deposition; 50,000 picocuries per kilogram (pCi/km) for forage concentration; and 15,000 picocuries per liter (pCi/l) for peak activity in milk. Note should be taken that the rainwater PAG is in units of pCi/m^2. Deposition takes into account the amount of rainfall as well as the concentration. If the amount of rainfall is slight, the deposition will be comparatively low even if the concentration is comparatively high. For example, the I-131 concentration of 130 pCi/l measured on May 4 in Portland had a deposition value of 740 pCi/m^2.

After its arrival on the west coast of the United States, the radioactivity continued to travel east across the United States-- not as a homogeneous cloud, but rather as patches of radioactivity. By May 6, Cheyenne, Wyoming and Denver, Colorado were detecting I-131 in air particulate samples, and Bismarck, North Dakota was reporting I-131 in rainwater.

No measurable increase in I-131 concentrations was found in South Dakota, however, until May 13. Then, on this date, both the site in in Pierre (0.48 pCi/m^3) and the site in Rapid City (0.20 pCi/m^3) showed the first signs of fall-out from the accident. Figure 1 shows the I-131 concentration levels in air particulate samples in Pierre while

Figure 2 shows the I-131 concentration levels in air particulate samples in Rapid City. It appears that one wave (or patch) of radioactivity moved over the Pierre site, followed by another wave a few days later. The site in Rapid City appears to have been affected by the first wave, but the second wave is not apparent. Figure 3 is included to illustrate the movement of radioactivity across the area. This graph shows I-131 concentrations found at three sites in the United States; Boise, Idaho; Pierre, South Dakota; and Minneapolis, Minnesota. Of special interest is the time lapse in between the sites and the subsequent decreases in concentrations.

The radioactivity first appeared in rain in South Dakota in a sample collected on May 23. This is not quite what was expected. It was expected that the radioactivity would show up in an area in rain first, particularly from a thunderstorm reaching altitudes of 20,000-30,000 feet or more, since wind speeds at these higher levels transport air more rapidly from west to east than the winds found at ground level. In the May 23 sample, the I-131 concentration was 75.0 pCi/l with a deposition value of 2960 pCi/m^2, a value well below the PAG of 130,000 pCi/m^2. After the accident, only two precipitation samples showed I-131 contamination. These values can be found in Figure 4.

Since the pathway leading from rainwater to milk takes several days, it should be expected that the first milk sample containing I-131 would occur after the first appearance of I-131 in rainwater. This was not the case in South Dakota; the first significant increase of radioactivity in milk occurred on May 20, three days before the first detection in rainwater. Two possible explanations are 1.) the I-131 was the result of dry deposition on forage that the cows were grazing or 2.) different thunderstorms than were sampled in Pierre rained on the forage the cows were grazing. The I-131 remained evident until June 10. Figure 5 gives the I-131 concentrations found in milk, and graphs the concentrations. Even at its highest level (70 pCi/l), the I-131 concentration was less than 0.5 percent of the PAG.

South Dakota received small amounts of the radioactivity released by the accident at the Chernobyl nuclear power plant. While levels remained low, the contamination was nonetheless detectable and could be found in air particulate, rain, and milk.

FIGURE 1.

I-131 CONCENTRATIONS FOLLOWING CHERNOBYL NUCLEAR ACCIDENT
PIERRE, SD
AIR PARTICULATES (pCi/m3)

DATE	I-131	DATE	I-131
5/01	ND	5/18	NS
5/02	ND	5/19	0.26
5/03	ND	5/20	0.26
5/04	NS	5/21	0.13
5/05	ND	5/22	ND
5/06	ND	5/23	ND
5/07	ND	5/24	NS
5/08	ND	5/25	NS
5/09	ND	5/26	ND
5/10	ND	5/27	ND
5/11	ND	5/28	ND
5/12	ND	5/29	ND
5/13	0.48	5/30	NS
5/14	0.26	6/01	NS
5/15	ND	6/02	0.006
5/16	ND	6/03	NS
5/17	NS		

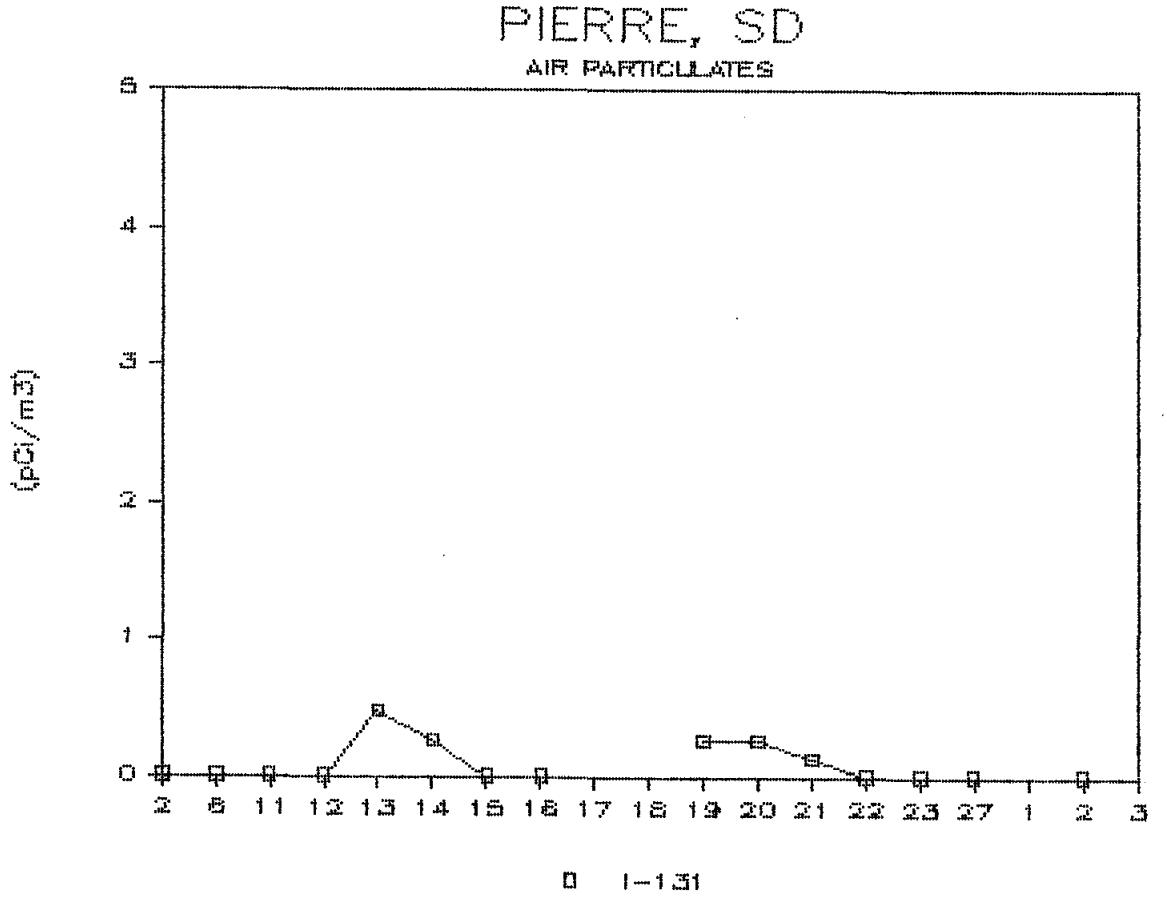


FIGURE 2.

I-131 CONCENTRATIONS FOLLOWING CHERNOBYL NUCLEAR ACCIDENT
RAPID CITY, SD
AIR PARTICULATES (pCi/m3)

DATE	I-131
5/02	ND
5/05	ND
5/07	ND
5/08	ND
5/09	ND
5/10	ND
5/11	ND
5/13	0.20
5/14	0.30
5/15	0.10
5/16	ND
5/17	ND
5/18	ND
5/19	ND
5/20	ND
5/21	ND
5/26	ND

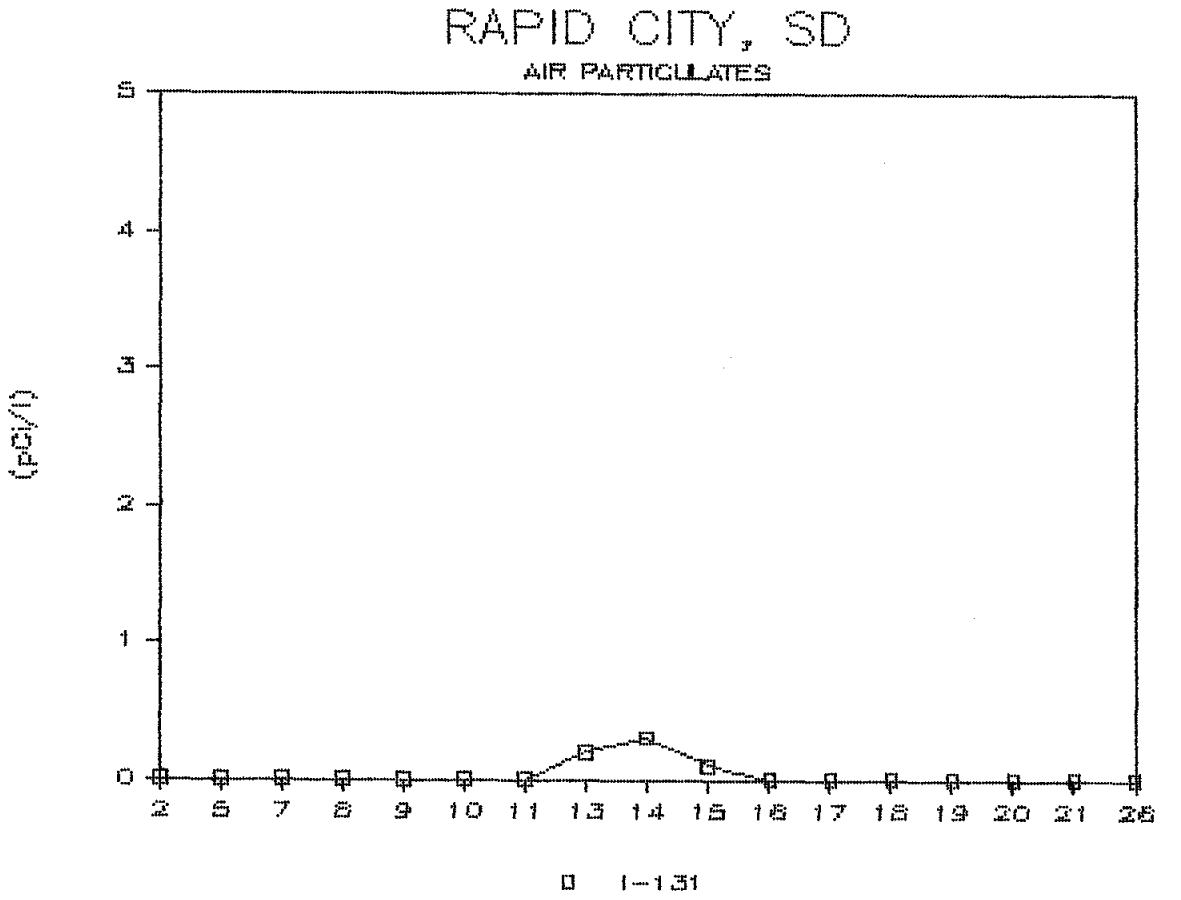


FIGURE 3.

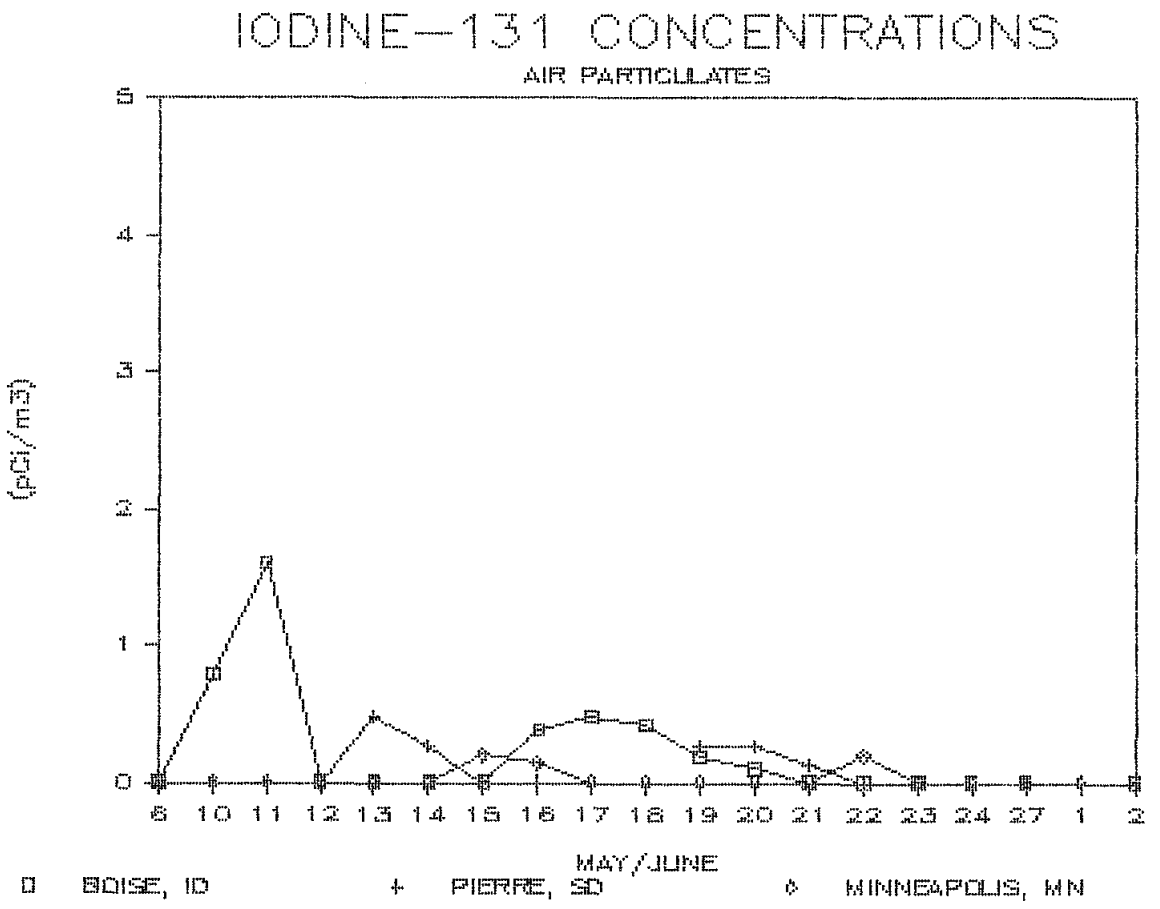

IODINE—131 CONCENTRATIONS
AIR PARTICULATES
(pCi/m3)
0
1
2
3
4
5
6 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 27 1 2
MAY/JUNE
BOISE, ID
PIERRE, SD
MINNEAPOLIS, MN

FIGURE 4.

I-131 CONCENTRATIONS FOLLOWING CHERNOBYL NUCLEAR ACCIDENT
PIERRE, SD
RAIN

DATE	I-131 (pCi/l)	I-131 (pCi/m2)
5/06	ND	ND
5/08	ND	ND
5/09	ND	ND
5/10	ND	ND
5/23	75.0	2960
5/26	33.9	271
5/27	ND	ND

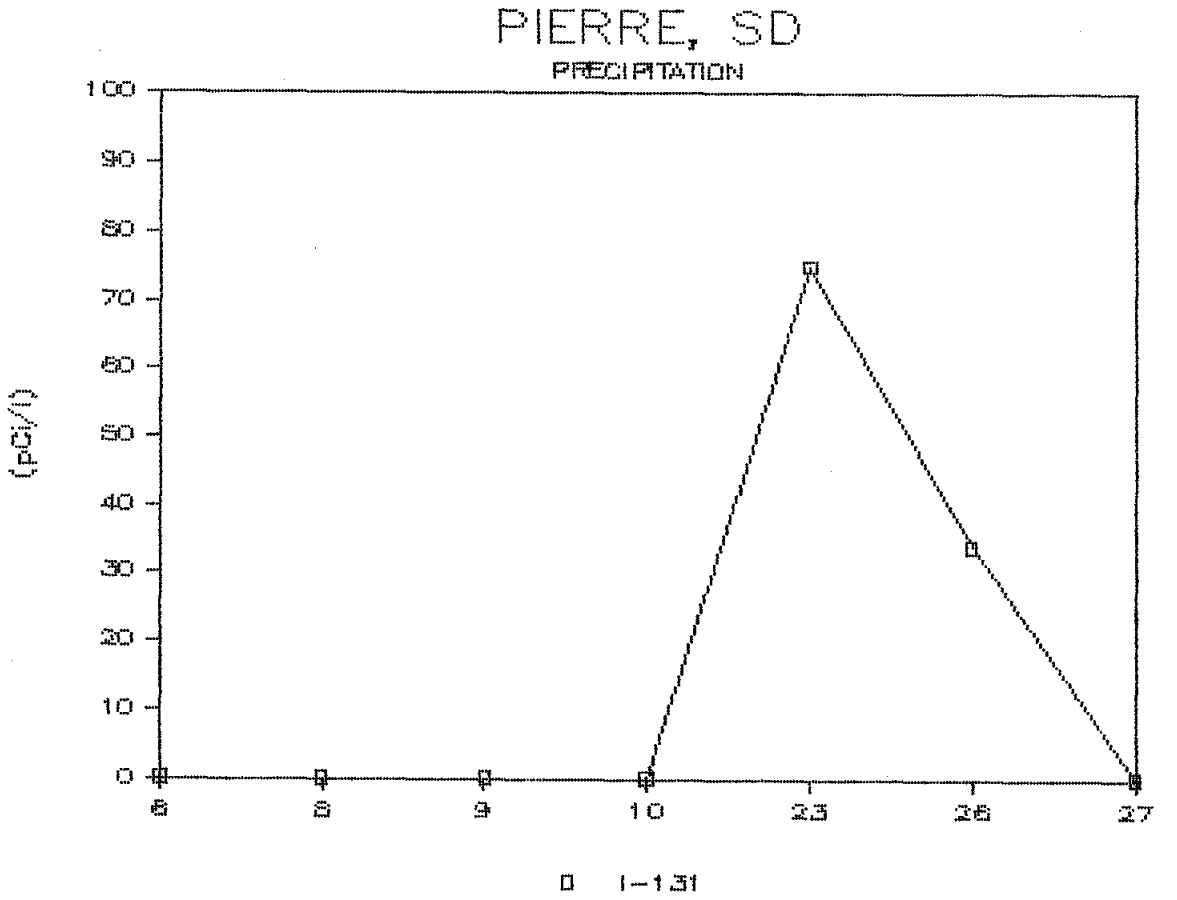
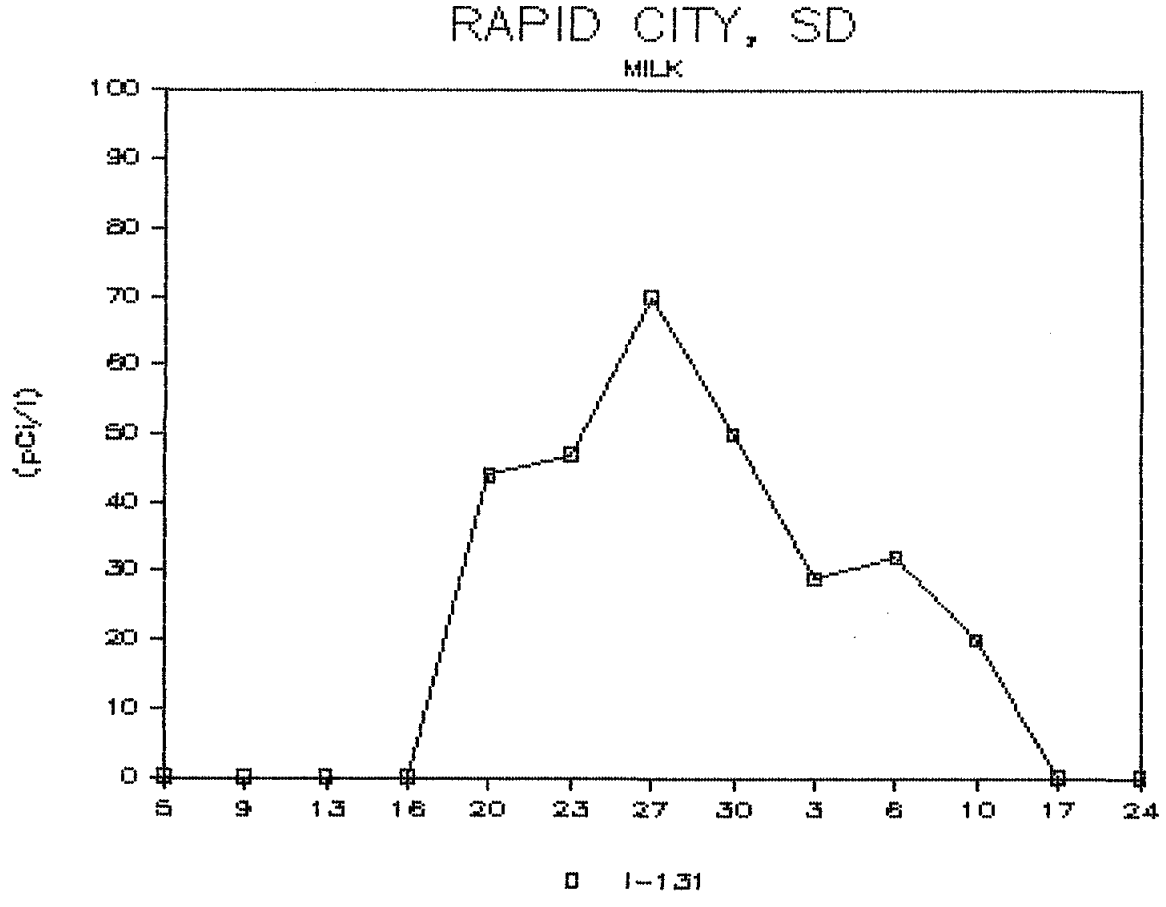


FIGURE 5.

I-131 CONCENTRATIONS FOLLOWING CHERNOBYL NUCLEAR ACCIDENT
RAPID CITY, SD
MILK (pCi/l)

DATE	I-131
5/05	ND
5/09	ND
5/13	ND
5/16	ND
5/20	44
5/23	47
5/27	70
5/30	50
6/03	29
6/06	32
6/10	20
6/17	ND
6/24	ND



References

1. Environmental News, U.S. Environmental Protection Agency, Office of Public Affairs, Washington, D.C., numerous press releases, April-May, 1986.

2. Hohenemser, Christoph, "Chernobyl: The First Lessons," Natural Hazards Observer, September 1986, pp. 1-2.

3. Radiation data, Eastern Environmental Radiation Facility, U.S. Environmental Protection Agency, Montgomery, Alabama, May-June 1986.

4. Radiation data, Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Las Vegas, Nevada, May 1986.

RADIATION FROM CHERNOBYL ACCIDENT

April 26	o Explosion at Chernobyl Nuclear Power Plant
April 29	o EPA increases sampling frequency for airborne radioactivity to daily
May 5	o Increased radioactivity found over central Japan Wind speeds at jet stream levels (30,000 feet) moving air rapidly west to east at speeds greater than 100 mph o Small amounts of radioactivity detected off of northwest U.S. coast by aircraft o First increase of radioactivity on ground level measured at Richland, WA - rainwater measured at 500 pCi/l of I-131
May 6	o Cheyenne, WY - 0.012 pCi/m^3 of I-131 o Denver, CO - 0.0057 pCi/m^3 of I-131 and 0.0002 pCi/m^3 of Cs-134 o Bismarck, ND - 6.7 pCi/l (Dep.= 13.4 pCi/m^2)* of I-131 in rainwater
May 7	o New York State - rainwater samples show small amounts of radioactivity o Chicago, IL - 0.0018 pCi/m^3 of I-131
May 8	o Phoenix, AZ - 0.091 pCi/m^3 of I-131 (only site showing levels above background)
May 9	o Cheyenne, WY - 230 pCi/l (Dep.= 450 pCi/m^2) of I-131 in rainwater
May 10	o Boise, ID - 900 pCi/l (Dep.= 9000 pCi/m^2) of I-131 in rainwater
May 11	o Montpelier, VT - 1660 pCi/l (Dep.= 12,300 pCi/m^2) of I-131 in rainwater
May 12	o Bismarck, ND - 560 pCi/l (Dep.= 590 pCi/m^2) of I-131 in rainwater
May 13	o Radioactivity first detected in milk - Helena, MT and Salt Lake City, UT - 26 pCi/l of I-131 o Radioactivity shows up in South Dakota - Pierre has 0.48 pCi/m^3 and Rapid City has 0.20 pCi/m^3 of I-131
May 20	o Milk in South Dakota first shows increase - 44.5 pCi/l of I-131 and 17.3 pCi/l of Cs-137 o Highest concentration in milk following accident reported by NRC - 320 pCi/l
May 23	o Rain in South Dakota first shows increase - 75 pCi/l (Dep.= 2960 pCi/m^2)

*Deposition of radionuclides is directly related to the amount of rainfall. Therefore, if the amount of rainfall is slight, the deposition will be comparatively low even if the concentration is comparatively high. Action levels based on deposition.

FDA RESPONSE LEVELS FOR THE
RECOMMENDED PROTECTIVE ACTION GUIDES (PAG's)

	Iodine 131	Cesium 134	Cesium 137
Initial Deposits (Rainwater) [pCi/m^2]	130,000	2,000,000	3,000,000
Forage Concentration (on grass, etc) [pCi/kg]	50,000	800,000	1,300,000
Peak Milk Levels [pCi/l]	15,000	150,000	240,000

EPA has established limits of I-131 in drinking water of 3 pCi/l. This level is much more protective than the FDA guide for milk (which was set for short-term emergencies--fallout from nuclear bombs or reactor accidents) because it is designed for a lifetime of consumption of drinking water.

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CONCENTRATIONS OF RADIONUCLIDES IN PASTEURIZED MILK

JANUARY - SEPTEMBER 1986

LOCATION	DATE COLLECTED	K g/l±2s	^{137}Cs pCi/l±2s	^{140}Ba pCi/l±2s	^{131}I pCi/l±2s
SD:RAPID CITY	1/ 8/86	1.53 0.09	1 5	1 6	4 5
SD:RAPID CITY	2/ 3/86	1.59 0.13	-1 7	1 9	-3 7
SD:RAPID CITY	3/ 3/86	1.56 0.13	11 7	2 9	8 7
SD:RAPID CITY	4/ 7/86	1.60 0.13	7 7	3 9	8 7
SD:RAPID CITY	5/ 5/86	1.48 0.16	-1 9	0 11	9 9
SD:RAPID CITY	5/ 9/86	1.53 0.16	-5 9	0 11	8 9
SD:RAPID CITY	5/13/86	1.53 0.16	4 9	7 10	2 9
SD:RAPID CITY	5/16/86	1.45 0.16	21 12	7 12	11 10
SD:RAPID CITY	5/20/86	1.38 0.16	17 12	6 12	44 11
SD:RAPID CITY	5/23/86	1.50 0.16	9 9	-2 11	47 11
SD:RAPID CITY	5/27/86	1.38 0.16	18 9	12 12	70 11
SD:RAPID CITY	5/30/86	1.60 0.16	4 9	0 11	50 12
SD:RAPID CITY	6/ 3/86	1.45 0.12	10 7	5 9	29 9
SD:RAPID CITY	6/ 6/86	1.59 0.16	11 9	4 12	32 12
SD:RAPID CITY	6/10/86	1.59 0.12	6 7	0 8	20 8
SD:RAPID CITY	6/17/86	1.52 0.16	4 9	-1 11	13 9
SD:RAPID CITY	6/24/86	1.54 0.16	3 9	-1 11	6 9
SD:RAPID CITY	7/ 7/86	1.54 0.09	6 5	-4 6	5 5
SD:RAPID CITY	8/ 4/86	1.62 0.12	8 7	2 8	5 7
SD:RAPID CITY	9/ 1/86	1.52 0.13	0 7	6 9	2 7

s SIGMA COUNTING ERROR