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Comparison of Radioactive Fallout in the United States from the Fukushima and Chernobyl Accidents

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Abstract

On March 11, 2011, an earthquake and tsunami of unprecedented magnitude led to significant damage at the Fukushima Daiichi Nuclear Power Plant in Japan. This damage resulted in both controlled and uncontrolled releases of radioactivity from multiple reactors at the plant. These releases have been considerable enough to be detected in several locations throughout the world. Due to the significance of this event and the widespread release of radioactivity, the Fukushima accident is now being compared in several aspects to the Chernobyl accident that occurred in 1986.

In the United States (US) and several other countries, radioactivity was beginning to be detected within a few days after the start of the Fukushima accident. In particular, commercial nuclear power plants detected radioactivity in multiple sample types as part of their operational radiological environmental monitoring programs (REMP). This was similar to what was seen from the radioactivity released as a result of the Chernobyl accident. The purpose of this paper is to present and compare the radioactivity concentrations detected in the entire commercial US nuclear power plant REMP samples from the Fukushima fallout. In addition, these concentrations and levels are compared to what was detected, and when, by US commercial nuclear power plants from the Chernobyl accident. Data was compiled and analyzed from all 104 US nuclear power plants in a variety of sample media types including air samples (particulates and iodines), drinking water, vegetation, food items, and milk. The Fukushima and Chernobyl sample data timeframes were 15/3/2011 to 14/4/2011 and 10/5/1986 to 25/6/1986, respectively. The principle radionuclides detected from both accidents included I-131, Cs-134, and Cs-137. Both the I-131 and Cs-134/137 radioactivity concentrations were roughly one order of magnitude less in the Fukushima samples.

Introduction

- On March 11, 2011, a magnitude 9.0 earthquake (Tohoku Pacific) occurred off the coast of Japan.
- The earthquake resulted in a 14m tsunami that struck the Fukushima Dai-ichi Nuclear Power Plant (NPP).
- The combination of the earthquake and tsunami (flooded the emergency diesel generators) led to a complete station blackout.
- Ultimately a meltdown of three reactors occurred and radionuclides were released into the environment over a period of one month.
- Airborne releases (I-131, Cs-134, Cs-137 fallout) have been detected in all 50 U.S. states.

Methods - NATC

- North American Technical Center (NATC) - Established by OECD/NEA in support of ISOE (Information System on Occupational Exposure) Program.
- In 1986, U.S. NRC asked NATC to compile NPP radiological effluent release data (formerly performed by Brookhaven National Laboratory (BNL)).
- Since 1998, NATC has collected and performed research on effluent data from U.S. NRC and licensees (support of UNSCEAR, EPRI, ANI, licensees and universities)
- The NATC works with commercial NPPs to disseminate information on radiological effluent releases and environmental monitoring
- For the Fukushima Accident, the NATC compiled and analyzed environmental monitoring data from the U.S. commercial NPPs
- At current time, 34 sites provided information - data analysis is ongoing

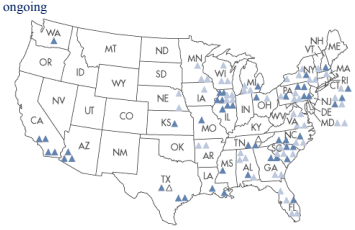

Fig. 1. Map of U.S. Commercial Nuclear Power Plants (U.S. NRC)

Methods – NPP Data

- West coast plants started 24 hour particulate and iodine sampling on 15 March 2011
- Setup air samplers for continuous monitoring and trending
- Trend relevant installed plant air monitors (plant vent particulate, iodine, pressurized ion chambers)
- Meteorological groups started jet stream plume modeling and tracking
- First detection (Diablo Canyon) of I-131 on 3/17/2011
  - Probably from U-3 explosion
- Additional sampling:
  - air samplers,
  - rain/precipitation,
  - vegetation
  - seafood (algae, mussels)

Results – I-131

- Highest results for I-131 detection in environmental media above MDA and background (above indicator media controls)
- Environmental samples from other agencies also reported I-131
- Analyses at Idaho State University are determining the ratio of particulate/gaseous fraction of I-131

Plant	Date Detected	Concentration	Units	Media
Oyster Creek	03/24/11	1.27E+02	pCi/L	Rain Water
TMI	03/23/11	9.54E+01	pCi/L	Rain Water
Limerick	03/23/11	9.27E+01	pCi/L	Rain Water
Davis- Besse	03/25/11	8.95E+01	pCi/l	Surface Water
TMI	03/25/11	5.11E+01	pCi/L	Rain Water
Quad Cities	03/24/11	3.90E+01	pCi/L	Rain Water
Ginna	03/22/11	2.68E+01	pCi/l	Rain water
Quad Cities	03/24/11	1.94E+01	pCi/L	Rain Water
Nine Mile Point	03/21/11	1.81E+01	pCi/l	Surface Water
Beaver Valley	03/25/11	1.48E+01	pCi/l	Surface Water
Perry	03/25/11	1.44E+01	pCi/l	Surface Water
Nine Mile Point	03/22/11	9.55E+00	pCi/l	Air Filter
Byron	03/22/11	1.00E-01	pCi/m^3	Air Filter
VC Summer	03/21/11	5.13E-02	pCi/m^3	Air Filter
Robinson	03/25/11	4.00E-02	pCi/m^3	Air Filter
VC Summer	03/16/11	3.93E-02	pCi/m^3	Air Filter
Calvert Cliffs	03/22/11	3.60E-02	pCi/m^3	Air Filter
Catawba	03/21/11	2.80E-02	pCi/m^3	Air Filter
McGuire	03/21/11	2.80E-02	pCi/m^3	Air Filter
Oconee	03/21/11	2.20E-02	pCi/m^3	Air Filter
Ginna	03/22/11	1.30E-02	pCi/m^3	Air Filter
Diablo Canyon	03/20/11	7.45E-12	uCi/cc	Air Filter

Table. 1. Highest concentrations for I-131 detected at U.S. NPPs

Results – Cs-137

- Highest results for Cs-137 detection in environmental media above MDA and background (above indicator media controls)
- Cs-134 detected a some plants (not reported here)
- Environmental samples from other agencies also reported Cs-137

Plant	Date Detected	Concentration	Units
Nine Mile Point	03/22/11	9.55E+00	pCi/l
McGuire	03/21/11	2.80E-02	pCi/m^3
Oconee	03/21/11	2.20E-02	pCi/m^3
SONGS	03/25/11	6.00E-12	uCi/cc
SONGS	03/21/11	1.80E-12	uCi/cc
Diablo Canyon	03/22/11	8.06E-13	uCi/cc
SONGS	03/22/11	7.00E-13	uCi/cc
SONGS	03/23/11	6.00E-13	uCi/cc
SONGS	03/24/11	6.00E-13	uCi/cc
SONGS	03/26/11	3.00E-13	uCi/cc
SONGS	03/27/11	3.00E-13	uCi/cc
SONGS	03/30/11	2.20E-13	uCi/cc
SONGS	03/28/11	2.00E-13	uCi/cc
SONGS	03/29/11	2.00E-13	uCi/cc

Table. 2. Highest concentrations for Cs-137 detected at U.S. NPPs

Results – I-131 Comparison

- Data collected from 18 NPP sites that detected fallout radionuclides from both the Chernobyl and Fukushima accidents

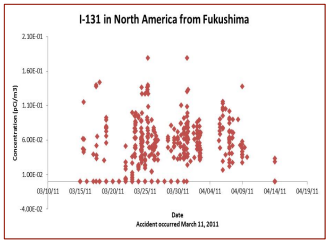

Fig. 2. I-131 detected in NPP air filters from Fukushima

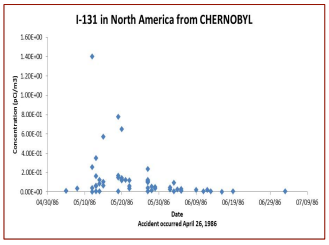

Fig. 3. I-131 detected in NPP air filters from Fukushima

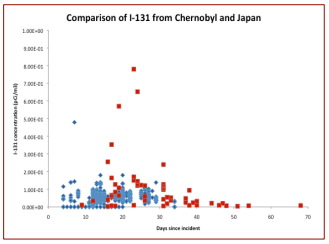

Fig. 4. Comparison of Chernobyl and Fukushima released I-131 detected in U.S. NPPs air samples

Conclusions

- Radioactive fallout from the Fukushima Accident has been detected in several environmental media from every U.S. commercial NPP site
- Preliminary I-131 levels (from 18 US NPP sites) are nearly an order of magnitude less then what was seen from Chernobyl
- Peaks in Fukushima data probably from sampling cycle
- The bimodal release from Chernobyl is not seen from this data
- A more comprehensive study of the Fukushima releases is currently underway. Data is being compiled from all of the US NPPs and the EPA RadNet locations, specifically
  - Study on I-131 gaseous vs. particulate fraction
  - Study on I-131/Cs-137 ratios
  - Geographical comparisons (plume movement)
  - Sampling and testing of other environmental media (i.e. honey)

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