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Analysis of the influence of the Fukushima nuclear accident on environmental radiation levels in the Qinshan area (Postprint)

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Abstract

To monitor the diffusion and deposition of the radioactive plume in the Qinshan area following the Fukushima nuclear accident, continuous air sampling was conducted from March 25 to May 6. Traces of ^{134}Cs and ^{131}I were detected during this period. Results from conventional environmental radiation monitoring also indicated that the specific activities of ^{90}Sr and ^{137}Cs in environmental samples exhibited abnormal variations in 2011, which nearly returned to normal levels in 2012. Although no abnormal changes in the environmental radiation levels of the Qinshan area have been observed to date, the influence of the Fukushima nuclear accident should continue to receive attention through future radiation monitoring.

Full Text

Preamble

Analysis of the Influence of the Fukushima Nuclear Accident on Environmental Radiation Levels in the Qinshan Area

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To monitor the diffusion and deposition of radioactive plume in the Qinshan area following the Fukushima nuclear accident, continuous air sampling was conducted from March 25 to May 6, 2011. Trace amounts of ^{134}Cs and ^{131}I were detected during this period. Conventional environmental radiation monitoring

results also showed that the specific activities of ^{90}Sr and ^{137}Cs in environmental samples exhibited some abnormal changes in 2011, which nearly returned to normal levels in 2012. Although no abnormal changes in environmental radiation levels have been observed in the Qinshan area to date, the influence of the Fukushima nuclear accident warrants continued attention through ongoing radiation monitoring.

Keywords: Fukushima nuclear accident, Qinshan area, environmental radiation monitoring

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Introduction

On March 11, 2011, a serious Level 7 nuclear accident occurred at Japan's Fukushima Daiichi Nuclear Power Plant due to a tsunami and earthquake, resulting in the release of massive amounts of radioactive materials and serious off-site consequences. On March 31, 2011, the China National Nuclear Accident Emergency Coordination Committee announced that trace amounts of ^{131}I and other artificial radionuclides had been detected in 25 provinces and districts across China [1, 2].

The straight-line distance between the Fukushima Daiichi Nuclear Power Plant and the Qinshan nuclear power base is approximately 2,300 km. Due to diffusion by wind and ocean currents, it is highly probable that some radioactive materials spread to the Qinshan area. "Qinshan area" is defined as a 10 km radius centered on the 300 MWe units around the Qinshan nuclear power base. The monitoring program analyzes nuclides including ^3H , ^{14}C , ^{90}Sr , ^{137}Cs , ^{131}I , and γ nuclides [3–5]. The sampled media include:

- Environmental γ radiation
- Air and fallout (aerosol, fallout, and rain)
- Soil (land surface soil, seabed mud, and beach soil)
- Agricultural products (tea, green vegetables, milk, herbage, rapeseed, mulberry, radish, rice, goat, green soybean)
- Aquatic products (mullet, hairtail, jellyfish, shrimp, spiral shell)
- Water (seawater, drinking water, pond water, groundwater)
- Biological indicators (pine needle, oyster, moss) [6]

Additionally, Qiaosi (WSW, 60 km), Hangzhou (WSW, 100 km), and Zhoushan (ESE, 140 km) serve as environmental reference sites where herbage, milk, fallout, tea, and seafood can be collected. These locations are situated in the low-frequency distribution range of wind direction from the nuclear power plant's wind field, are far enough from the plant, and are not affected by other radioactive facilities or industrial pollution. Therefore, these environmental references are not influenced by the operation of nuclear facilities and serve as strong reference points when analyzing the influence of the Fukushima nuclear accident on environmental radiation levels in the Qinshan area.

II. Analysis of the Influence on Environmental Radiation Level of Qinshan Area Caused by Fukushima Nuclear Accident

There are five pressurized water reactors (PWR) and two heavy water reactors (HWR) operating in the Qinshan area. To identify effects caused by the Fukushima nuclear accident, a parallel comparative analysis of data was conducted, focusing on specific activity changes of ^{90}Sr , ^{134}Cs , ^{137}Cs , and ^{131}I in the sampled media.

A. Emergency and Intermediate Phase

To monitor the diffusion and deposition of radioactive plume in the Qinshan area after the Fukushima nuclear accident, continuous air sampling was performed at seven monitoring positions (Fig. 1 [Figure 1: see original paper]) from March 25 to May 6, 2011, enabling detection of the early effects of the accident in the Qinshan area.

^{90}Sr , ^{134}Cs , and ^{137}Cs in aerosol samples: Aerosol and gaseous iodine were collected jointly through continuous pumping for 72 hours, with each sample representing approximately 600 m^3 of air. To analyze ^{90}Sr and ^{137}Cs in aerosol samples, all samples from one quarter were combined and analyzed using radiochemical methods. In the second quarter of 2011, immediately after the nuclear accident, the specific activity of ^{137}Cs in aerosol samples was tenfold higher than usual. Gamma spectrum analysis of aerosol samples revealed trace amounts of ^{134}Cs in air that could not be detected before the accident.

^{90}Sr and ^{137}Cs in fallout samples: Fallout samples were collected monthly. Before and after the nuclear accident, the specific activities of ^{90}Sr and ^{137}Cs in fallout samples remained in the same order of magnitude. However, in the second quarter of 2011 following the Fukushima accident, the specific activity of ^{90}Sr in fallout samples was higher than usual. For example, values at Xiajiawan (WSW, 1.25 km) and Qinlian (WNW, 2.4 km) were tenfold higher than in the first quarter of 2011, and values in the last three quarters of 2011 remained above the minimum detectable concentration (MDC) of 1.3 mBq/dm^2 for ^{90}Sr in fallout samples. The specific activities of ^{90}Sr and ^{137}Cs in fallout samples from Qiaosi (WSW, 60 km) remained at usual levels.

^{131}I in air samples: From March 25 to May 6, 2011, trace amounts of ^{131}I were detected in air samples according to the method specified in GB/T14584-1993 (Fig. 2 [Figure 2: see original paper]). Normally, the specific activity of ^{131}I in air samples is below the MDC of 0.10 mBq/m^3 . From April 3 to 6, the specific activity of ^{131}I in air samples peaked at 2.73 mBq/m^3 .

Other samples: In April 2011, drinking water samples were analyzed, with no abnormal changes in radioactivity measurement results. Analysis of rain, fallout, and air samples indicated that the Fukushima nuclear accident had no effect on ^3H , ^{14}C , and total α/β results. Gamma spectrum analysis of iodine

boxes showed that in addition to ^{131}I , ^{134}Cs and ^{137}Cs were also present in the activated carbon boxes. From April 3 to 18, the specific activities of ^{134}Cs and ^{137}Cs absorbed by the iodine boxes were higher than their respective MDCs of 0.04 mBq/m^3 and 0.07 mBq/m^3 (Figs. 3 and 4 [Figure 3: see original paper] [Figure 4: see original paper]).

Overall, after the Fukushima nuclear accident, the specific activity of ^{137}Cs in air and fallout samples was significantly higher than usual, and particularly in the second quarter of 2011, trace amounts of ^{134}Cs and ^{131}I were detected in the Qinshan area. During this period, the Qinshan nuclear power base was operating normally, demonstrating that part of the radioactive plume released from the Fukushima accident had diffused to the Qinshan area.

III. Long-Term Phase

In the long-term phase of a nuclear accident, radioactive plume becomes deposited into soil, plants, and the groundwater circulation system [7]. Radioactive materials diffused through seawater are taken up by plankton into the food chain cycle or deposited on the seabed. Therefore, internal exposure from ingestion of food and water becomes the most important monitoring objective.

A. Soil Samples

The specific activities of ^{137}Cs and ^{90}Sr in land surface soil samples from Qinlian (WNW, 2.4 km) and Qiaosi (WSW, 60 km) were only slightly higher than usual, remaining in the same order of magnitude as typical values. To date, the Fukushima nuclear accident has had no abnormal effect on seabed mud or beach soil. However, the migration trends of ^{90}Sr and ^{137}Cs in soil still require continuous monitoring.

B. Agricultural Product Samples

Agricultural products represent an important ingestion pathway for internal exposure. Trace amounts of ^{134}Cs were detected in rapeseed, tea, herbage, and green vegetable samples in 2011. The specific activity of ^{134}Cs was $(26 \pm 5) \text{ mBq/kg}$ in rapeseed samples from Qinlian (WNW, 2.4 km), $(190 \pm 10) \text{ mBq/kg}$ in tea samples from Hangzhou, 1.2 mBq/kg in herbage samples from Qiaosi (WSW, 60 km). Trace amounts of ^{131}I were also detected in green vegetable, herbage, and milk samples, with specific activities of $(220 \pm 20) \text{ mBq/kg}$ in herbage from Qiaosi (WSW, 60 km) and $(350 \pm 30) \text{ mBq/kg}$ in herbage from Zhapu (NE, 22 km).

Concurrently, the specific activity of ^{137}Cs in most green vegetable and herbage samples increased compared to the same period in previous years, as did rapeseed samples from Qiaosi (WSW, 60 km). The maximum specific activity of ^{90}Sr in green vegetable samples collected in the first half of 2011 reached $(657 \pm 40) \text{ mBq/kg}$, nearly four times higher than usual. Particularly, the specific activity

of ^{90}Sr in green vegetable samples from Qiaosi (WSW, 60 km) was (370 ± 3) mBq/kg.

The specific activities of ^{134}Cs and ^{137}Cs in herbage samples from Qiaosi (WSW, 60 km) increased after the accident in 2011 but fell back to usual levels in 2012, as did the specific activity of ^{90}Sr in green vegetable samples from Qiaosi. This clearly demonstrates that migration of ^{90}Sr , ^{134}Cs , and ^{137}Cs occurred in the environment.

The specific activity of ^{137}Cs in radish samples from 2011 was slightly higher than usual. The specific activities of ^{90}Sr and ^{137}Cs in rice samples from Qiaosi (WSW, 60 km) also increased slightly. For other agricultural products such as goat and mutton bones, radioactive content did not change significantly.

C. Biological Indicator Samples

Biological indicators are organisms with large concentration factors for particular radionuclides that can indicate pollution trends [8]. According to ecological surveys [9], pine needles, moss, and oysters are designated as biological indicators for the Qinshan area, with analysis of nuclides such as ^3H , ^{14}C , and ^{90}Sr . After the Fukushima nuclear accident, trace amounts of ^{134}Cs were detected in moss from Baita Hill (NE, 2 km), with a specific activity of approximately 180 mBq/kg in 2011, decreasing to about 37 mBq/kg in 2012.

D. Seawater and Aquatic Product Samples

The ocean is a vast, complex system where dispersion, mixing, and transfer of radioactive materials depend not only on the physicochemical properties of the radioactive substances but also on pollutant emissions, sea hydraulic characteristics, and hydrologic features. In the ocean, radioactive substances undergo various physical, chemical, and biological processes in a complex series of changes [10, 11].

Data from two years after the accident showed stable radioactive measurement results for seawater, indicating that the Fukushima nuclear accident has had no influence on seawater in the Qinshan area to date. Seafood is also an important ingestion pathway for internal exposure. Except for a slight year-by-year increase in the specific activity of ^{90}Sr in mullet bone samples, other radioactive measurement results showed no obvious changes. Because the territorial sea is adjacent, spiral shell (as a freshwater aquatic product) and jellyfish (as seafood) were added to analyze specific activity changes of radionuclides in seawater and seafood in the Qinshan area after the Fukushima nuclear accident.

IV. Conclusion

After the Fukushima nuclear accident, trace amounts of ^{134}Cs and ^{131}I were detected, and the specific activities of ^{90}Sr and ^{137}Cs were higher than usual in air. Due to the small amount of radioactive plume that spread to the Qinshan

area and the short diffusion duration, ^{131}I was no longer detected in air samples after May 6, 2011, and the specific activities of ^{90}Sr , ^{134}Cs , and ^{137}Cs fell back to normal levels from the third quarter of 2011.

Through analysis of environmental radiation monitoring two years after the Fukushima nuclear accident, the specific activities of ^{90}Sr , ^{134}Cs , and ^{137}Cs were slightly higher than in 2010, and ^{131}I had transferred from air to vegetables, herbage, and milk. Although these nuclides had low specific activities and significant changes in environmental radiation levels are unlikely to be observed now, their migration changes still warrant sustained attention in the future.

The Fukushima nuclear accident provides several important insights:

1. **Medium types of environmental radiation monitoring samples should be increased after the Fukushima nuclear accident, and monitoring items should be adjusted according to radionuclide migration in the environment** [12, 13].
2. **Radiation monitoring of seawater and seafood needs to be strengthened in the future.**
3. **A long-term environmental radiation monitoring program is needed to enable precise consequence accumulation.**

References

- [1] Wang L, Zheng G, Zhao S, et al. Radiat Prot, 2012, 11: 325–335, 347. (in Chinese)
- [2] Zong L, Yan D. Fukushima nuclear accident impact on China and related countermeasures. The 9th session of early 21st century radiation protection forum. 2011-09-26.
- [3] EJ/T 1131-2001. Regulation for environmental radiation monitoring of nuclear power plant.
- [4] HJ/T61-2001. Technical criteria for radiation environmental monitoring.
- [5] GB6249-2011. Regulations for environmental radiation protection of nuclear power plant.
- [6] EJ527-1990. Basic regulation for biological sampling in environmental radiation monitoring.
- [7] PAN Z. Ionizing radiation environment monitoring and assessment. Beijing: Atomic Energy Press, 2007, 649-650.
- [8] Qian D. Atom Energy Sci Technol, 1987, 4: 487–490. (in Chinese)
- [9] HOU A. Survey report of environmental radioactive background in Qinshan region. China Nucl Sci Technol Report, 1994, 705–728. (in Chinese)
- [10] Zhang Y, Li H, Zhu C. Ship Sci Technol, 2010, 12: 76–79. (in Chinese)
- [11] Li B, Yang D, Chen X, et al. Radiat Prot, 2012, 32: 398–403.
- [12] Chen X, Li B, Yu S. Radiat Prot, 2012, 32: 348–361, 372. (in Chinese)
- [13] Zhang J, Yao R, Ren X, et al. Radiat Prot, 2012, 32: 362–372. (in Chinese)

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