

Release of Pu isotopes from Fukushima accident to the marine environment was negligible

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Introduction

- Pu isotopes attracted great public attention after the Fukushima Daiichi Nuclear Power Plant (FDNPP) accident because they present a high risk for internal radiation exposure via ingestion of contaminated agricultural crops and seafood. Tiny amount of Pu has been detected in soils and aerosols, indicating atmospheric deposition of Pu released from FDNPP accident in the terrestrial environment (Zheng et al., 2012, 2013).
- In the marine environment, besides the possible atmospheric deposition, contaminated water was directly discharged into the offshore of the FDNPP site, which is another possible pathway of Pu to enter the marine environment after the accident.
- To better understand the Pu contamination in the marine environment after the accident, starting from May 2011, we made a 4-years continuous investigation on the distribution of Pu isotopes in seawater and marine sediments.

Our results: Release amount of plutonium isotopes

FDNPP source Pu contamination: not only in the Northwest, but also in the South of the plant in the 20-30 km zones

Isotopic composition of FDNPP source Pu: Pu was released from Unit 1-3 reactors, no release from the spent fuel pools

The amounts of Pu isotopes released: four orders of magnitude lower than that of the Chernobyl accident

Isotopic evidence of Pu release



Fukushima DNPP source Pu was found not only in Northwest but also South of the plant
Zheng et al., Sci. Rep. 2012; ES&T 2013

Estimation of the amounts of Pu isotopes released from the FDNPP accident

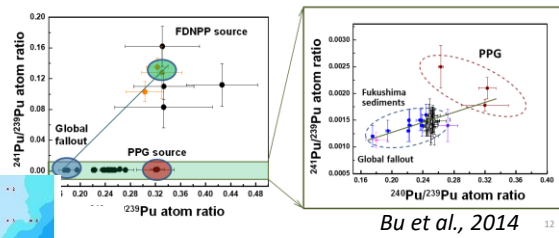
	FDNPP accident		
	Chernobyl	METI calculated	Estimation of this study
Amount of released (Bq)			
Pu-239+240	8.7x10 ¹³	6.4x10 ⁹	1.0x10 ⁹ – 2.4x10 ⁹
Pu-241	7.2x10 ¹⁵	1.2x10 ¹²	1.1x10 ¹¹ – 2.6x10 ¹¹
Pu-238	3.5x10 ¹³	1.9x10 ¹⁰	2.9x10 ⁹ – 6.9x10 ⁹
Pu inventories at reactors (Bq) at the time of accident initiation			
Pu-239+240	2.4x10 ¹⁵	---	8.3x10 ¹⁵
Pu-241	1.9x10 ¹⁷	---	7.0x10 ¹⁷
Pu-238	1.0x10 ¹⁵	---	1.1x10 ¹⁶
Percentage of core inventory released (%)			
Pu-239+240	3.5	---	1.2x10 ⁻⁵ – 2.9x10 ⁻⁵
Pu-241	3.5	---	1.6x10 ⁻⁵ – 3.7x10 ⁻⁵
Pu-238	3.5	---	2.0x10 ⁻⁵ – 4.7x10 ⁻⁵

The amount of released Pu from the FDNPP accident was 4 orders of magnitude lower than that of Chernobyl accident

Our results: Pu impact in marine environment

To better understand the Pu contamination in the marine environment after the accident, starting from May 2011, we made a 4-years continuous investigation on the distribution of Pu isotopes in seawater collected from the near coastal area to the open ocean 900 km away from the FDNPP site using newly developed SF-ICP-MS analytical methods (Men et al., 2018; Bu et al., 2014). Pu isotopes in seawater and marine sediments. The results suggested that there is no significant Pu contamination in seawater from the accident.

Source identification of Pu in marine sediments off Fukushima coast 5 km---220 km

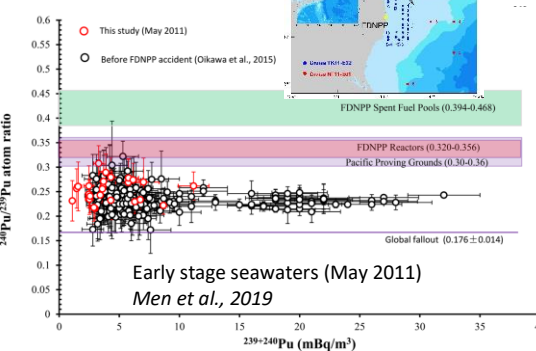
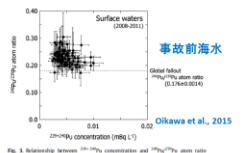
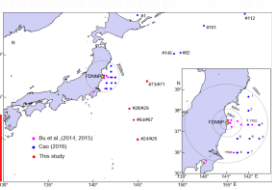
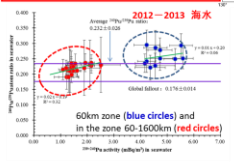


Bu et al., 2014

Pu isotopes in seawater samples (5 – 1600 km) off Fukushima coast

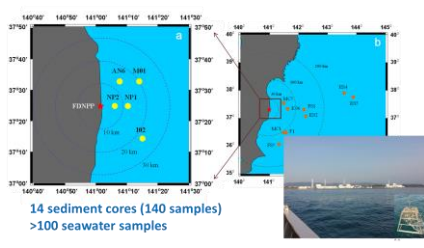
Wu et al., J. Nucl. Radiochem. Sci. Chem. Geol. 2015

No observable increase of Pu activity and change of ²⁴⁰Pu/²³⁹Pu atom ratio



Early stage seawaters (May 2011)
Men et al., 2019

Distribution of Pu isotopes in marine environment (2011-2017) 5-220 km from FDNPP



14 sediment cores (140 samples)
>100 seawater samples

Conclusion: The Pu atom ratios (²⁴⁰Pu/²³⁹Pu and ²⁴¹Pu/²³⁹Pu) suggested that global fallout and the Pacific Proving Ground (PPG) close-in fallout were the main sources for Pu contamination in the marine sediments. As Pu isotopes are particle-reactive and they can be easily incorporated with the marine sediments, we concluded that the release of Pu isotopes from the FDNPP accident to the marine environment was negligible.