

2025_“ShuWei Cup”

Problem D: Modeling and Optimization Research on the Impacts of Fukushima Nuclear Wastewater Discharge on the Marine Environment

(I) Background

On August 24, 2023, the Japanese government unilaterally launched the nuclear wastewater discharge plan from the Fukushima Daiichi Nuclear Power Plant without fully soliciting opinions from the international community or exhausting all safe disposal methods. By April 2025, it had discharged a total of over 200,000 tons of nuclear wastewater. As per its plan, it will continue to discharge approximately 1.3 million tons of nuclear wastewater over the next 30 years, which has aroused strong doubts and opposition worldwide.

According to the latest public data released by Tokyo Electric Power Company, the Fukushima Daiichi Nuclear Power Plant still stores about 1.05 million tons of untreated nuclear wastewater, and approximately 100 tons of new wastewater containing radioactive substances are generated daily for reactor cooling. Tests have shown that apart from tritium, the nuclear wastewater contains various long-lived radionuclides such as carbon - 14, strontium - 90, iodine - 129, and cobalt - 60. Among them, carbon - 14 has an extremely long half-life of 5,730 years and can accumulate in organisms through the marine food chain, with its physiological concentration in fish being 50,000 times that of tritium. Iodine - 129 has a half-life of about 15.7 million years and can persist in the marine ecosystem for a long time. Eventually, its intake through seafood will affect human thyroid health. The enrichment concentration of cobalt - 60 in marine sediments can reach 300,000 times that of tritium, posing a long-term threat to benthic organisms and the marine sedimentary environment.

Currently, trace amounts of radionuclides related to Fukushima nuclear wastewater have been detected in some waters of the Pacific Ocean. The fishing

catches of countries surrounding Japan have dropped significantly, and global consumers' trust in Pacific seafood continues to decline. Against this backdrop, using scientific simulation technologies to quantify the diffusion path of nuclear wastewater, assess environmental impacts, and optimize disposal schemes has become the key to addressing this global environmental challenge.

(II) Competition Tasks

Task 1: Global Marine Diffusion Modeling of Nuclear Wastewater

On the basis of collecting data such as surface and deep ocean current (speed and direction), seawater temperature and salinity, and tidal data (from Argo buoys, satellite remote sensing, and marine station measurements) in the three major oceans as well as seabed topographic data around Fukushima from 2023 to 2025, complete data cleaning and standardization. Establish a three-dimensional marine diffusion model that couples the effects of ocean currents, tides, and seawater mixing to simulate the diffusion process of nuclear wastewater within 0 - 10 years after it is discharged into the sea. Calculate the earliest arrival time and concentration curves of the polluted seawater in the sea areas adjacent to Shanghai, Los Angeles, and Busan.

Task 2: Impact Degree Modeling and Risk Classification of Typical Countries

Construct an evaluation index system from three dimensions: marine ecology (radionuclide accumulation in key ecosystems and plankton mortality rate), fishery economy (30-year fishing catch reduction rate and export volume loss), and food safety (radionuclide dosage ingested by residents through seafood). Classify countries into high, medium, and low-risk levels according to the degree of impact, clarify the classification standards and representative countries, and output the simulation curves of core indicators for each level.

Task 3: Modeling and Optimization Decision-Making of Nuclear Wastewater Treatment Schemes

For three treatment schemes (current marine discharge, enhanced treatment plus long-term storage, and zero marine discharge), collect relevant data of the Fukushima

Nuclear Power Plant and establish a three-dimensional evaluation model involving cost, environmental impact, and safety time. Quantify the 30-year marine environmental impacts, total costs, and the decay compliance time of radionuclides for each scheme, and conduct multi-objective optimization.

Task 4: Based on the modeling results from Tasks 1 to 3, write two letters of suggestion respectively to the Japanese government and the International Atomic Energy Agency.

(III) Reference Materials (Not Limited To)

- [1]. Tokyo Electric Power Company. Report on the Treatment and Discharge of Nuclear Wastewater from the Fukushima Daiichi Nuclear Power Plant (2023 - 2025)[R]. 2025.
- [2]. Food and Agriculture Organization of the United Nations (FAO). Monitoring Data of Radionuclides in Seafood from the North Pacific Ocean (2023 - 2025)[DB/OL].
- [3]. Zhang Qianran. Research on Ocean Current Simulation Based on Drifting Buoys and Marine Models[D]. Jinan: Shandong University of Science and Technology, 2017.
- [4]. International Atomic Energy Agency. Technical Guidelines for Marine Diffusion Models of Radioactive Substances[R]. 2024.
- [5]. Argo Float Program. Global Real - time Marine Observation Dataset (2023 - 2025)[DB/OL].

Appendix

Ways to Obtain the Above 5 Reference Materials

1. *Report on the Treatment and Discharge of Nuclear Wastewater from the Fukushima Daiichi Nuclear Power Plant (2023 - 2025)* by Tokyo Electric Power Company: There is no direct dedicated report page for this report on Tokyo Electric Power Company's website. You can try to start from its Chinese information page

(<https://www.tepco.co.jp/zh-cn/decommission/index.html>) and gradually search for relevant discharge data and report contents.

2. *Monitoring Data of Radionuclides in Seafood from the North Pacific Ocean (2023 - 2025)* by the Food and Agriculture Organization of the United Nations: The data of FAO is released centrally through its comprehensive database FAOSTAT. Log on to <https://www.fao.org/statistics/data-releases/en> and search for and locate relevant data in the system using keywords.
3. *Research on Ocean Current Simulation Based on Drifting Buoys and Marine Models* by Zhang Qianran: This document may be included in CNKI. Visit CNKI via <https://www.cnki.net/>.
4. *Technical Guidelines for Marine Diffusion Models of Radioactive Substances (2024)* by the International Atomic Energy Agency: IAEA publications can be uniformly searched for on the webpage <http://www.iaea.org/zh/publications>. Locate this guideline by filtering according to the technical report category.
5. *Global Real - time Marine Observation Dataset (2023 - 2025)* of the Argo Float Program: It can be downloaded from the China Argo Real - time Data Center at https://data.argo.org.cn/Global_Argo/Global_Argo_TS_dataset.tar.gz. The mirror address of the AOML Sub - center in the United States is https://data.argo.org.cn/mirror_gdac/aoml.tar.gz.

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