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Long-term tracking of Fukushima-Derived Radionuclides in Seawater and Coastal Groundwaters

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The Fukushima Dai-ichi nuclear accident on March 11, 2011, released large amounts of ^{131}I, ^{134}Cs, and ^{137}Cs, along with smaller quantities of ^{90}Sr, ^{129}I, ^{239}Pu, ^{240}Pu, and other isotopes into the environment. The geochemical properties of these radionuclides govern their transport, mobility, and long-term fate across different environmental compartments. While remediation and monitoring efforts have been ongoing, contamination concerns persist, particularly regarding the controlled discharge of treated wastewater from reactor cooling. Although most radionuclides are largely removed(*1*), tritium remains entirely, raising questions about the long-term behaviour and transport of residual contaminants.

This study presents a comprehensive time-series analysis (2011–2024) of radionuclide concentrations in seawater around Fukushima, focusing on wastewater discharge impacts. The present work expands on previous studies ((*2*) and references therein) by incorporating data collected from 2018 to the present, offering insights into evolving trends. Our findings show a continued decline in ^{137}Cs, ^{90}Sr, and ^{129}I in seawater near the plant, while ^{240}Pu/^{239}Pu ratios remain consistent with Pacific background levels, suggesting no significant plutonium contamination.

Beyond open-ocean contamination, groundwater has emerged as an additional reservoir and a potential source of Fukushima-derived radionuclides. Previous work by Sanial et al. (*3*) detected anomalous ^{137}Cs concentrations in groundwater at Yotsukura Beach (~100 km south of Fukushima). Here we present new results of ^{137}Cs data from 2018 and 2024 and the first-ever ^{129}I measurements in beach groundwater in the region. Results show unexpectedly high ^{129}I concentrations increasing as salinity decreases, suggesting a different source mechanism than ^{137}Cs, likely unrelated to seawater infiltration. By integrating long-term monitoring, transport analysis, and geochemical insights, this research enhances our understanding of radionuclide behavior, particularly as wastewater discharge continues.

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