1–14 Estimation of Total Radiocesium Discharged from Fukushima Daiichi NPS to the Coast

—Discharge Inventory Decreased to Approximately 1/100000th Since the Accident—

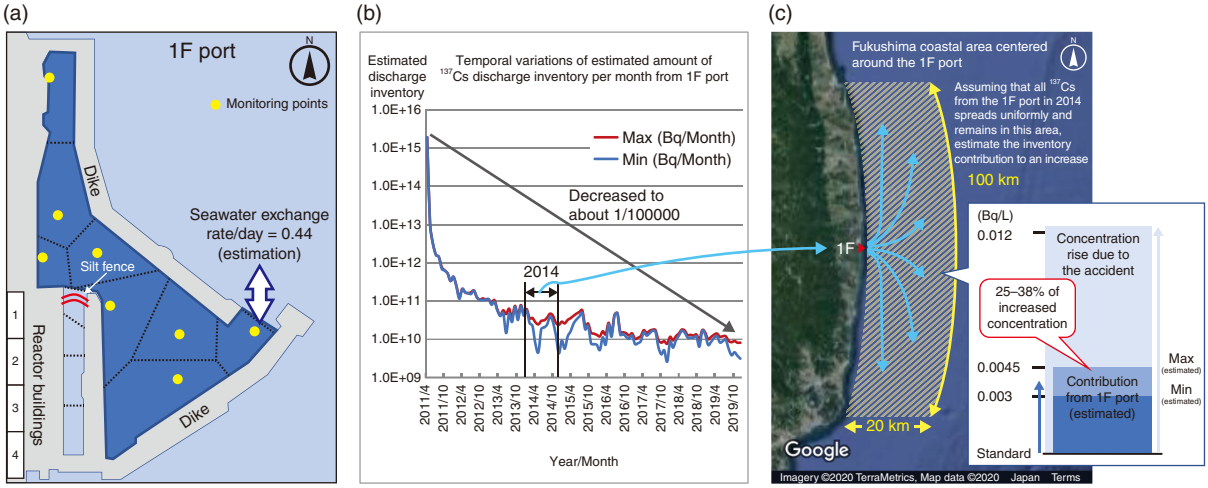

Fig.1-28 (a) Schematic of the Fukushima Daiichi NPS (1F) port, (b) temporal variations of estimated ^{137}Cs discharge per month from the 1F port and (c) 20 km (east–west) and 100 km (north–south) coastal area around the 1F port

(a) The concentration of ^{137}Cs in seawater has been monitored (yellow dots) inside the 1F port since 2013 and the concentration data have been published nearly every day. The black dotted lines represent the borders of the Voronoi cells obtained by using Voronoi tessellation for a set of the monitoring points. (b) The estimated monthly discharge decreased to approximately 1/100000th of that in the early stage of the accident. (c) Assuming that all ^{137}Cs from the 1F port in 2014 spread uniformly and remains in the coastal area, the inventory discharge is estimated to contribute an increase of 0.003 to 0.0045 Bq/L. Since the observed concentration in the sea area was increased by 0.012 Bq/L due to the accident, the contribution of the ^{137}Cs from the 1F port to the concentration rise is approximately 25% to 38%.

Radionuclides (notably, ^{137}Cs) were released into the environment by the accident at the TEPCO's Fukushima Daiichi NPS (1F). Some rose into the atmosphere and fell on the ground and sea, whereas others were discharged directly into the ocean as contaminated water. Just after the accident, radionuclide concentration of seawater increased near the 1F port due to the direct discharge. However, since the direct discharge was suppressed by the Japanese government and TEPCO, the observed concentrations then decreased rapidly; current concentrations are very low. This work therefore scientifically estimated the amount of ^{137}Cs released from the initial stage of the accident to the present and evaluate the impact on the environment.

As most radionuclides released into the ocean were assumed to be from the 1F port, the amount of ^{137}Cs in the port was focused on. Since the concentration is monitored daily at the eight points shown in Fig.1-28(a), the 1F port was divided into eight areas using the Voronoi tessellation method. The amount of ^{137}Cs in each area was calculated by multiplying the volume of seawater by the observed concentration of ^{137}Cs in each area. When the observed concentration is below the detectable limit, the true concentration is between zero and the detectable limit; therefore, the total amount of ^{137}Cs inside the 1F port (shown in Fig.1-28(a)) was estimated with the interval from zero to the detectable limit. Thus, the daily discharge inventory was estimated by multiplying the estimated total amount in the port and 0.44, which is the seawater exchange rate between the inside and outside of the port. This rate was estimated from the concentration decrease observed in the early stages of the accident. The monthly discharge inventory of ^{137}Cs from the port from April 2011 to March 2020 is shown in Fig.1-28(b). The results indicate that by 2018 the discharge inventory had decreased to approximately 1/100000th of that in the initial stages of the accident.

Assuming that all ^{137}Cs discharged from the port in 2014 spread uniformly and remained in the coastal area surrounding 1F (Fig.1-28(c)), its contribution to the concentration rise was evaluated to be approximately 25% to 38%. However, this is likely to be an overestimate, as ^{137}Cs is spread further than this area. This indicates a greater contribution of other sources (such as run-off from rivers) to the increase in the coastal concentration, and a lesser contribution of the 1F port.

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Reference

Machida, M., Yamada, S. et al., Seven-Year Temporal Variation of Cesium-137 Discharge Inventory from the Port of Fukushima Dai-ichi Nuclear Power Plant: Continuous Monthly Estimation of Cesium-137 Discharge in the Period from April 2011 to June 2018, Transactions of the Atomic Energy Society of Japan, vol.18, issue 4, 2019, p.226–236 (in Japanese).