# Estimate of spatial and temporal variation of radiocaesium amount derived FNPP1 accident in the North Pacific Ocean

*Yayoi Inomata[1], Michio Aoyama[2], Takaki Tsubono[3], Daisuke Tsumune[3], Masatoshi Yamada[4]

1. Kanazawa University, Institute of Nature and Environmental Technology, 2. Fukushima University, Institute of Environmental Radioactivity, 3. Central Research Institute of Electric Power Industry, 4. Hirosaki University, Institute of radiation emergency medicine

$^{134}$Cs and $^{137}$Cs (radiocaesium) were released to the North Pacific Ocean by direct discharge and atmospheric deposition released from the TEPCO Fukushima Dai-ichi Nuclear Power Plant (FNPP1) accident in 2011. It is recognized that estimation of the total amount of released $^{134}$Cs and $^{137}$Cs is necessary to assess the radioecological impacts of their release on the environment. It was reported that the inventory of $^{134}$Cs or $^{137}$Cs on the North Pacific Ocean after the FNPP1 accident was 15.2-18.3 PBq based on the observations (Aoyama et al., 2016a), 15.3±1.6 PBq by OI analysis (Inomata et al., 2016), 16.1±1.64 PBq by global ocean model (Tsubono et al., 2016). These suggest that more than 75 % of the atmospheric-released radiocaesium (15.2-20.4 PBq; Aoyama et al., 2016a) were deposited on the North Pacific Ocean. It was revealed that these radiocaesium existed in the Subtropical Mode Water (STMW, Aoyama et al., 2016b; Kaeriyama et al., 2016) and Central Mode Water (CMW, Aoyama et al., 2016b), suggesting that mode water formation and subduction are efficient pathway for the transport of FNPP1 derived radiocaesium into the ocean interior within 1-year timescale. Kaeriyama et al. (2016) estimated the total amount of FNPP1 derived radiocaesium in the STMW was 4.2 ±1.1 PBq in October–November 2012. However, there is no estimation of the amount of radiocaesium in the CMW. Therefore, it is impossible to discuss about the mass balance of radiocaesium injected into the North Pacific Ocean. In this study, we conducted the optimum interpolation (OI) analysis to estimate the inventory of radiocaesium in the ocean interior as well as surface sweater by using the measured activities. Furthermore, transport speed of radiocaesium in the surface layer in the North Pacific Ocean were also estimated. The data used in this study were derived from all of the available data reported by such as the Tokyo Electric Power Company (TEPCO), the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT), and voluntary cargo ships. The data analysis period was until December 2015 after the FNPP1 accident. It was found that the radiocaesium across the North Pacific Ocean were reached to 180˚ E around 40˚ N latitude at July, 2012 by OI analysis. The transport speed was estimated to 8.5 cm $s^{-1}$ . These were reached to the coastal site of America continent and the activities were increased after the year of 2014. The transport speed across 70˚ W (40˚N latitude) was decreased to 5.2 cm $s^{-1}$.
We estimated the inventory of radiocaesium in the surface seawater (depth; 0-100m) during the periods from August to December, 2012, based on the OI analysis. Amount of $^{134}$Cs inventory was estimated to 4.7 PBq with decay-corrected to 1 October 2012 (7.9 PBq at the time on 11 March 2011). (In the case of $^{137}$Cs, the inventory was estimated to 12.5 PBq with decay-corrected to 1 October 2012 and 13 PBq at the time on 11 March 2011 which includes pre-Fukushima $^{137}$Cs). These correspond to 43-53% of the injected $^{134}$Cs in the North Pacific Ocean. It was reported that the 4.2±1.1 PBq of $^{134}$Cs were distributed in the STMW (Kaeriyama et al., 2016). Taking into account these estimation, FNPP1 derived radiocaesium existed in the CMW in the North Pacific Ocean would be about 3-6 PBq.

(References)

Aoyama, M., Hamajima, Y., Hult, M., Uematsu, M., Oka, E., . 2016. J. Oceanogr. 72:53–65.
Aoyama, M., Kajino, M., Tanaka, T. Y., Sekiyama, T.T., Tsumune, D., Tsubono, T., Hamajima, Y., Inomata, Y., Gamo, T., .2016. J. Oceanogr. 72:53–65.

 

Inomata, Y., Aoyama, M., Tsubono, T., Tsumune, D., Hirose, K. 2016. Environ. Sci. Process. Impacts 18:126–36
Tsubono, T., Misumi. K., Tsumune, D., Bryan, F.O., Hirose, K., Aoyama, M. 2016. Deep-Sea Res. I. 115:10–21
Kaeriyama, H., Shimizu, Y., Setou, T., Kumamoto, Y., Okazaki, M., Ambe, D., Ono, T. 2016. Sci. Report., 6:22010 | DOI: 10.1038/srep22010

Keywords: Radiocasium, FNPP1, North Pacific Ocean

 