Fukushima-derived radiocesium in the North Pacific subarctic region and Arctic Ocean in summer 2014

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Accident of Fukushima-Dai-ichi Nuclear Power Plant (FNPP1) on 11 March 2011 resulted in a large amount release of radiocesium (^{134}Cs and ^{137}Cs) into the North Pacific Ocean. Oceanographic observations have revealed that the Fukushima-derived radiocesium in surface seawater is transported eastward along the North Pacific Current. However, penetration of the radiocesium into ocean interior is not understood well. From July to October 2014 we measured vertical profiles of radiocesium from surface to 800 m depth in seawater from the North Pacific subarctic region and Arctic Ocean. The seawater samples (20-40 liter) were collected using a bucket or a pump for surface water and Niskin Sampler for deeper water. Some of them were filtrated and all the samples were acidified with nitric acid on board. In laboratories on shore, radiocesium in the sampled seawater was concentrated onto ammonium phosphomolybdate (AMP). Radiocesium in the AMP was measured using ultra-low-background gamma-ray detectors in Low Level Radioactivity Laboratory, Kanazawa University. Uncertainty of the radiocesium measurement was estimated to be about 8 %. In the Arctic Ocean, about 1.5 and 3.5 Bq/m^3 of ^{137}Cs were observed in surface layer from sea surface to about 200 m depth and subsurface from about 200 m to 800 m depth, respectively. Because these concentrations of ^{137}Cs were observed in the Arctic Ocean before the FNPP1 accident, these could be derived from nuclear weapon testing in the atmosphere mainly in the 1950-60s and release from nuclear fuel reprocessing plants mainly in the 1980-90s. On the other hand, Fukushima-derived ^{134}Cs was detected only at 150 m depth although the concentration was very low (0.07 Bq/m^3). The depth of 150 m corresponded to a salinity minimum layer originated from seawater from the North Pacific. Fukushima-derived ^{134}Cs was not detected in the salinity minimum layer in 2012 and 2013. On the other hand, the ^{134}Cs was observed in surface seawater (less than 0.3 Bq/m^3) in the Bering Sea in 2012, 2013, and 2014. These results imply that transportation of ^{134}Cs from the Bering Sea to the Arctic Ocean takes about 3.5 year after the FNPP1 accident. At stations along 47°N in the subarctic region, activity concentration of ^{137}Cs in surface seawater was lower in the west (less than 2 Bq/m^3) than that in the east centered about 150°W (less than 8 Bq/m^3). The concentration of ^{137}Cs decreased with depth and was about 0.2 Bq/m^3 at 800 m depth both in the west and east. Fukushima-derived ^{134}Cs was detected in seawater from shallower layer than 200 m depth, surface mixed layer, suggesting that ^{137}Cs in layer deeper than 200 m depth was derived not from the FNPP1 accident but the nuclear weapon testing. Activity concentration of Fukushima-derived ^{134}Cs in the surface mixed layer was lower in the west (less than 0.3 Bq/m^3) than that in the east centered about 150°W (less than 2.5 Bq/m^3). The ^{134}Cs-rich surface water was observed at the international-date-line approximately in summer 2012. These results suggest that ^{134}Cs deposited in coastal area near Japan and directly-discharged from FNPP1 had been transported eastward in the surface mixed layer to around 180° by summer 2012 and subsequently around 150°W by summer 2014.
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