Processes affecting long-term change in ^{137}Cs abundance in seabed sediment off Fukushima

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Based on continuous observation data at 68 stations in the 150 km radius from the Fukushima Daiichi Nuclear Power Plant, temporal change in cesium-137 (^{137}Cs) abundance in surface (0-10 cm) layer of seabed sediment were quantified, and the primary process affecting the temporal change was identified.

Until February 2015, the ^{137}Cs abundance in surface sediment in the coastal region (bottom depth ≤100m) decreased at the rate of about 30%/year (radioactive decay is not included). In the offshore region (>100 m depth), no significant temporal change in the ^{137}Cs abundance was observed. Here we focus on the following three processes that affect the decrease in the ^{137}Cs abundance, and assess their effectiveness.

1) Dilution of ^{137}Cs by vertical mixing of sediment: This process can be assessed by applying time-series data of vertical distribution of sedimentary ^{137}Cs into a pulse input sediment mixing model. The model estimated up to 70% of ^{137}Cs in the coastal sediment was efficiently transported to the lower sedimentary layers in the first 5 years after accident.

2) Resuspension and lateral transport: This process was assessed by comparing horizontal export flux of particulate ^{137}Cs estimated from sediment trap experiments off Fukushima and total ^{137}Cs inventory in the coastal sediment. Sediment traps in the outer shelf certainly collected ^{137}Cs-bound particles originating from the coastal region, but the annual ^{137}Cs export to the offshore was only 1~2% of total ^{137}Cs inventory in the coastal sediment.

3) Desorption of ^{137}Cs from sediment: Desorption of ^{137}Cs was verified by speciation and suspension experiments. Most of ^{137}Cs in the coastal sediments was incorporated into lithogenic fractions. The estimated annual desorption rate was less than 5%, and the result indicated that this incorporation is almost irreversible.

In conclusion, we consider that the primary process affecting the ^{137}Cs abundance in surface sediment is vertical mixing of sediment due to bioturbation or storm events. Although the dilution effect slows down with time, we expect that, by 2060, the abundance of ^{137}Cs in the coastal surface sediment will decrease to about 5% of the initial abundance by the dilution and radioactive decay.