THESIS SUMMARY

Difference in Migration of Radioactive Element Originating from Fukushima Daiichi Nuclear Power Plant Accident: Factors affecting transfer factor of ^{137}Cs from soil to rice and Difference in migration between ^{137}Cs and ^{90}Sr in the Environment

(福島第一原子力発電所事故に由来する放射性元素の移行の相違：土壌からコメへの ^{137}Cs の移行係数に及ぼす因子と環境中での ^{137}Cs と ^{90}Sr の移行の違い)

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Both ^{90}Sr and ^{137}Cs are the products of the fission reaction inside core of the nuclear reactor and are highly radioactive with intermediate half-lives of 28.7, 30.2 years, respectively. After Fukushima Daiichi Nuclear Power Plant (FDNPP) accident both were expelled into the environment and ^{90}Sr concentration was about 1/1000 that of ^{137}Cs in the soil after FDNPP disaster. ^{90}Sr is accumulated in the bone and its biological half-life is about 50 years, thus it is of concern just like ^{137}Cs which affects the whole body although it has a shorter biological half-life of 70-100 days compared to ^{90}Sr. The study of distribution and migration of both nuclides is important from the point of protection against external and internal exposure. In the present PhD Thesis, we investigated the distribution and migration of ^{137}Cs and ^{90}Sr in the soils of Kawauchi and Fukushima and the transfer factor of ^{137}Cs from

In Chapter 2, soil characteristics (soil particle distribution, exchangeable cation and ^{137}Cs, mineral composition, Fe oxidation state) were analyzed for the samples from Fukushima and Kawauchi. Because more studies have focused only on one sampling field and there have not been much discussion comparing various fields. The ^{137}Cs concentration was higher for Fukushima soil compared with Kawauchi soil. Figure 1 shows ^{137}Cs transfer factor of Kawauchi and Fukushima samples. The transfer factor of ^{137}Cs is higher in Kawauchi paddy field compared to that of Fukushima despite the soils of Fukushima being more radioactive than that of Kawauchi. Both X-ray diffraction pattern of the soils and the ^{57}Fe Mössbauer spectrometry analysis showed that the soils are different in their composition and Fe (II)/ (Fe (III)+Fe (II)) ratio.

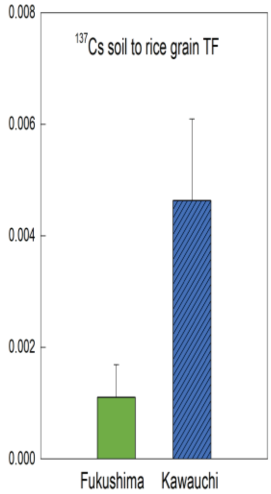
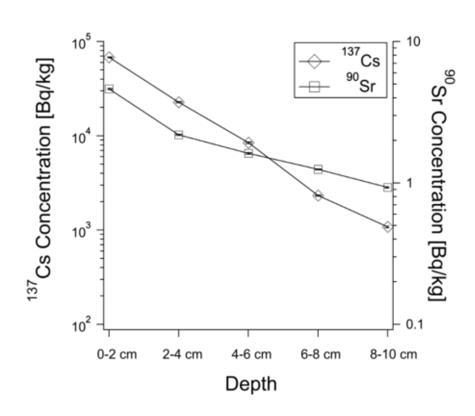


Fig. 1. ^{137}Cs soil to rice average TF in Paddy Fields in Fukushima and Kawauchi.

In Chapter 3, ^{90}Sr and ^{137}Cs distributions were investigated by analyzing their concentration in the soil of Kawauchi (KP) and Fukushima paddy rice fields (FP), and the depth distribution of ^{90}Sr and ^{137}Cs in Lake Ogi valley sediments (LS) and its forestry catchment area soil (CA) and the sediment to soil ratio were also investigated. ^{90}Sr is a pure β-emitter and its daughter nuclide (^{90}Y) is also radioactive. ^{90}Sr was extracted from the soil and after the radioactive equilibrium was attained, the radioactivity was measured using liquid scintillation counter. The rough correlation between ^{90}Sr and ^{137}Cs concentrations was shown. The relation deviates from original point (0, 0) that suggests the global fallout of ^{90}Sr. The coefficient of variation for ^{90}Sr was larger than that of ^{137}Cs for Fukushima and Kawauchi paddy. Furthermore, the coefficient of variation for ^{90}Sr was also larger than that of ^{137}Cs for Ogi Lake Sediment (LS) and its catchment forestry area (CA). The results suggest that the migration of ^{90}Sr is more affected by external factor. Figure 2 shows the depth dependence of ^{90}Sr and ^{137}Cs at Catchment forestry area (CA). ^{90}Sr penetrates more than ^{137}Cs in the soils of CA.



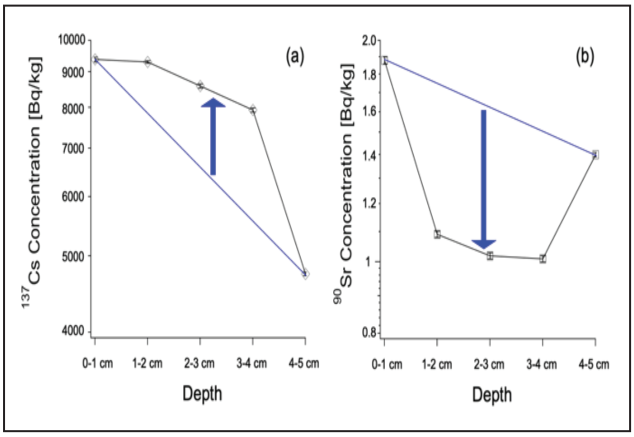


Fig. 2. Depth dependence of ^{90}Sr and ^{137}Cs at Catchment Forest area (CA).

Fig. 3. Depth dependence of ^{137}Cs (a) and ^{90}Sr(b) at Lake Ogi sediments (LS).

The LS/CA ratio of ^{90}Sr was greater than that of ^{137}Cs, which might relate to ^{90}Sr faster horizontal migration than ^{137}Cs. Figure 3 shows depth dependence of ^{137}Cs (a) and ^{90}Sr(b) at Lake Ogi sediments (LS). Exponential change for both ^{137}Cs and ^{90}Sr was largely interfered near the surface (0 to 4 cm) for the sediment. One of the possibilities is that surface sediments become relatively uniform by the disturbance near surface (0~4 cm). ^{137}Cs adsorbed strongly to sediment becomes uniform, while ^{90}Sr weakly adsorbed to sediment re-dissolves to the lake water. The re-dissolved ^{90}Sr is adsorbed to the sediment again (0~1 cm). Therefore, the surface sediment (0~1 cm) has significantly higher ^{90}Sr than that of deeper sediment layer. The $^{90}Sr/^{137}Cs$ ratio for Fukushima soil and sediment samples ranged from 0.0001 to 0.0019 with an average value of 0.0007±0.0005, which is in a good agreement with some previous results.

Chapter 4 shows the general conclusions.

LIST OF PUBLICATIONS:

1. W. C. Bekelesi, T. Basuki, S. Nakashima, **^{137}Cs Soil to Rice Transfer Factor and Soil Properties: Fukushima and Kawauchi Case Study.** Radiation Safety Management Vol. 21 (1–12) (2022). [doi:10.12950/rsm.220131]
2. W. C. Bekelesi, T. Basuki, S. Higaki, S. Nakashima, **Distinction of strontium-90 and cesium-137 migration of Fukushima soil and sediment following Fukushima accident.**
   Radiation Safety Management Vol. 21 (26–35) (2022).
   [doi:10.12950/rsm.220527]

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   https://academicjournals.org/journal/AJEST/article-abstract/759E8E064123
2. W. C. Bekelesi. Thesis, Master of Philosophy Degree (2015).
   http://ugspace.ug.edu.gh/handle/123456789/8571 p38-41 (accessed 2021/10/01)
3. T. Basuki, W. C. Bekelesi, M. Tsujimoto, S. Nakashima, **Air dose rate to ^{137}Cs activity per unit area ratio for different land use 7 years after the nuclear accident -Case of the slope catchment, Ogi reservoir, Fukushima-**, *Radiation Measurements*, 137 (2020).
   https://doi.org/10.1016/j.radmeas.2020.106424
4. T. Basuki, W. C. Bekelesi, M. Tsujimoto, S. Nakashima, **Investigation of radiocesium migration from land to waterbody using radiocesium distribution and soil to sediment ratio: A case of the steep slope catchment area of Ogi reservoir, Kawauchi Village,Fukushima,** *Radiation Safety Management*, **19**, 23-34 (2020). DOI 10.12950/rsm.190924
5. M. A. Habib, T. Basuki, S. Miyashita, W. Bekelesi, S. Nakashima, K. Techato, R. Khan, A. B.K. Majlis, K. Phoungthong, **Assessment of natural radioactivity in coals and coal combustion residues ……** *Environmental Monitoring and Assessment*, **191**: 27 (2019) .DOI10.1007/s10661-018-7160-y
6. M. A. Habib, T. Basuki, S. Miyashita, W. Bekelesi, S. Nakashima, K. Phoungthong, R. Khan,M. B. Rashid, A. R. M. T. Islam, K. Techato, **Distribution of naturally occurring radionuclides in soil around a coal-based power plant and their potential radiological risk assessment,** *Radiochimica Acta* (2018). DOI 10.1515/ract-2018-3044