A Review of Transfer Parameters of I, Cs and Pu (3)
-Concentration Ratios of I and Pu in Marine Biota-

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Abstract. In part (2), we have reviewed water-to-fish concentration ratio (CR) data. Our new data survey showed that not many data were available for I and Pu. In this report, therefore, we calculated concentration ratios (CRs) of iodine (I) and plutonium (Pu) from water to marine biota in Japan using open available data sources. For all the available CR data obtained in this study and those previously reported in Japanese literature, we summarized the edible part CR data of I and Pu for algae, cephalopods, crustaceans, molluscus (except cephalopods), and fish groups. The newly summarized geometric mean values of these biota groups provided similar values to those recommended by the IAEA TRS 422 but it was clear that algae data were much smaller than values in TRS 422.

Keywords: Water-to-biota concentration ratio; Long-term dose assessment; Iodine; Plutonium

1. INTRODUCTION

Many types of environmental transfer parameters, such as concentration ratios of radionuclides from environmental media to foods, are used for radiation dose assessment models. We note that recommended parameter values compiled in IAEA reports, e.g., [1, 2], consist of old literature values with some updates. To keep data transparency, the data collection processes are need to be recorded thus we traced back references in IAEA reports. The results for transfer coefficient from feed to cow's milk and concentration ratio from water to fish for Cs, I and Pu were reported in the Proceedings of IRPA 15 [3, 4].

According to the summary report on seawater-to-marine biota concentration ratio (CR, L/kg) of radionuclides by the Radioactive Waste Management Center (RWMC) in Japan [5], there are numbers of data available for CR of cesium (Cs) although not many of them were used in the IAEA Technical Reports Series 422 (TRS 422) [1]. A recent publication by Takata et al. [6] presents a way that allows researchers to use more CRs of Cs data for different fish species by using global fallout ^{137}Cs values in fish and the ambient seawater samples. In TRS 422 [1], the recommended CR value was 100 L/kg for fish, while the average CR value for each fish species reported by Takata et al. [6] ranged from 33-111 L/kg; thus the recommended value was close to those observed in Japan.

However, the number of data for seawater-to-marine biota CRs of I and Pu were still limited according to ref. [5]. In part (2), we reported a literature survey for CR values for these two radionuclides in marine fish; however, not many data were reported after publication of TRS 422 in 2004. We especially noted that the CR value obtained in the Cumbrian coastal areas, 5 L/kg [7], was two to three orders of magnitude lower than CRs observed in the Baltic Sea for four fish species, 100-1900 L/kg [8]. We thought it was not clear how realistic and reliable CR values for long-term dose assessment should be considered in high level radioactive waste disposal.

Thus further calculated data are needed to provide more CR data for environmental dose assessment of radioiodine and Pu. In this report, therefore, we have carried out further data observation using environmental monitoring data for ^{129}I ($T_{1/2}$=1.57 $\times 10^7$ y) and Pu in marine biota and seawater. We also checked stable iodine data in marine biota because after a long time period, the long-lived radioiodine and stable iodine will behave similarly. Thus the data are also applicable for long-term dose assessment.

2. MATERIALS AND METHODS

Before the FDNPP accident, the Japanese government had carried out environmental monitoring for Pu from global fallout. These values are openly available [9] and can be used in addition to the concentration ratio information. Activity concentrations of Pu for biota and ambient water data are available in data sets.

First, we surveyed the radioactivity data in biota then checked them against those in seawater taken from the same sampling area; water sampling should be made within 10 days before or after the biota sampling date. CR-Pu was calculated as follows.

CR-Pu = Pu activity concentration in biota (Bq/kg wet) / Pu activity concentration in seawater (Bq/L).

For I, we checked the stable iodine concentrations in edible part of marine biota reported in the Food Composition Database [10]. Stable iodine concentrations in seawater collected at coastal areas in Japan were reported in our previous paper [11]; because stable I concentrations did not change much among samples, we used the average value of the data for seawater. Thus, CR-I was calculated as follows.

CR-I = Stable I in biota (mg/kg wet) / Average stable I in seawater (mg/L).

3. RESULTS AND DISCUSSION

In previous RWSC data sets [5], for crustaceans and molluscs (cephalopods and shellfish), the numbers of CR data were usually low for both elements (N=1-5); for fish muscles, relatively more numbers of CR data were found, i.e., 11 for I and 15 for Pu, but still the numbers were not enough. Because fish habitats may lead to different CR values, it is better to classify fish species into fish types, i.e. benthic and pelagic, if possible.

The number of calculated CR data of Pu in algae was the largest (N=88); and the calculated data were distributed log-normally. We estimated that the other groups also would show log-normal distributions; thus, geometric mean (GM) values were calculated and these data were compared with the recommended values by IAEA TRS 422 [1] as shown in Table 1. Except for algae, GM of CRs for both elements were similar to those recommended by IAEA. The CR-I and CR-Pu in algae recommended by the IAEA were obtained from brown algae; CR values would change among different algae groups [11], thus, classification of algae type is necessary for analysis.

Table 1: Geometric means of newly calculated concentration ratios (L/kg) of Pu and I from seawater to biota (edible part).

Group	CR-I (This study)	CR-I (TRS 422)	CR-Pu (This study)	CR-Pu (TRS 422)
Algae	150 (N=32)	10000	930 (N=88)	4000
Cephalopods	10 (N=7)	-	93 (N=10)	50
Crustaceans	8.1 (N=4)	3	186 (N=4)	200
Molluscs (except cephalopods)	21 (N=7)	10	1070 (N=50)	3000
Fish (muscles)	4.3 (N=34)	9	20 (N=10)	100

For the next step, we combined all the available data obtained in Japan, that is, previous study results [5, 9, 13] were also included to calculate GM values of each biota group. The results are shown in Table 2. In this study, we could provide more detailed information for I and Pu using the Japanese data sets than we found in IAEA TRS 422 [1]. From these results, it was clear that the data in TRS 422 were similar for biota groups except algae; GM values of I and Pu were about 4-9 times lower than the recommended values in TRS 422.

For I, numbers of data for brown algae reached 130, and the GM value was 1790 L/kg; compared to other algae groups (red and green), the value was about ten times higher. For Pu, however, the GM values were 916 L/kg for brown algae and 946 L/kg for other groups. Thus different accumulation mechanisms were expected for I and Pu. For fish, we classified the data into pelagic and benthic fish groups, however, the GM values were close between these groups although CR-I tended to be higher in benthic fish than that in pelagic fish but CR-Pu showed opposite tendency. However, numbers of data were still small for further analysis. Further data collation is needed.

Table 2: Geometric means of concentration ratios (L/kg) of Pu and I from seawater to biota (edible part) observed in Japan.

Group	CR-I Japan	CR-I (TRS 422)	CR-Pu Japan	CR-Pu (TRS 422)
Algae	1120 (N=165)	10000	919 (N=108)	4000
Algae, brown	1790 (N=130)	-	916 (N=98)	-
Algae, other	196 (N=35)	-	946 (N=10)	-
Cephalopods	2.6 (N=10)	-	94 (N=11)	50
Crustacean	4.9 (N=22)	3	211 (N=7)	200
Molluscs (except cephalopods)	13 (N=42)	10	900 (N=50)	3000
Fish (muscles)	5.0 (N=48)	9	13 (N=25)	100
Fish (muscles), pelagic	4.2 (N=37)	-	18 (N=17)	-
Fish (muscles), benthic	9.4 (N=11)	-	7 (N=8)	-

4. CONCLUSIONS

In this report, we calculated CR values of I and Pu by checking possible data sets for marine biota. Together with these calculated values and reported values, GM values of CR for biota groups were obtained. Except for the GM data for algae, we found that the newly derived CR values using Japanese data agreed well with the recommended values in IAEA TRS 422. Algae tended to have lower CR values for both I and Pu. Numbers of data are still limited for crustaceans and cephalopods. Further data collation is necessary for these groups to provide reliable data for long-term dose assessment.

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