Development of freshwater foodchain model for estimating radionuclide concentration in aquatic products following nuclear accident

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1. Introduction

There have been various cases of contamination of freshwater by radioactive materials released due to nuclear facility accidents, such as Khystym-waste tank explosion at Mayak production association, the release of radioactive materials from the Hanford site to the Columbia River, Chernobyl Nuclear Power Plant (NPP) accident, and Fukushima NPP accident. From a long-term point of view, it is important to evaluate the impact of the accidental radioactive contamination of the aquatic environment.

A food chain model named LARIAS (Land and Aquatic Radionuclide transport and Ingestion dose Assessment System) is under development for calculating radionuclide transfer through the terrestrial and aquatic food chain and ingestion doses in Korea following a nuclear accident. The terrestrial food chain model of LARIAS has already been developed [1-3], and the aquatic food chain model has recently been developed as an early version. We carried out a simple calculation using our model and presented the results in this study.

2. Materials and Methods

2.1. The code system

A model for evaluating the behavior of radionuclide in aquatic ecosystems can be divided into three broad categories as follows: Equilibrium model, kinetic-allometric model, and dynamic model. The freshwater food chain model of LARIAS is based on a dynamic model. It considers four groups of aquatic organisms which are phytoplankton, zooplankton, prey fish, and predatory fish.

2.2. Input parameters and assumptions

We performed a simple calculation of Øvre Heimdalsvatn in Norway. This lake was affected by the Chernobyl accident and one of the study site of an aquatic working group of IAEA VAlidation of environmental Model Prediction (VAMP) project [4]. VAMP Aquatic working group, which has been divided in to 2 subgroups for lake system and river system, studied behavior of Cs-137 in freshwater systems.

Input parameter values were taken from IAEA-TECDOC-1143 and IAEA-TRS479 [4, 5]. Cs-137 depositions from the air (Chernobyl plume) to lake water and catchment area were considered as a source term. Cs-137 deposition concentration value of 130 kBq/m^2 was applied in calculation [4]. The contamination of inflow water to lake was not considered.

3. Results and Discussions

Calculation of Cs-137 concentration in water and aquatic organisms of Lake Ø vre Heimdalsvatn was performed for a period of 10 years after the Chernobyl accident. Figure 1 shows Cs-137 concentration (Bq/m^3) in lake water.

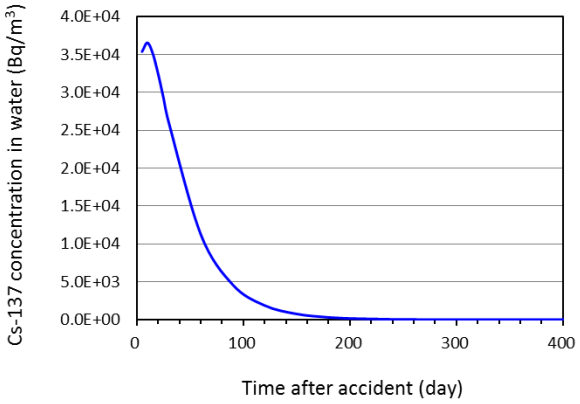

Fig. 1. Cs-137 concentration (Bq/m^3) in lake water

Peak concentration in lake water was estimated to be about 3.7E+4 Bq/m^3. Estimates of Cs-137 peak concentration in water of Lake Ø vre Heimdalsvatn was about 5.0E+3 ~ 6.0E+3 Bq/m^3 according to IAEA-TECDOC-1143 [4]. About one year after the accident, Cs-137 concentration in lake water was expected to fall below 1 Bq/m^3 without additional contamination.

Figure 2 shows Cs-137 concentration (Bq/kg ww) in prey and predatory fish. Peak concentrations in prey and predatory fishes were estimated to be about 1.2E+3 and 1.1E+3 Bq/kg fresh weight, respectively. Estimates of Cs-137 peak concentration in Minnow and trout of Lake Ø vre Heimdalsvatn were 5.8E+3 and 4.7E+3 Bq/kg, respectively, according to IAEA-TECDOC-1143 [4].

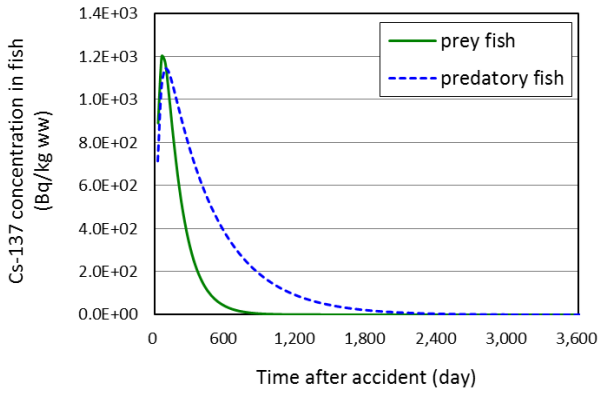

Fig. 2. Cs-137 concentration (Bq/kg ww) in prey and predatory fish

Cs-137 concentrations in prey and predatory fishes were expected to fall below 1 Bq/kg fresh weight about 3 and 9 years after the accident, respectively, without additional contamination.

Peak concentrations in phytoplankton and zooplankton were calculated to be about 1.5E+3 and 3.5E+3 Bq/kg fresh weight, respectively. Cs-137 concentrations in phytoplankton and zooplankton were expected to fall below 1 Bq/kg fresh weight about 9 and 10 months after the accident, respectively, without additional contamination.

4. Conclusions

In this study, the early version of model has been developed to predict concentrations of radionuclides in aquatic organisms in freshwater. The calculation were carried out using the developed model with simple assumptions. There has been a limited the parameter values and experimental data, therefore, the data taken from a several of previously published reports were used in the model. Our model will be improved through the collection of reliable input data and comparison with the results from other model and experimental data.

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