Validation of an Environmental Transfer and Dose Assessment Model for Radionuclides Released from the Nuclear Fuel Reprocessing Plant in Rokkasho

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Abstract

The first commercial nuclear fuel reprocessing plant in Japan, located in Rokkasho, Aomori Prefecture, is now undergoing its final testing using actual spent nuclear fuels. An environmental transfer and dose assessment model (ETDAM) was developed for estimating areal and temporal distributions of the radionuclides around the plant and the radiation dose that results from the radionuclides. To validate the model using actual field data, concentrations of radionuclides (^{3}H, ^{14}C, and ^{129}I, etc.) in various environmental samples around the plant and the environmental γ-ray dose at IES were measured. Because no nuclear fuel rods have been sheared or dissolved at the plant since October 2008, concentration levels of the radionuclides in most environmental samples collected in FY 2010 were similar to the background ones before the plant test operation. Although radionuclide concentrations higher than the background were detected in several samples of soil and sediment, the validation results of ETDAM, that is monthly γ-ray dose rates from ^{85}Kr and monthly atmospheric concentrations of ^{14}C, ^{3}H, and ^{129}I at IES, are reported here using the data obtained from April 2006 to February 2009 (FY 2006-2008) when many nuclear fuel rods were sheared and dissolved and significant amounts of radionuclides were released from the plant.

Accuracy of the simulation was evaluated by using the ratio of the number of cases in which the estimated value was within a factor of 2 or 5 of the measured one to that of the total cases as an index. The agreement ratio within a factor of 2 for the γ-ray dose rate from ^{85}Kr was approximately 40% and within a factor of 5, approximately 80%. Similar ratios were obtained for the atmospheric concentration of ^{14}C, while the ratios for ^{3}H and ^{129}I were smaller and much smaller than those for the γ-ray dose rate, respectively. The other indices for the difference between estimated and measured values such as the absolute ratio of mean of error to the average of the measured values ($|ME_{nd}|$) and the ratio of the square root of the error squared to the average of the measured values ($RMSE_{nd}$) showed similar results.

Although the estimated values of atmospheric concentration of ^{14}C were evenly scattered around the measured ones, the γ-ray dose rate from ^{85}Kr was systematically higher than the measured one. As well, the estimated concentrations of ^{129}I were almost 10 times higher than the observed values. The reasons for those systematic differences are unknown, and further study is required to improve the accuracy of the model.

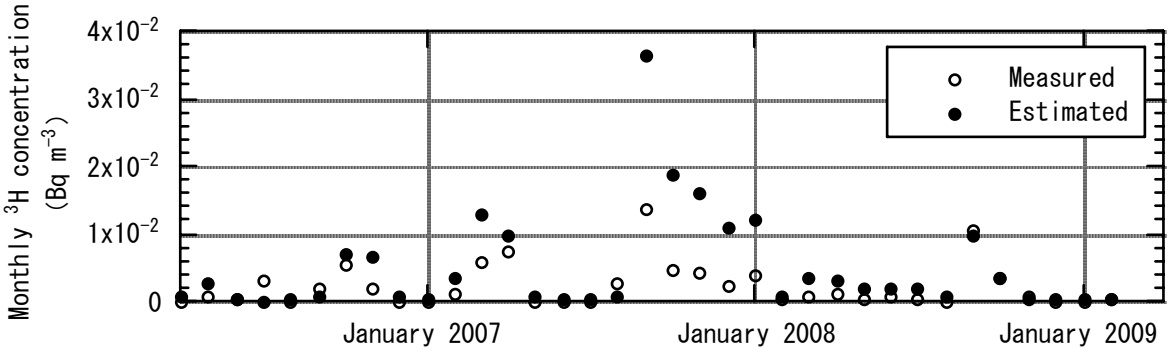

Fig.1 Monthly concentrations of ^{3}H in atmospheric water vapor estimated with ETDAM and measured at IES. The measured concentrations were obtained by subtracting background concentrations estimated as mean ^{3}H concentrations in monthly precipitation obtained before test operation using actual spent nuclear fuels (April 2001 – March 2006). ETDMA calculation conditions: calculation area, 50 x 50 km with a grid resolution of 500 x 500 m.

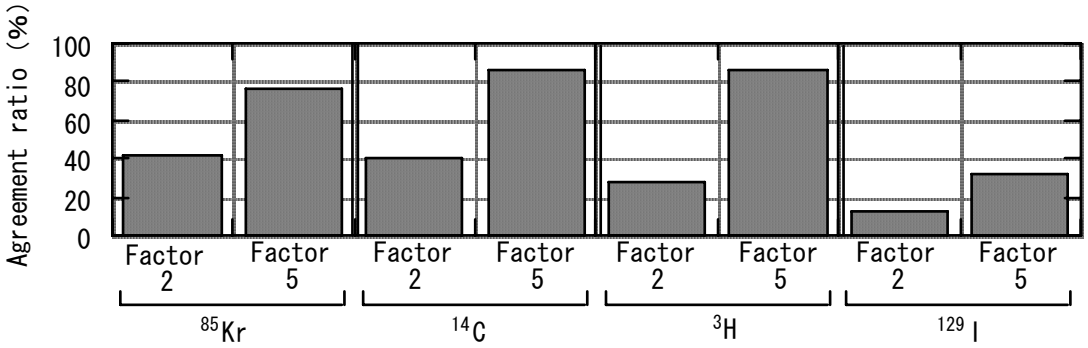

Fig.2 The agreement ratios of number of cases in which the estimated value was within a factor of 2 or 5, for monthly γ-ray dose rate from ^{85}Kr and atmospheric concentration of ^{14}C, ^{3}H, and ^{129}I at IES.

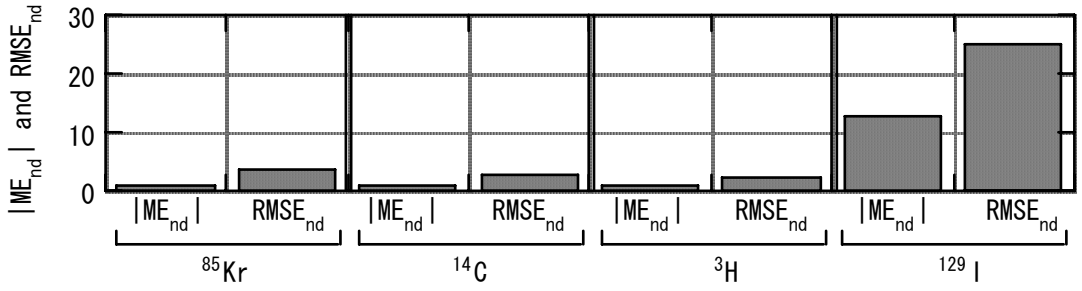

Fig.3 The absolute ratios of mean of error to the average of the measured value ($|ME_{nd}|$) and the ratios of the square root of the error squared to the average of the measured value ($RMSE_{nd}$), for monthly γ-ray dose rate from ^{85}Kr and atmospheric concentrations of ^{14}C, ^{3}H, and ^{129}I at IES.