Tritium Metabolism in the Human Body

Tsuyoshi MASUDA, Kensaku MATSUSHITA, Yasuhiro TAKO, Yuji NAKAMURA
Department of Environmental Simulation

Abstract

In the radiation safety assessment prior to the construction of the first commercial spent nuclear fuel reprocessing plant in Rokkasho, Japan, the internal radiation dose to the public due to tritium was estimated using the dose conversion factors based on the ICRP metabolic model of hydrogen in the human body. The ICRP metabolic model is very simple and is comprised of a free water tritium and organically bound tritium (OBT) compartments having biological half-lives of 10 and 40 d, respectively.

Although the biological half-time of tritium water (HTO) in the human body was examined in several cases such as accidental intakes or experimental administrations, actual data on the metabolism of OBT are quite limited. The objective of this research program is to establish experimentally the metabolism of tritium including OBT in the human body for more realistic dose estimation. In the experiment, the stable isotope of hydrogen, deuterium (D), was used as a substitute for tritium.

In FY 2011, urine, breath and serum samples were collected from volunteers administered with D-labeled glucose or D_2O up to 16 weeks after the administration, and analyzed for the isotopic ratios (D/H) with a mass spectrometer. Since D resulted from decompose of the D-labeled glucose in the human body entered to free water which is a relatively large pool of hydrogen, the decomposition rate of glucose is not directly monitored from those samples collected. To obtain decomposition rate of the administered glucose, ^{13}C-labeled glucose was also administered to the same volunteers, and ^{13}C isotopic ratios in their urine and breath samples were analyzed.

The D isotopic ratios in the urine and breath samples increased after the administrations, and then decreased with an exponential function, while the ^{13}C isotopic ratios decreased with two exponential components with the first short half-time and the second long one. Since the range of D isotopic ratio between increasing level just after the administration and background one was one order of magnitude narrower than that of ^{13}C isotopic ratio, the long component was not observed for the case of D. Half-times of the D isotopic ratios in urine and breath after D-labeled glucose administration were 6.4 and 6.0 d, which were similar with 7.4 and 7.2 d after D_2O administration, respectively. The half-times for D_2O intake were comparable with 5-13 d in the literature, and slightly shorter than 10 d in the ICRP model. The observed short and long half-times of the ^{13}C isotopic ratios after administration of ^{13}C-labeled glucose were 1.3 d and 2.1×10^2 d for urine and 1.1 d and 1.4×10^2 d for breath, respectively. All procedures of the experiment were approved by the IES Review Board for Human Subject Experiments, and written informed consents were obtained from all volunteers.

Table 1 Half-life of D ratio (day)

Administration	Urine	Breath
D, ^{13}C labeled glucose	6.4	6.0
D_2O	7.4	7.2

Table 2 Half-life of ^{13}C ratio (day)

Component	Urine	Breath
1st	1.3	1.1
2nd	2.1×10^2	1.4×10^2

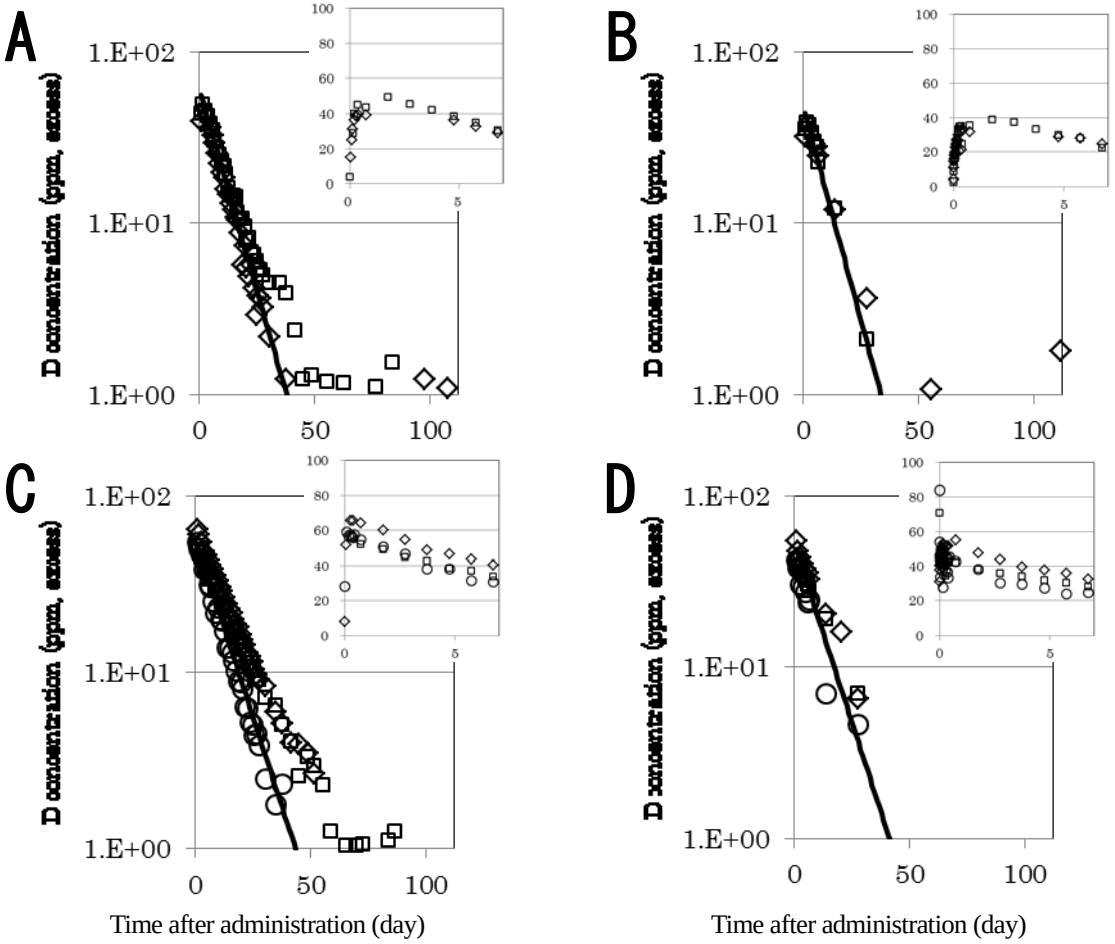

Fig. 1 D concentration (D/H) after D labeled glucose and D_2O administration

A, B: D and ^{13}C labeled glucose administration.

C, D: D_2O administration

A, C: urine, B, D: breath. Inserted panels: enlargement of data from day 0 to 7.

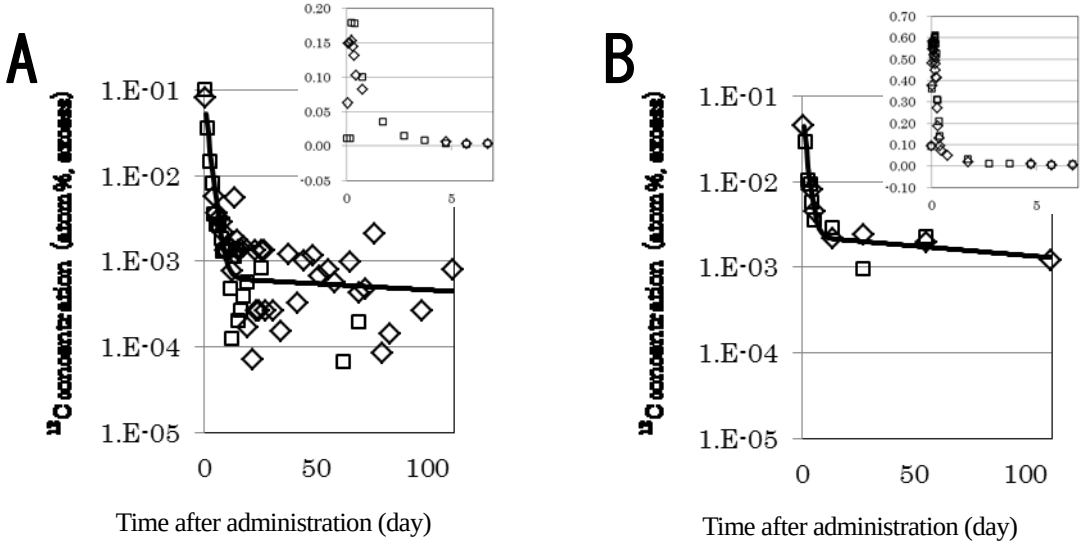

Fig. 2 ^{13}C concentration after ^{13}C labeled glucose

A: urine, B: breath. Inserted panels: enlargement of data from day 0 to 7.