Study on Carbon Metabolism in the Human Body

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Abstract

In the safety assessment around the spent nuclear fuel reprocessing plant at Rokkasho, Aomori, ^{14}C is expected to be the most attributable to radiation dose received by the neighboring population, among radioactive nuclides released from the plant. The radiation dose due to ^{14}C reaches around one third of the total annual radiation dose estimated as 22 μSv. However, the estimate of ^{14}C dose is thought to be rather conservative, because of possible overestimation of ^{14}C dose conversion factor. This might be largely attributed to excessive simplification of the metabolic model of ^{14}C in the human body. The objective of the study is to clarify experimentally carbon metabolism, especially the biological half-time, of ^{14}C in the human body.

Using the data from previous experiments on carbon metabolism through ingestion of protein, fat and sugar, a Human Body Carbon Metabolism Model was developed. To confirm the validity of the the model, changes in ^{13}C isotopic ratio after oral administration of ^{13}C labeled foods (rice and soybean) were examined during 16 weeks in breath air, urine, feces, hair and serum in three adult males. The estimate of the change in ^{13}C concentration by the model was compared to experimental data. Finally, retention of ^{14}C in the human body after oral intake of ^{14}C through ingestion of a typical Japanese diet was estimated by the model. The estimate of ^{14}C retention was lower than that predicted by the ICRP model on which is based the dose coefficient of organic ^{14}C intake for the general public.

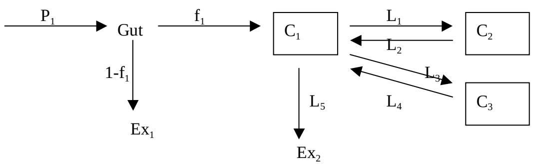

Fig. 1 Human Body Carbon Metabolism Model.

C_1: low molecular weight carbon pool, C_2: high molecular weight carbon pool, Gut: intestine, P_1: intakes of carbon, f_1: fraction absorbed, L_1, L_3: transfer rate, L_2, L_4, L_5: excretion rate, Ex_1: feces, Ex_2: breath and urine. Absorption of carbon in Gut was assumed to continue during the short period between administration and time when the highest ^{13}C concentration in breath was observed.

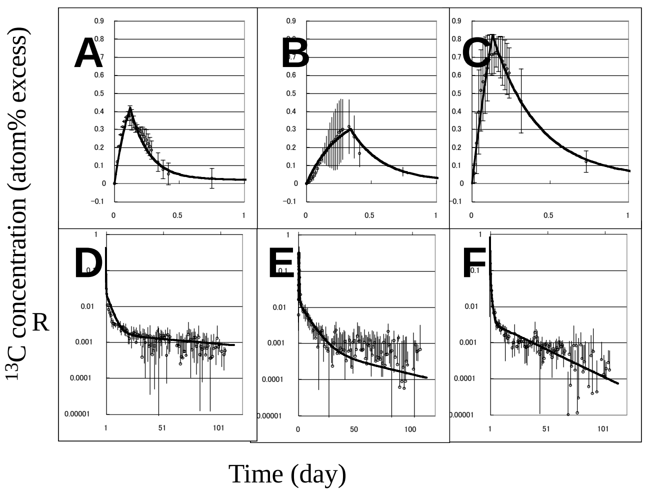

Fig. 2 ^{13}C concentration in breath after oral administration of amino acid, fat, and sugar.

A, D: amino acid, B, E: fat, C, F: sugar, A-C: time 0 to 24 hr, D-F: day 1 to day112. Solid lines show approximation by the Human Body Carbon Metabolism Model. Data were adopted from a series of experiments preceding this study.

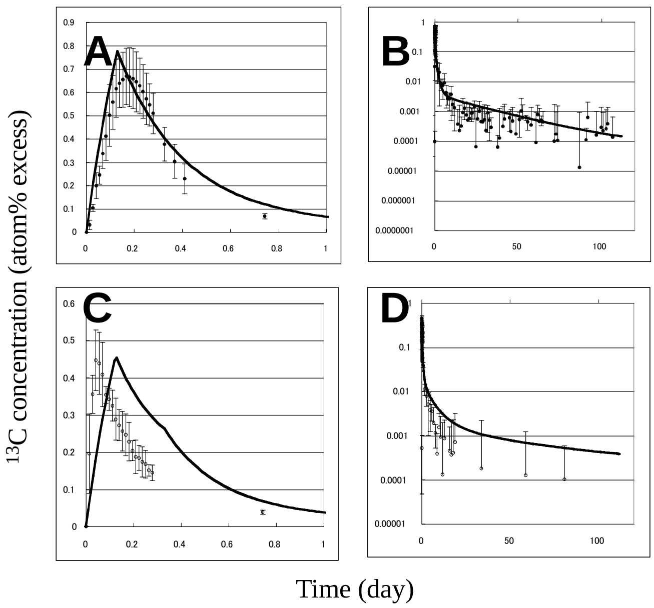

Fig. 3 Comparison between the expected ^{13}C concentration and experimental data in breath.

A, B: rice, C, D: soybean, A, C: time 0 to 24 hr, B, D: day 1 to day 112. Solid line show the predictions by Human Boby Carbon Metabolism Model.

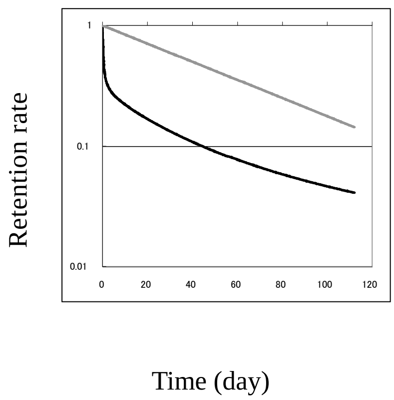

Fig. 4 Comparison between the model and the ICRP estimates of ^{14}C retention in the human body.

Black line: estimate by the developed model, Gray line: estimate by ICRP model.