Preliminary results on ^{137}Cs in soil core samples collected from the under-floors of houses built within 1-4 years after the Hiroshima Atomic Bomb

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Introduction

Twenty to 30 minutes after the explosion of the Hiroshima atomic bomb (A-bomb), rainfall occurred mainly in northern and northwestern areas from the epicenter. That rain, the so-called Black-rain, might transport fission products, induced radionuclides and fissile materials of the A-bomb to the ground, and contribute to radiation exposure to people living there. With a concern of possible radiation exposure due to the Black-rain, some kinds of radionuclides such as ^{137}Cs, ^{90}Sr and U isotope have been measured in soil samples collected from ground surface in Hiroshima city and its surrounding areas (e.g. JPHA, 1976 and 1978; Takada, et al., 1983). However, excess activities of the radionuclide derived from the Hiroshima A-bomb, especially ^{137}Cs, could not be clearly recognized due to the interference of a huge amount of global fallout deposition originating from atmospheric nuclear tests in the 1950s and 1960s. Thus, radioactive characteristics as well as spatial distributions of the close-in fallout by the Hiroshima A-bomb have not been specified even after 65 years from the A-bombing.

In this paper, we report trial to evaluate the level and spatial distribution of close-in fallout related to "Black-rain" through the measurements of ^{137}Cs, and Pu and U isotopes in some soil core samples taken under-floors of houses built within 1-4 years after detonation of the Hiroshima A-bomb. We present, here, preliminary results of ^{137}Cs in soil samples.

Material and method

In May 2010, four under-floor soil cores up to a depth of 30 cm (11 cm in diameter) were newly collected from 3 locations around Hiroshima city by considering the previously measured ^{137}Cs deposition patterns by Yamamoto et al. (2010). All these houses where floor soils were taken were built during the period of 1945 to 1948 (Table 1). Usually, before building a new house in paddy or dry field, floor soil preparation such as dipping out surface soil, clearing the ground and so on might be carried out. Although details on the soil preparation at that time are not clear now, homebuilder says that floor soil was not so largely disturbed. Each core sample

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was divided into 5 or 6 parts: 0-3, 3-6, 6-9, 9-15, 15-20 and 20-30 cm in depth. A portion (about 100 g) of soil sample was used for radionuclide determination. The pre-treatment and leaching methods were conducted with the same manner as those for the soil samples previously taken from Ishikawa prefecture and Hiroshima city (Sakaguchi et al., 2009 and 2010). The total amount of leaching solution for each sample was weighed and separated into three aliquots: (1) 1/200 for determining the total amount of leached ^{238}U and $^{235}U/^{238}U$ by ICP-MS, (2) 1/50 for determining the $^{236}U/^{238}U$ and $^{235}U/^{238}U$ atom ratios by MC-ICP-MS and AMS, and (3) the rest was used for ^{137}Cs and Pu isotope measurements with Ge semiconductor detector and AMS.

Table 1 Descriptions of soil core samples.

Sample name	locattion		distance from hypocentre	year of built up, place, previous using
	N	E		
H3a	34 27' 57.3"	132 25' 15.3"	7.22 km	1949, inside strage, paddyfield
H3b	34 27' 57.3"	132 25' 15.3"	7.22 km	1949, inside home, paddyfield
H4	34 28' 38.6"	132 26' 39.3"	8.82 km	1946, underfloor, field
H6	34 28' 18.2"	132 27' 23.9"	8.16 km	1946, underfloor, field

For the measurement of ^{137}Cs, a known amount of Cs (^{133}Cs) was added to the rest solution (3) as yield carrier. From this solution, Pu isotope was at first separated with $Fe(OH)_3$ coprecipitation by adjusting the solution to pH 8 with NH_4OH. The supernatant for ^{137}Cs fraction was adjusted to pH 1 with HNO_3, and ammonium phosphomolybudate (AMP) powder was added to it. After stirring 1 hour and standing for 24 hours under the room temperature, the solution was centrifuged, and the obtained AMP was dried at 105 ^oC for 12 hours. The AMP was packed into a plastic tube (1.4 cm x 4.0 cm), and its ^{137}Cs was determined by γ-ray spectrometry using a well type Ge-detector (ORTE, GWL-120230-S). The spectrometer was calibrated with mixed standard prepared by the Japan Radioisotope Association, No. MX-033. The treatments and measurements for other nuclides will be presented elsewhere.

Results and discussion

Results of ^{137}Cs at the sampling date are shown in Figure 1. The depth profiles in terms of an accumulated level show that 70-100% of the ^{137}Cs detected were retained within the layers up to the depth of 6 cm.

The ^{137}Cs in the core H6 was detected only in the layer up to a depth of 6 cm. The ^{137}Cs in the cores H3b and H4 were found in the layers up to a depth of 9 cm. The core H3a had a subsurface maximum in the 3-6 cm depth below the top and its ^{137}Cs was found in the layers up to a depth of 9-15 cm. Why such a depth profile is obtained for H3a core cannot be explained. One probable reason of this may be that the floor of this house was affected by flood or heavy rain. Additionally, there may be the disturbance of surface soil for the construction of housing base. Actually, we found a broken roof tile in the depth of 3-6 cm of this core. However, compared with the depth distribution of ^{137}Cs in soil cores from outcrop (e.g. Sakaguchi et al., 2010), which ^{137}Cs was found even in the depth of 20-30 cm, these four cores from under-floor seem not to be largely affected by rain and/or flood with global fallout radionuclide.

The ranges of areal inventories of ^{137}Cs were 19-62 Bq/m^2, and these levels were about thirtieth to one hundred fiftieth of global fallout level (2000-3000 Bq/m^2) found in Hiroshima

(Yamamoto et al., 2010; Sakaguchi et al. 2010). It must be noted that the fission yield of the Hiroshima A-bomb (15 kt: UNSCAER, 2000) is only 0.01% of the total fission yield due to atmosphere nuclear tests (160 Mt). This suggests that significant amounts of radionuclides due to close-in fallout deposited locally, if soil samples used in this study were uncontaminated by global fallout.

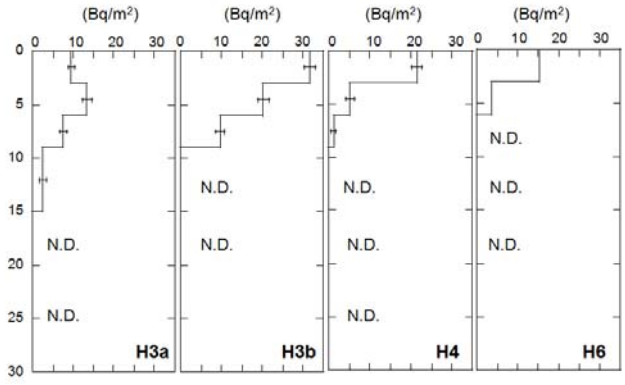

Figure 1 The depth distribution of ^{137}Cs in soil samples from under-floors of houses which were built

Thus, we could detect low-level ^{137}Cs in the under-floor soil samples. Most important problem in next step is what the origin of detected ^{137}Cs is. And, how can we identify the origin of detected ^{137}Cs. Now, as the candidate nuclides, Pu and U isotopes were selected for identification and their measurements are ongoing for these samples. Furthermore, we are also trying to get information on radiological composition of Black-rain from the analysis of its drops on walls and surface soil samples which were collected within only three days after the bombing by Nishina research group.

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