CO10-1 Activation Analysis for Soils of Hiroshima City and Gamma-ray Exposure due to Neutron-induced Radionuclides by Hiroshima Atom Bomb

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INTRODUCTION: For early entrance survivors in Hiroshima and Nagasaki atomic bomb (A-bomb), radiation doses from activated materials induced by the A-bomb neutrons are dominant. For estimation of such doses, element compositions of environmental materials such as soil and rubbles are necessary. Especially Sc density in soil is important for estimating radiation doses at the time of a few 10 days after explosion because ^{46}Sc has the half-life of 84 days. However, few data of Sc density in soil are available in both of Hiroshima and Nagasaki cities. Purpose of this study is evaluation of Sc density in soil and the uncertainty using activation analysis.

EXPERIMENTS: Soil samples were taken from 11 locations within 4 km from A-bomb hypocenter at Hiroshima city. The soil samples were dried by an oven at 120 degrees for over night. The dried samples were sieved through a 2-mm mesh to remove pebbles and plant remains. The sieved samples of about 10 g were grained to fine mesh by a mortar for activation analysis. The soil samples and reference rock sample of JA-1[1)] were activated in Kyoto University Reactor (KUR). Element compositions of soil samples were obtained by comparing counting rates of each identified radionuclide by Ge-detectors with those from reference rock.

RESULTS: Twenty three element compositions including Al, Mn, Na and Sc are obtained by the activation analysis as listed in Table 1. The obtained element compositions are compared with values used in Dosimetric System 1986 (DS86) [2)] and found roughly the same as the reported values in DS86. Sc density in Hiroshima soil was estimated to be 5.12±0.59 (ppm). It was found the unevenness of Sc density in soils for 11 location of Hiroshima city is about 12%.

Using element compositions by the activation analysis, time variation of the exposure rate by activated soil was estimated. It was found that the exposure rate during a few minutes after the explosion is dominated by ^{28}Al, several days by ^{24}Na, and in a few 10 days by ^{46}Sc. This estimated result is compared with values of dose rate measured after a few months after explosion [3,4)]. It was found that the estimated dose rate reproduces well the measured ones.

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Table 1. Averaged values of element concentration in soil and DS86 values[1)]

element	Z	Concentration (ppm)		DS86 value (ppm)	
				Hiroshima Castle	A-bomb Dome
Na	11	19300±	20%	16000	12400
Al	13	63300±	14%	71000	64900
Sc	21	5.12±	12%	5	5
V	23	21.4±	26%	22.3	25.3
Cr	24	20±	65%	20.5	27.3
Mn	25	517±	13%	467	587
Fe	26	17100±	16%	17700	20600
Co	27	4.13±	23%	3.7	3.8
Rb	37	137±	12%	230	225
Sr	38	45±	38%	88	70
Zr	40	105±	40%	41	35
Nb	41	2.0±	60%	7	5
Sb	51	1.87±	11%	1.4	0.8
Cs	55	4.4±	14%	5	5
La	57	27.4±	23%	23	21
Ce	58	88±	24%	40	36
Sm	62	3.7±	27%	3.4	3
Eu	63	0.81±	15%	0.9	0.9
Gd	64	2.23±	44%		
Lu	71	0.133±	33%		
Hf	72	4.17±	19%	4	4
Th	90	14.3±	30%	13.3	9.9
U	92	0.85±	18%	2.8	2.6

採択課題番号 23005　広島・長崎原爆中性子による誘導放射能評価のための組成分析　　共同通常
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CO10-2 ***Damage of USB Semiconductor Memory by Radiation Exposure***

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INTRODUCTION: In estimating the damage of the nuclear disasters and planning how to defense the damage, quantitative evaluation of the radiation effect on the semiconductor equipment is important [1]. Our group has been working on evaluating this radiation effect [2]. In 2011, the radiation damage to condenser-resistor (CR) circuit was investigated.

EXPERIMENTS: The irradiation was performed with Kyoto University Research Reactor Institute Heavy Water Neutron Irradiation Facility (KUR-HWNIF). The utilized modes were standard mixed neutron irradiation mode (OO-0000-F), and standard epithermal neutron irradiation mode (CO-0000-F). As semiconductor equipment, condenser-resistor (CR) circuit was utilized. The condenser was metalized polyestel film type (Nissei corporation, MMX0630K474: 0.47 μF) in irradiation #1, and ceramic type (RS corporation, RS630-1646: 0.1 μF) in irradiation #2. The register was 'RS477-1964 by RS corporation, of 47 Ω.
The CR circuit was connected with PC outside the irradiating room through the USB cable of 5m in length, the USB hub, and the repeater cable of 5m in length. The circuit was tested as to its function by measuring the time constant. The experimental setup is shown in Fig. 1 and Photo 1.

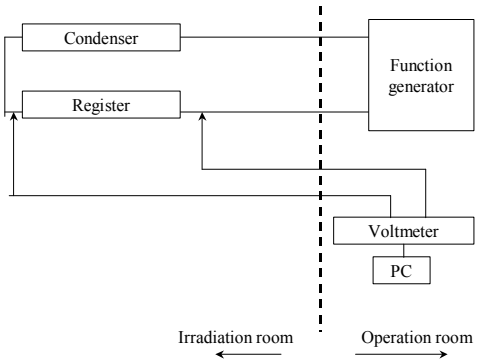

Fig. 1. Experimental setup

Fig. 1. View of irradiation port

RESULTS: Table 1 shows the dose irradiated. The values correspond to the total dose (neutron + gamma rays) to human tissue. The time constant (τ) measured is also shown. In both trials, the time constant was not changed by the irradiation.

Table 1 Summary of irradiation

Irradiation	Mode	Time (min)	Dose (Gy)	τ (ms)
#1	Mix + epi	120	2.6	19.7
#2	Mix	111	2.7	5.1

SUMMARY: The result obtained in 2011 indicates the CR circuit was not destroyed by the irradiations in this study.
The circuit did not have influence by irradiations at about 1 Gy/h. The study on tolerance of the semiconductor is to be continued. This includes the investigation of condenser structure, mode of function generator, and irradiation conditions such as quality, dose, dose rate.

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採択課題番号 23062　　核放射線照射による電子機器の誤作動の検証　　共同通常
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CO10-3 Evaluation of Gold in Melting Residue of the Municipal Wastewater Sludge

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INTRODUCTION: Noble and rare metals are common components of various electronic devices, and their widespread use is resulting in rapid depletion. In particular, noble metals such as Gold (Au) are becoming highly depleted, which has a significant impact on the environment. Thus, there is an urgent need to develop substitute materials and establish a material's cycle system.
Au is found in municipal wastewater sludge. Lottermoser reported high Au concentrations (56 mg/kg-dry) in dewatered sludge from the German jewelry industry [1]. Moreover, it was found that Au was abundant at 28.8 to 2,130 mg/kg in melting residue from a Toyota wastewater treatment facility at Suwa, Japan [2]. However, little information is available regarding the Au concentration and behavior in melting residue at other Japanese facilities. Accordingly, the resource value of other melting residues has not been determined.
In this study, Au concentrations in various melting residues and related municipal sewage sludge materials were investigated using ICP-MS analysis after tellurium coprecipitation and INAA. Subsequently, the resource values of these residues were determined.

EXPERIMENTS: A total of 28 melting residues and related materials, including melting plant input sludge, slag, melting fly ash and other dusts, were sampled at three melting plants at municipal wastewater facilities. The Au concentrations of these samples were analyzed using ICP-MS after acid digestion with tellurium coprecipitation [3]. Moreover, Au concentrations were re-evaluated using INAA. All measurements were performed in duplicate.

RESULTS: The Au concentrations in the samples are shown in Table 1. Au concentrations in dust from air pre-heaters, waste heat boilers, and suspended solids in wet-scrubbing wastewater ranged from 9.63 to 153 mg/kg, which is relatively high. Although the mass of these media is low, the Au quality was similar to ore. Thus, these media may be a valuable resource.
Additionally, there was an increased Au concentration in dust derived from lower points in the flue gas treatment process. Au exists as a simple substance in sludge at normal temperatures, and not as chemical compounds. After treatment in the melting furnace, it could melt (melting point: 1337 K) and react with other elements to form volatile compounds, e.g., gold chloride (gaseous phase).
A comparison of the Au concentrations determined using ICP-MS after tellurium coprecipitation and INAA is shown in Fig.1. The ICP-MS results are highly correlated with the INAA results. Thus, ICP-MS after acid digestion with tellurium coprecipitation was validated. However, the slope of the regression line was 0.704. The analytical result using ICP-MS tended to be higher because Au concentration in the standard sample; BCR-176 was lower than that of real samples. Thus, this point is currently being investigated.

Table 1 Au concentration in each media.

Facility	Class	Item	ICP-MS	INAA
A	INPUT	Dewatered sludge	0.330	N.A.
A	INPUT	Cokes	0.0226	N.A.
A	INPUT	Lime	0.100	N.A.
A	INPUT	Clushed stone	0.0592	N.A.
A	OUTPUT	Slag	0.428	N.A.
A	OUTPUT	Dust from melting furnace	0.344	N.A.
A	OUTPUT	Dust before air preheater	9.63	8.53
A	OUTPUT	Dust after air preheater	13.6	16.0
A	OUTPUT	Dust from waste heat boiler	35.8	36.2
A	OUTPUT	SS in wet scrubbing wastewater	9.8	N.A.
A	OUTPUT	Dust from wet electric precipitator	92.4	N.A.
B	INPUT	Dried sludge	0.122	N.A.
B	INPUT	Iron powder	0.0387	N.A.
B	INPUT	Lime	0.467	N.A.
B	OUTPUT	Slag	3.61	N.A.
B	OUTPUT	Dust from waste heat boiler	38.7	29.1
B	OUTPUT	SS in wet scrubbing wastewater	43.0	N.A.
C	INPUT	Dried sludge	0.0599	N.A.
C	INPUT	Cokes	0.0233	N.A.
C	INPUT	Lime	0.0729	N.A.
C	INPUT	Clushed stone	0.139	N.A.
C	OUTPUT	Slag	2.37	N.A.
C	OUTPUT	Dust from upper side of melting furnace	0.573	0.788
C	OUTPUT	Dust from middle of melting furnace	0.426	1.01
C	OUTPUT	Dust from lower side of melting furnace	7.67	9.76
C	OUTPUT	Dust from air preheater	9.44	9.74
C	OUTPUT	Dust from waste heat boiler	49.8	22.3
C	OUTPUT	SS in wastewater for washing boiler	153.0	N.A.

※Output samples in each facility were showed from upstream to downstream of flue gas treatment process.
※N.A. Not analyzed.

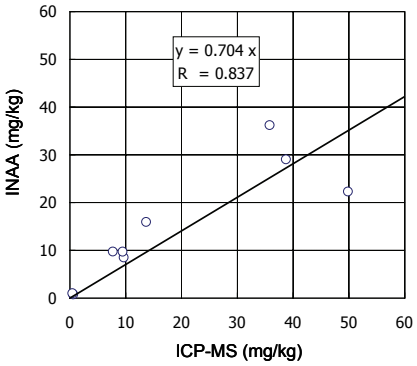

Figure 1 Relationship of analytical result between ICP-MS and INAA.

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採択課題番号 23/68　廃棄物焼却炉からの微小粒子の排出にともなう重金属の実態把握　ぴ　通常（京大院・工）高岡　昌輝、米田　稔、大下　和徹、松井　康人、塩田　憲司、今井　玄哉、角　壮志、山口　修史、劉　露、西岡　和久（京大・原子炉）福谷　哲