CO10-1

Application of KURAMA-II to Radiation Monitoring of Cement Solidification Facility in Fukushima Prefecture

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INTRODUCTION: KURAMA (Kyoto University Radiation Mapping system)-II is a radiation measurement system characterized by its compactness, autonomous operation, and acquisition of pulse-height spectrum data (Fig. 1) [1]. KURAMA-II measures ambient dose equivalent rate (hereafter referred to as air dose rate) and GPS position and automatically transmits them to a dedicated cloud server. In this study, we used a backpack-style KURAMA-II (Fig. 2) for the cement solidification facility (handling incinerator ash contaminated with radioactive cesium derived from the Fukushima Daiichi NPP accident) to assess whether the radioactive cesium was scattered under demolition.

EXPERIMENTS: The air dose rates of the cement solidification facility were measured on foot with a KURAMA-II in a backpack. The measurement dates were 20 June 2024 (first), 23 Jul. 2024 (second), and 23 Jan. 2025 (third). The second measurement was carried out during demolition.

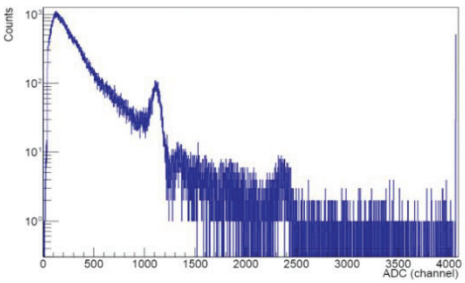

Fig. 1. A typical example of the pulse-height spectrum obtained by KURAMA-II measurement.

Fig. 2. KURAMA-II in a backpack.

A CsI (Tl) scintillation detector (C12137-4034, Hamamatsu Photonics) was used for measurement. The air dose rate and GPS position were measured every second. For the first and second measurements, the air dose rate was measured by walking along the facility's boundary, while the third measurement was carried out in the whole area of the facility. The measurement data were averaged in a 15-meter mesh and visualized to the colored air dose rate maps using GIS software (QGIS 3.28.6).

RESULTS: The air dose rate maps are shown in Fig.3. No apparent differences were found among the three measurements around the facility. As shown in Fig.3(c), no apparent contamination was found in the study area. In conclusion, no clear effect of the demolition of the cement solidification facility on the air dose rate was found in the present study.

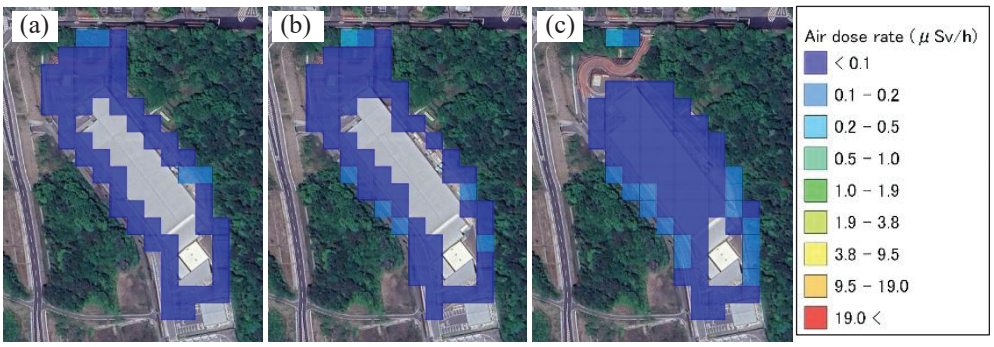

Fig. 3. The air dose rate maps obtained by (a)first, (b)second, and (c)third measurements.

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CO10-2

Determination of Chlorine and Bromine Concentration in Plastics in Construction Waste by Neutron Activation Analysis

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INTRODUCTION: In the recycling of waste plastic contained in construction waste (construction waste plastic), there are restrictions on chlorine concentration. However, the elemental composition varies from item to item, and this needs to be clarified. In this study, neutron activation analysis (NAA) was performed on 36 new plastics that can be generated at construction sites to analyze chlorine and bromine concentrations.

EXPERIMENTS: NAA was performed four times for each sample. Samples were irradiated for 3 min with a thermal neutron flux of $2.0\text{-}2.4\times10^{13}$ $cm^{-2}\cdot sec^{-1}$ at KURRI. ^{38}Cl ($t^{1/2}$ = 37.18 min, E_γ = 1642, 2168 keV) and ^{80}Br ($t^{1/2}$ = 17.68 min, E_γ = 616, 666 keV) were measured by using a Ge semiconductor detector for 300 sec.

RESULTS: Figure 1 shows a histogram of chlorine concentrations. Chlorine is shown separately on the low and high concentration side because the concentration differs greatly between PVC and non-PVC products. Thirteen samples were below 200 ppm, which is the standard for oil conversion in chemical recycling (the value obtained from interviews with plant manufacturers). The samples exceeding 20% were flooring materials, window frames, and corrugated sheets, which can be assumed to be PVC. These results suggest that chemical recycling with chlorine concentration restrictions should start with packaging and curing, which are non-chlorinated items.

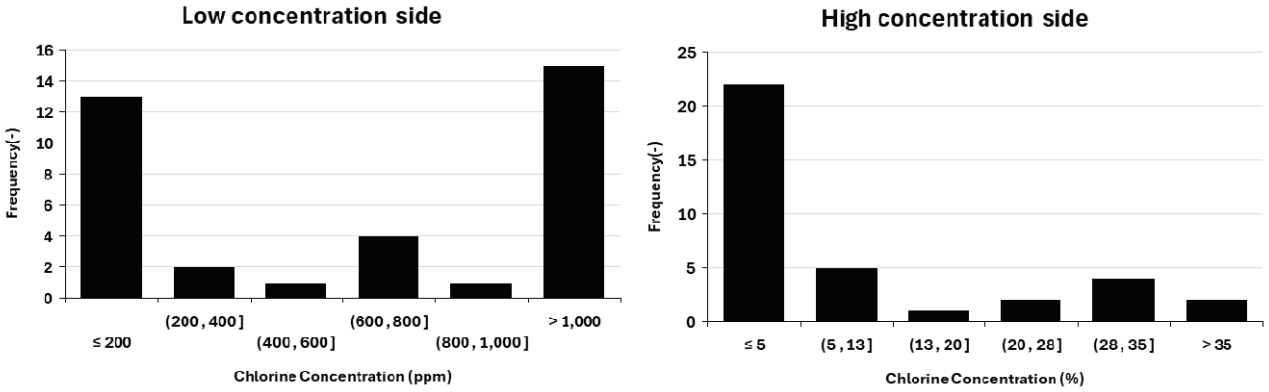

Fig.1. Histograms of chlorine concentrations

Figure 2 shows a histogram of bromine concentration. Most of the 28 samples did not contain bromine, with 28 samples containing less than 200 ppm, and if they did contain bromine, it was in trace amounts. This bromine is considered to be derived from additives.
This experiment made it possible to accurately detect chlorine concentrations on the low side, which is important in plastic recycling, and to classify items that are unsuitable for recycling.

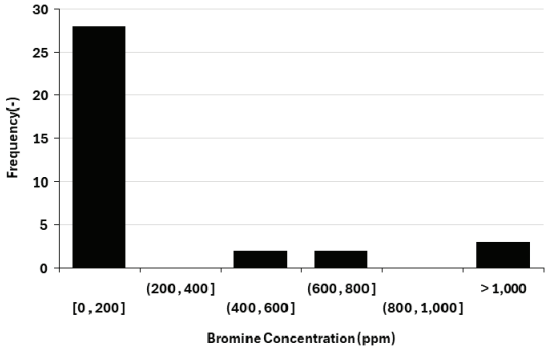

Fig.2. Histograms of bromine concentraitions

CO10-3

Prompt γ-ray Analysis for Chlorine Content in Power Cable Sheath used in a large-scale accelerator facility

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INTRODUCTION: In the previous year, neutron activation analysis (NAA) was conducted to determine chlorine content in power cable jackets used in the KEK 12 GeV proton synchrotron facility. Accurate quantification is essential for evaluating long-lived nuclide production, such as ^{36}Cl, which poses environmental concerns. However, the actual chlorine content in cable materials is often unknown. This year, prompt γ-ray analysis (PGA) was applied to quantify chlorine in the same samples. PGA allows real-time measurement during neutron irradiation and enables rapid assessment. This study compares PGA with NAA in determining chlorine content and assesses its utility for waste characterization.

EXPERIMENTS: The power cable jacket of the septum magnet of KEK-PS was collected, cut into 1-5 mm pieces, washed with water and ethanol, and weighed 100 mg to prepare irradiation samples. The chlorine-containing plastic standards (JSM_P713-1 series) distributed by the JFE Techno-Research Co. were employed as references and prepared in the same way. Samples were irradiated at the horizontal beam port E-3 at a thermal power of 1 MW. The average flux was on the order of 10^4 n/cm²/s. Prompt γ-rays emitted during irradiation were measured in real-time using a Ge detector (ORTEC) for 5 to 10 minutes.

RESULTS: The γ-ray spectra of the representative sample and standard are shown in Fig. 1. The γ-ray spectra revealed distinguishable peaks at 786 keV and 788 keV for chlorine. A calibration curve based on plastic standards and NaCl showed excellent linearity. Estimated Cl contents in cable insulation were 2–4% higher than those by NAA. Interference by aluminum (e.g., alumina additives) or cobalt may have influenced results. The small sample mass (<0.1 g) relative to the ~1 cm beam diameter may also contribute to uncertainty.

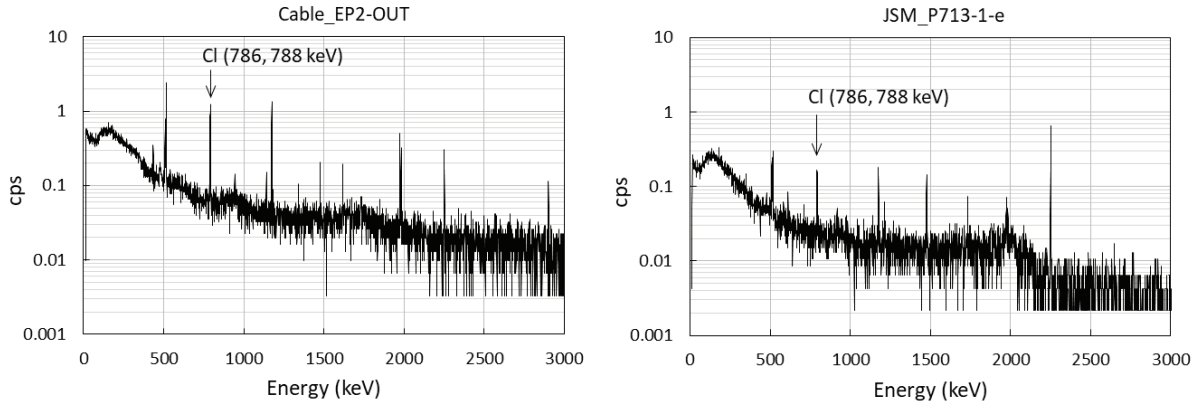

Fig. 1. Prompt γ-ray spectra of representative cable sheath sample (right) and standard (left)

CO10-4

Measurement of Number-Based and Radioactivity-Based Size Distributions of Aerosol Particles Generated in the Accelerator Room of an Electron LINAC Facility Using Screen-Type Diffusion Battery (II)

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INTRODUCTION: Accelerator safety has become increasingly important in recent years with the advanced use of high-energy and high-intensity accelerators. During accelerator operation, the accelerator room is filled with radioactive gas and radioactive aerosols. Particle size information of the aerosol particles is essential for estimating internal doses and designing exhaust systems in accelerator facilities. This report describes the measurement of the aerosol particle size using a diffusion battery at the electron linac facility, which has been performed for the past several years.

EXPERIMENTS: When fine aerosol particles of about 100 nm or less pass through a stack of wire screens, some of the particles are deposited on the wire surface of the screen by diffusion, depending on the particle size. The percentage of particles that can pass through the screen (penetration ratio) is expressed as a function of particle size, roughness and number of screens, and particle flow rate. By measuring the penetration ratio by varying the number of screens or flow rate, the particle size can be calculated from the theoretical equation.

Radioactive aerosol particles were produced by air irradiation using an irradiation chamber at the electron linac of our institute. The irradiated air containing the aerosol was introduced to a screen-type diffusion battery (SDB) consisting of stacked multiple wire screens and a backup PTFE filter. Simultaneously with the aerosol measurements, the radioactivity of the radioactive gas in the chamber was also measured using an ionization chamber. The SDB measurements were made both by changing the flow rate (Method 1) and the number of screens (Method 2). In Method 1, during irradiated air sampling, the air velocity in the irradiation chamber was always corrected to be constant, as described in the previous report [1]. In Method 2, a method of calculating the penetration ratios by measuring the radioactivity of multiple screens and the backup filter simultaneously using a large format IP was employed [2], instead of the conventional method of repeating the measurement by changing the number of screens,

RESULTS: Since a stable lognormal-type particle size distribution was observed in the SMPS (scanning mobility particle sizer) measurement performed during irradiation, the geometric mean and geometric standard deviation of the particle diameter were calculated, assuming a lognormal particle size distribution, by fitting the penetration ratios obtained by each of the two methods to the theoretical equation [1]. Number-based particle diameter tended to increase with increasing beam current (20-100 μA) in the SDB measurements, ranging from 20 to 60 nm. The size distributions obtained with Methods 1 and 2 were in good agreement, and the results were also in very good agreement with the SMPS measurements. In the radioactivity-based size measurement for ^{13}N-bearing aerosol particles, even a small percentage of radioactive gas deposited on the SDB screen or backup filter would be expected to cause errors in the particle size because the results of the radioactive gas measurements showed that a high percentage of ^{13}N formed in the chamber was present in gaseous form.

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[2] Y. Oki *et al.,* J. Radiat. Prot. Res., **41** (2016) 216-221.