CO10-1 Effective Measures on Safety, Security, Hygiene and Disaster Prevention in Laboratories

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INTRODUCTION: Important aspects of the study can be found in the following keywords, such as safety, security, hygiene and disaster prevention. Nuclear research reactor is one of representative facilities together with these keywords under their operation. It is effective to investigate the latest status on practical measures on these keywords in various facilities including nuclear research reactors, to compare each other among facilities, and to discuss more optimized ones for our positive safety management. Through this process, it is also essential to investigate the latest international and/or national regula-tions and the movement of revision of them. In addition, development of human resource and public literacy on nuclear science and technology is also within the scope of the research. The total discussion contents and their fruits are directly useful for all relating laboratories.

RESEARCH APPROACH:

General research approach is as follows.

- Measures of safety management during operation or standstill status of the real facilities would be investigated. This information would be used for our research discussion on the positive and more optimized safety management.
- It would not be a single year research, but maybe two to three years research for one theme.
- Information source of facilities would not be only KUR, KUCA or the other facilities in Kyoto University, but also the Kinki university research nuclear reactor or the facility of National Institute of Fusion Science, etc. This research is an active joint-research with these relating facilities and positive researchers on safety management.
- One of the distinctive features of this research is to involve office staffs as cooperators as well as researchers and technical staffs. In The University of Tokyo, most of the members in Division for Environment, Health and Safety are office staffs who knows real situation of safety management in laboratories very well.

Concrete discussion target in FY of 2019 was determined as following two; “standardizing education system for safety managers and users in universities for application of small amount of U and Th” and “radiation education and human resource development in secondary school from global viewpoint” through our member discussion.

EDUCATION SYTEM IN UNIV. FOR SMALL AMOUNT U&Th APPLICATION:

Safety education system for managers and users of small amounts of U and Th has been discussed to standardize it in universities. Latest status of their education in several Japanese universities have been investigated and concluded the common and needed viewpoints. In addition, throughout this discussion, not only good practices and ideas for nuclear material safety management at the laboratory and laboratory levels, but also issues to be overcome under the current Japanese legal system were shared. The discussion fruits are started to be opened through technical journals, for example, the first article was published in the early 2020 as the reference [1].

RADIATION EDUCATION AND HRD IN SECONDARY SCHOOL:

International Atomic Energy Agency (IAEA) RAS0065/0079 (2012-2021) Technical Cooperation Programme (TCP) relating secondary school education on nuclear science and technology (NS&T) in Asia and Pacific region became a trigger for us to organize Team JAPAN. This team consists of several Japanese experts to support the activities and develop several educational tools and modules with “WOW factor” using the STREAM (Science, Technology, Robotics, Engineering, Arts and Mathematics) education concept. So far, a hand-made Air-GM counter, a wide-view Peltier type cloud chamber, a handy radiation monitor for school application, motivation-up movies, etc, has been developed by us. Team JAPAN continues its activities with the cooperation with experts, teachers, and other stakeholders in the world. The discussion fruits are started to be opened through technical journals, for example, several articles were published as the reference [2][3][4].

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CO10-2

Scientific Ethnography for Nuclear Science, Part 1
-Responsibility of Science, Post 3.11, IItate Village, Fukushima-

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In this report, we will report the ethnography of the retuned residents of Iitate Village in the 9th year after the disaster in two parts. Part 1 is about the responsibility of science, which is the main subject of this research. In Part 2, I will briefly report on the criticism of science that can be intensely drawn from the story of villagers who lives in nature.

Former UNSCEA Commission on Radiation Effects Prof. Wolfgang Weiss stated the responsibility for science after the Fukushima nuclear accident as follows; “The most serious damage caused by Fukushima accident is that people lost trust for science and scientists. This certainly will influence long- term human history, and we cannot recover such situation so easily. We scientists are responsible to such situation.” (Prof. Wolfgang Weiss)

Clearly explaining the responsibility of science is difficult. Because it is an essential factor unavoidably embedded in the uncertainty of science. What is science to humanity? In particular, regarding the responsibility of science in nuclear accidents, it is important to structurally analyze various factors in addition to science and approach where responsibility lies. There are much factors involved such as politics, economy, energy and environment are numerous. There is always a danger in using the results of natural science as a technology in society. Technology is always absorbed by human society while maintaining a sympathetic relationship with safety, such as danger due to immaturity of technology and danger as the sum total due to interaction with other technologies. Nuclear power generation technology has been used for human welfare while balancing danger and safety issues at unrealizable levels.

Occasionally, in the human society, it is not uncommon for security to be neglected by paying attention to the return of capital based on the logic of investment.Once the basic science is put into practical use and used as a technology in society (politico-economic engine), the logic of capital, such as investment in technology and recovery and recovery of wealth, will return the basic science to investment (positive feedback), and the position of science will be politico-economically jeopardized (Fig.1).

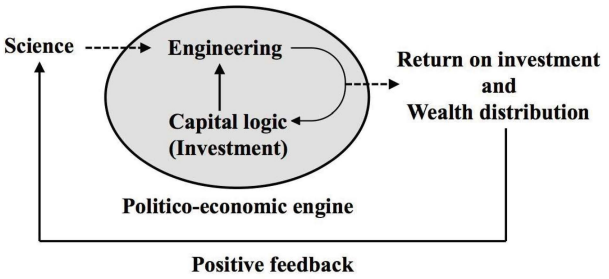

Fig.1 Politico-economic engine for technologizing the science.

Scientists should be discreet enough to apply their science findings to technology. If the principle of capital intervenes at this stage, science will possibly become a non-science, and it will become one of the engines absorbed by the capital principle as technology, and the location of risk will no longer be clear. Professor Hideki Yukawa, who was the first member of the Reactor Promotion Committee under the Nakasone administration, resigned in opposition to the promotion of nuclear technology, saying that safety could not be guaranteed. I don't know if his actions can be justified, but it could be considered as a waiver of scientists' responsibility. I have long argued for the need for regulatory anthropology, but few researchers have shown understanding. A cultural anthropology department that investigate the safety of nuclear science with the peace of mind that the public is convinced should be installed in a nuclear research institute.

Is it possible to regulate so that both scientific safety and psychological security can be achieved at the same time, or not? Such regulation science does not exist in much fields of our natural science, but rather in fields of medicine and drug safety. Approximately 10 years before the accident occurred, National Institute of Radiological Sciences (NIRS) tried to advance the field of regulatory science, but the Science and Technology Agency at that time showed little understanding. It means that the Science and Technology Agency was just for promoting nuclear power, so safety was just an excuse. I wonder if the gaps around it will be filled up a little with anthropology.

CO10-3 Assessment of non-homogenous exposure of radiation workers in accelerator facility – situation in the small linac facility -

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INTRODUCTION: The reduced occupational dose limit for the lens of the eye has been adopted by the International Atomic Energy Agency [1], the European Union [2] and the United States [3]. Annual equivalent dose limit for the lens of the eye for occupational exposure in planned situations was reduced from 150 mSv to 20 mSv averaged over five consecutive years and 50 mSv in any single year. Comprehensive survey was made and the technical document for eye lens monitoring has been released from the IAEA [5].

The study focuses on how the inhomogeneous exposure of radiation workers due to radiation from activated apparatus of the accelerators can be assessed. The purpose of the study is to evaluate whether the additional monitoring of the eye lens dose is required for the radiation workers in the accelerator facility. The authors introduce a quantitative index, HI which expresses how much radiation workers are exposed non-homogeneously for their radiation work. HIs were defined as the ratio of the personal dose equivalent for the eye lens and the extremity monitoring to that for the whole-body monitoring.

EXPERIMENTS: We focused on the exposure situation of radiation workers who are engaged in the handling of the activated target in the linac facility. The HIs for this exposure situations were experimentally evaluated using a water-filled phantom with the Optically Stimulated Luminescence (OSL) dosimeters (nanoDot^{TM}, Nagase Landauer Ltd.) incorporated with a water-filled phantom. The phantom was placed in the workplace to mimic the respective work Since inhomogeneous exposure will be expected in terms of extremities as well as the lens of the eye, OSL dosimeters were put on the fingers and palms of the physical phantom. The ambient dose equivalent rate of the vicinity of the target was measured to be around 100 μSv h^{-1}. The physical phantom with the OSL dosimeters was set for 18 hours and the OSL dosimeters were read after the irradiation.

RESULTS: Table 1 was listed the comparison of the ratio of the eye lens dose or the extremity dose to the trunk dose measured on the physical phantom set close to the accelerator target for mimicking the target handling and adjustment. Table 1 also showed the results of the ratio of HIs analytically estimated in accordance with the inverse square law of the radiation emission. The theoretically estimated HIs can predict the measured HIs within factor two. However, the discrepancy between analytically estimated and measured HIs were found to be factor 5. This might be explained by the difference of the exact distance between the source and the hand (palm) and the influences of the shielding and the source shape of the target.

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Table 1. Evaluated HIs from measurement using the physical phantom and the OSLs in the expo-sure situation which the adjustment of the target is simulated

	HI^{eye} or HI^{ext}	Ratio analytically estimated from the inverse square law
Right eye lens dose vs Trunk dose $H_p(3)_{eye}$ / $H_p(10)_{trunk}$	3.09 ± 0.09	5.67
Left eye lens dose vs Trunk dose $H_p(3)_{eye}$ / $H_p(10)_{trunk}$	4.62 ± 0.09	6.93
Right finger dose vs Trunk dose $H_p(0.07)_{ext}$ / $H_p(10)_{trunk}$	23.2 ± 0.63	149
Left finger dose vs Trunk dose $H_p(0.07)_{ext}$ / $H_p(10)_{trunk}$	20.7 ± 0.5	149

CO10-4 Investigation for valiation of trace elements concentration in accelerator room concrete

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INTRODUCTION: We are working on the research for establishment of more reasonable decommissioning process of accelerator facilities with the aid of Japan Nuclear Regulation Authority. Especially, concrete materials used as shields and buildings occupy the most amount of weight in a facility, and significantly contribute to the cost of decommissioning. The generated radionuclides should be identified in advance and waste should be separated into activated and non-activated are-as for efficiency and waste reduction, when decommissioning an accelerator facility.

However, the assessment of an activation concrete material is not easy. Currently, the destructive analysis by core boring is the only method of investigating that. From this background, we had developed a breakthrough method to estimate the activity of ^{60}Co and ^{152}Eu in activated concrete in the accelerator facility from the contact dose rate measurement with a survey meter [1,2]. This method strongly depends on the concentrations of cobalt and europium which is trace elements in a concrete. From the viewpoint of practical use, the variation of trace elements concentration in the concrete must be understood.

We also had developed the method for prediction the activity in the concrete material at future, by measuring the activities of ^{24}Na and ^{56}Mn immediately after the accelerator operation [3]. For this method, information of variation of natural sodium and manganese in concrete of accelerator facilities is indispensable.

In this study, we analyzed trace element concentrations in concrete samples of some accelerator facilities in Japan with neutron activation analysis which suitable for trace element analysis of ppm order, and compared the result.

EXPERIMENTS: Total 89 of core concrete samples collected from 8 facilities were prepared as irradiation samples. Each core sample were grounded to 100 μm mesh particle size by a ball mill. Two igneous rocks (JA-1, JG-3) were employed as references and prepared in the same way. For analysis of short-lived nuclides generated by neutron irradiation, 40 samples were irradi-ated at Pn-3 with 1 MW during 10 s, and measured with a Ge detector immediately after irradiation. All samples including the above 40 samples were irradiated at Pn-2 with 5 MW during 3000 s, and measured with a Ge de-tector after short lived nuclides were attenuated.

RESULTS: From the gamma-ray spectra of the samples, total 26 radionuclides generated by neutron capture reaction were identified. Although the analysis is in progress, variations of elemental concentration in concrete of the samples were determined as shown in Fig. 1. The concentration of cobalt and europium had been discussed in elsewhere [4]. We will discuss the other elements in the near future. Currently, we are working on a database of accelerator facility concrete measurements and plan to update it as needed.

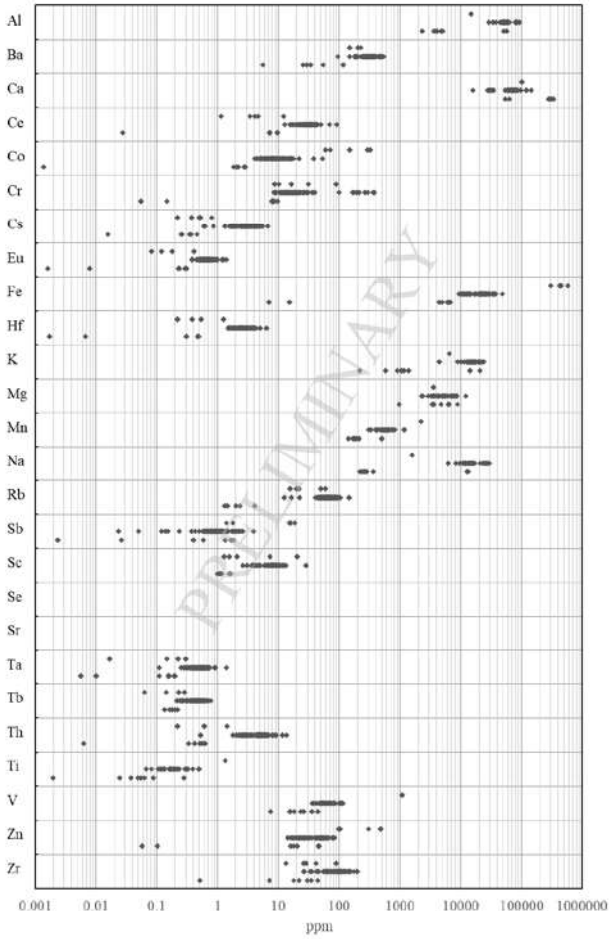

Fig. 1. Variation of elemental concentration in concrete samples of accelerator facilities determined by neutron activation analysis.

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CO10-5 Comparison of Chlorine Concentration in Each Municipal Solid Waste Fraction Measured by Neutron Activation Analysis and Bomb Calorimeter- Ion Chromatography

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INTRODUCTION: In recent years, plastic contained in waste has become a serious problem worldwide. Specifically, from the viewpoint of hazardous substances, some plastics generate hydrogen chloride and organic chlorine compounds when they burn, so information on chlorine is necessary. Therefore, in this study, the chlorine in each fraction contained in the municipal solid waste (MSW) was analyzed by the bomb calorimeter - ion chromatographic method (B-IC) and the neutron activation analysis (NAA), and the results were discussed and compared.

EXPERIMENTS: The MSW sampled from the pit of the MSW incineration facility of municipality A was classified into 20 categories, dried at 100 °C, and then homogenized to 2 mm or less with a crusher. Chlorine measurement was carried out for 16 categories listed in the Table 1 in which sufficient amounts were obtained for measurement. First, NAA for chlorine was performed four times for each sample. Samples were irradiated for 5 min with a thermal neutron flux of 2.0–2.4×10 ^{13} $cm^{-2}\cdot S^{-1}$ at KURRI. ^{38}Cl ($t_{1/2}$ = 37.18 min, E_γ = 1642, 2168 keV) were measured by using a Ge semiconductor detector for 60 sec. Chlorine conc. was also measured once by B-IC based on JIS K 7302-6 [1].

RESULTS: The chlorine concentrations measured by NAA and B-IC are shown in the Table 1. The difference in chlorine concentrations between the two methods was small except for used papers.

Regarding the kitchen wastes, the chlorine concentration of other kitchen wastes was smaller than that of the left untouched or uncooked foods. Except for the results of NAA for used papers, the chlorine concentration of disposable diapers was higher than that of other paper fractions. Especially for disposable diapers for infants, NAA result was about 13,000 mg/kg and B-IC result was about 18,000 mg/kg. It has been reported that it has not been disposed so long and that urine contains 8,600 mg/L of chlorine [2]. The high chlorine concentration in the disposable diaper is considered to be due to the adherence of chlorine derived from human. As the amount of disposable diaper waste increases with aging society, it is expected that the chlorine concentration in all papers will increase. The chlorine concentration of textiles, waste wood and grass were lower than that of the other categories. Plastics, except for PET bottles, generally had a high chlorine concentration. Although the composition of PET bottles does not contain chlorine, it is considered that chlorine was detected due to the adhesion of beverages and the like on the bottle. Wrapping plastics, other plastics, rubber and leather had a significantly high chlorine concentration. In particular, wrapping plastics exceeded 300,000 mg/kg by either method. It is conceivable that the chlorine content of the plastic as a whole and of the MSW as a whole will change greatly depending on how much of the wrapping plastics accounts for.

The chlorine concentrations measured by the two methods were compared (Fig.1). The slope of the regression line was 0.873, the correlation coefficient was 0.997, and the p-value was 1.5×10^{-16}, indicating a correlation. The chlorine concentration measured by B-IC was smaller than that measured by NAA, neutron activation analysis, and it was considered that only combustible chlorine was measured by the former.

Table 1 Chlorine conc. in each fraction of MSW measured by NAA and B-IC.

Items	Sub-Items	NAA mg/kg	B-IC mg/kg
Kitchen wastes	Left untouched or uncooked foods	10,100	13,000
	Others kitchen wastes	8,210	6,120
Papers	Disposable diaper for adults	6,170	6,180
	Disposable diaper for infants	13,300	18,000
	Used papers (Newspaper, Magazine, etc.)	11,400	1,360
	Packing papers (Cardboard, Carton)	2,480	1,100
	Other papers	4,140	2,030
Textiles	Textiles	3,200	1,130
Waste wood and grass	Waste wood and grass	1,530	729
Plastics	Packing plastics	17,700	8,510
	PET bottles	1,690	913
	Plastic container for lunch pack	10,700	7,880
	Other plastics	60,800	63,000
	Wrapping plastics	339,000	300,000
Others	Rubber and leather	142,000	108,000
	Others (Combstibles)	8,090	13,000

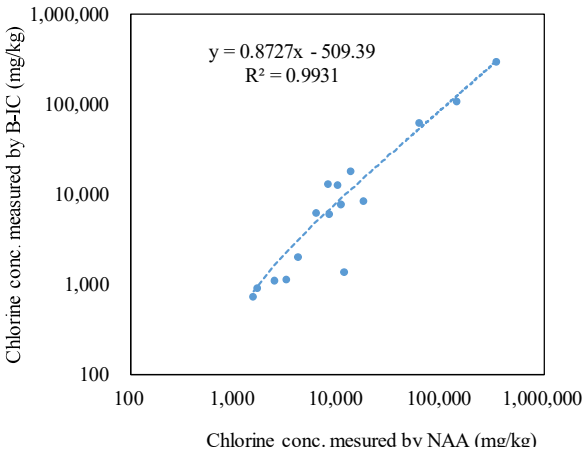

Fig.1. Relationship of chlorine conc. measured by between NAA and B-IC.

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CO10-6 Effect of Ammonium Ion Washing of Radiocesium Contaminated Soil

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INTRODUCTION: The radioactive Cs released by Tokyo Electric Fukushima Daiichi Nuclear Power Plant accident deposited on the widespread soil. Decontamination of the contaminated soil was carried out in residential area, but, when we consider disposal of contaminated soil on the occasion of final disposal, reduction of soil volume and Cs concentration by soil washing method may be necessary. So, elution of Cs from the soil needs to be care about, and the studies for its elution rate are often performed. This study clarified how problems of the liquid waste treatment can be improved by the ammonium ion soil washing method, how recycling rate of washed soil can be improved, and how Cs density of soil particle decreases quantitatively, by experiments using simulated pollution soil.

EXPERIMENTS: Two kings of soil, Soil A and Soil B, from the experiment forest of Iwate University were used. Each soil was used without any treatment or with heat treatment. Heat treatment was 1 hour heating at 500°C in a muffle kiln. So, four types of soil were used, which were Soil A without treatment, Soil B without treatment, Soil A with heat treatment, and Soil B with heat treatment. Contaminated soil was created artificially by adding 25 g of water solution containing 0.030 mg of Cs and 0.10 mg of Sr to 10g of each soil. They were dried for two nights at 45°C, then, added 25g of pure water again, and dried again by the same condition. 10 g of each soil was put into 250cc PP bottle, 50g of pure water or NH_4HCO_3 (0.56 mol/L) water solution was added to it, and shaken one hour. Then, 2.5cc solution was collected from each PP bottle, 1cc was used for metal element measurement by MP-AES and ICP-MS, and 1.5cc was used for NH_4^+ concentration measurement. After sieving out about half weight of total amount of soil with appropriate size of sieve, sieved solution was applied for ammonia stripping for the search of effects of decreasing the concentration of NH_4^+. 2.5cc of solution was collected at scheduled some times, and used for measurement of elements and NH_4^+.

RESULTS: Comparing the quantity of Cs and Sr elution by NH_4^+ before ammonia stripping with those by pure water, Sr elution by NH_4^+ is 1/2-1/5 of that by pure water, but, Cs elution by NH_4^+ is 70-300 times more of that by pure water. It means that residual rate of the Cs in soil by pure water elution was more than 98%, although, it was about 27.7-67.6% in the case of NH_4^+ washing depending on soil type. It also means that the concentration of Cs in soil treated with NH_4^+ washing can be decreased about half compared with that with pure water washing. Regarding the treatment of elution water by ammonia stripping where NH_4^+ concentration decreased shown as Fig.1, clear decrease was found in the case of following: all ions in soils with heat treatment; only Cs and K in soils without treatment shown as Fig.2. The concentration of just two monovalent ions in elution clearly decreased with elapsed time by the decrease of NH_4^+ concentration. Although, all metal ions in elution of soils with heat treatment, which had less changeable electric charge sites, decreased with process of ammonia stripping, those of soils without treatment, which had more changeable electric charge sites, showed clear decrease of adsorption of just only monovalent K and Cs which has less adsorption strength than multivalent ions and less effect from decrease of changeable electric charge sites at 180min elapsed time of ammonia stripping. It probably means that pH decreased with the decrease of NH_4^+ and cation exchange capacity by changeable electric charge sites where multivalent ions mainly adsorbed decreased. It is thought that competition adsorption theory with detail geological ion dynamics is necessary to understand the change of ion elution based on the existence ratio of various adsorption sites of each soil. The ratio is also changeable with pH changing with concentration of NH_4^+ in the process of ammonia stripping.

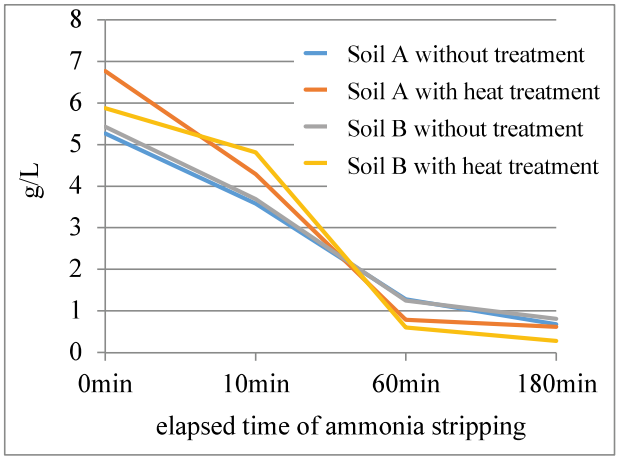

Fig. 1. Change of concentration of NH_4^+ by ammonia stripping.

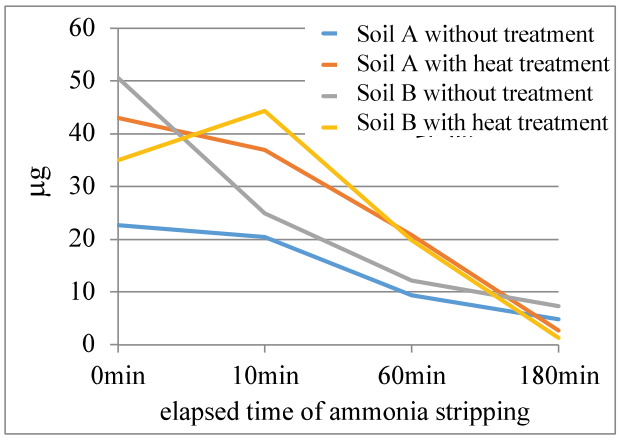

Fig. 2. Change of quantity of Cs in the solution by ammonia stripping.

CO10-7 Measurement of Radioactivity-Based Particle Size of Radiation-Induced Aerosols using a Diffusion Battery System in Accelerator Facilities

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INTRODUCTION: Recently mA-class accelerators have been used for isotope production and medical use. In the medical application, high intensity beams are necessary to reduce irradiation time for patients. The nature of radioactive species in air of the accelerator rooms is very important from the viewpoint of radiation safety in the high intensity accelerators.

During machine operation the accelerator room is filled with radiation-induced aerosol particles in the size range of several nm to ca. 100 nm in addition to radioactive gases. The size for the radioactive particles was often measured using a wire screen technique in accelerator facilities. Convenient size measurement techniques are needed for radiation protection in accelerator facilities.

In this work, continuing from the previous years [1], a newly-assembled screen-type diffusion battery (SDB) system was applied to measure aerosol particle size in the accelerator room (target room) of an electron linear accelerator (LINAC) facility.

EXPERIMENTS:

Principle: When very fine aerosol particles pass through wire screens, a part of the particles are deposited on the wire surface of the screens by their diffusion according to their particle size. The loss by the screens is expressed as a function of particle size, coarseness and number of screens, and flow rate of particles. The radioactivity-based size distribution of the aerosol particles can be calculated by measuring the penetration ratio (A/A_0), where A_0 and A are activity of the nuclide of the aerosol particles before and after penetrating screens, respectively.

The measurement system: The SDB system used in this work consists of an SDB line (Line A in Fig. 1) and a compensation line (Line B). Each line was connected to a ball valve and a mass flow controller (MFC) to change a flow rate independently. All valves and MFCs were controlled by a PC for automatic measurement of aerosol size distribution. In the SDB line, an air-tight wire screen cylinder containing a stack of three pieces of stainless steel screens (500 mesh).

Irradiation: The air-irradiation experiment was carried out in the 46-MeV electron LINAC of the Institute for Integrated Radiation and Nuclear Science, Kyoto University (KURNS). An irradiation chamber was placed at a rear position of a platinum target. During the irradiation, aerosol-free air was introduced to the chamber from the experiment room next to the target room. The target was bombarded with a 30-MeV electron beam to produce bremsstrahlung. The bremsstrahlung ionizes air and produces the radiation-induced aerosol. The beam current was ca. 80 μA.

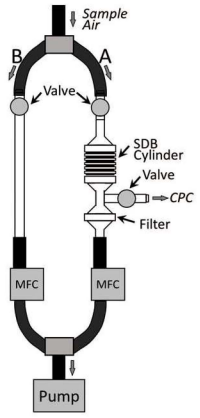

Fig. 1 The SDB system employed in this work

Measurement of activity-based aerosol size for the radiation-induced aerosol: The irradiated air containing the aerosol was simultaneously introduced to the SDB line and the compensation line. The aerosol particles were collected at the rear position of the SDB cylinder on a polytetrafluoroethylene (PTFE) membrane filter at the flow rate in the range of 0 to 15 L/min. During the sampling, the flow rate of the compensation line was adjusted so that total flow rate of both lines was 15 L/min.

Principal radionuclides collected on the filter were positron emitters such as ^{13}N and ^{15}O. The 511-keV annihilation γ-ray of the filter was measured to determine the activity with a coincidence counting system using two BGO detectors. The irradiated air was sampled continuously from both the upstream and downstream positions of the SDB cylinder, and the penetration ratios were calculated.

RESULTS: The particle size of ^{13}N-bearing aerosol particles was analyzed in this work. The PTFE filter is useful for accurate analysis of the particle size because the ^{13}N particles can be collected without absorption of NO_x and nitric acid gases on PTFE. The ^{13}N activity was determined by analyzing the decay curve of each filter. The curve of the penetration ratios (A/A_0) obtained by changing air flow rate were fitted to a theoretical function [2] for lognormal distributions to obtain the geometric mean and geometric standard deviation of particle diameter. The preliminary result of the size was 60 nm.in diameter.

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CO10-8 Consideration of radon concentration measurement under natural fluctuation environment by a new monitor using two filter method

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INTRODUCTION: This study focuses on improving a prototype monitor for accurately and versatilely measuring the concentration of radon and its decay products in response to increasing international demand for monitors that measure both radon and its decay products under several conditions. We have already developed the prototype monitor based on the two-filter method. The measurement target of this method is α-ray from ^{218}Po generated from the decay of ^{222}Rn as shown in Fig.1.

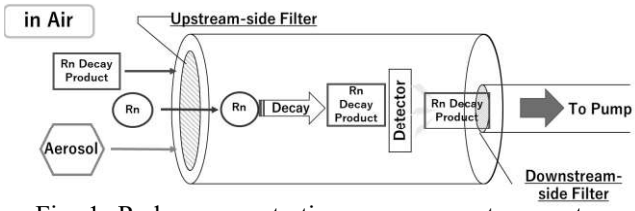

Fig. 1. Radon concentration measurement apparatus of 2filter method.

Through simple calibration tests and characteristic tests of the prototype monitor, we selected the suitable detector position for measurement and filters for up-stream side and down-stream side. From the results of these tests, we developed a new prototype monitor that can measure accurate radon concentration. The conversion factor from the counts of prototype monitor to the radon concentration was also obtained [1]. In order to evaluate the measurement ability of the new monitor, we measured radon concentration in the reactor room of KUCA where the fluctuation of radon concentration is close to that in the natural environment using the monitor.

EXPERIMENTS: To measure the radon concentration in KUCA reactor room, the new prototype monitor using two-filter method and a calibrated radon concentration monitor (RAD7) were installed in the room to compare with the results of these monitors. Experimental conditions of the prototype monitor were; detector: PIPS CAM300-17AM (40V), Upstream-side filter: No.4A+HE-40T, Downstream-side filter: GF/F, distance of detector-filter: 5mm, pump flow: 10L min^{-1}. The measurement interval was set to 1 run: 5 min × 5 times= 25 minutes, and this run was repeated for 50 hours. All ventilation systems of the reactor room were stopped because the radon concentration was not controlled. Therefore, the indoor condition in which the radon concentration will increase naturally was set.

RESULTS and DISCUSSION: Radon concentration (Bqm^{-3}) measured by the calibrated radon concentration monitor and the number of counts (cpm) measured by the prototype monitor are shown in Fig.2. From the results in Fig.2, the radon concentration increased to about 300 Bq in 50 hours with a tendency similar to the previous study [2]. The number of counts measured by the prototype monitor also increased to about 15 cpm in 50 hours. On the other hand, large fluctuations in both the concentration and the counts were observed after 45 hours. These behaviors were caused by unexpected changes in the measurement environment. Therefore, the conversion factor of relation the concentration and the count was calculated from the measurement result obtained from the start to 44 hours after. As a result, an average value of the conversion factor was 17 Bqm^{-3} / cpm.

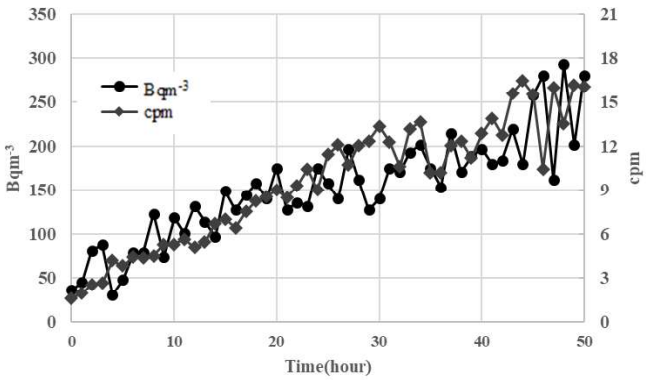

Fig. 2. Radon concentration (Bqm^{-3}) of the RAD7 and number of counts (cpm) of the prototype monitor in KUCA reactor room.

From the above results, the radon concentration measurement for a long time can be performed stably under the environment that a radon concentration naturally increases. There are some problems that the unintended noise significantly affects the measurement results. Therefore, it is necessary to consider an operating method that can eliminate the noise for outdoor measurements. In the future, we will improve the prototype monitor to measure the deposition of particulate nuclides on the inner wall of the decay chamber and the effect of the aerosol for the radon decay products to investigate for the operational stability of the concentration measurement of radon decay products.

REFERENCES:

[1] Y. Igarashi *et al.*, Rad. Prot. Dosim., **184** (2019) 418-421.
[2] KUR Aerosol Research Group, KURRI-TR-232 (1982).