Impact Analysis on the Uranium Evaluation Related to the Collecting Location of the Environmental Sample

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1. Introduction

International Atomic Energy Agency (IAEA) have been operating Environmental Sampling program (ES) based on the conclusion that nuclear material from the declared facilities or undeclared location could provide the basis to compare with the declaration. ES program process is as shown as Fig. 1. The step of planning and sampling could be easily underestimated rather than laboratory analysis

Fig. 1. Environmental sampling process.

There was a special case where the tons of Depleted Uranium (DU) sludge were deposited in the several tanks, out of compliance, in 2016. KINAC inspectors collected and analyzed it to determine whether the safeguards implementation is required [1].

This article shows the importance of the location of sample collection, based on the analysis results with the Monochromatic Micro X-ray Fluorescence (MMXRF), Alpha spectrometry (Alpha), and Thermal Ionization Mass Spectrometry (TIMS).

2. Method

Fig. 2 shows the specific tank (D: 12 m, H: 20 m) which was chosen for the analysis. This tank had included the many catalyst elements, such as Sb, SiO_2, Mo, etc. with the DU below 2.3 m height over 20 years [1]. The potable HM-5 device showed the DU seemed to exist only below 1.5 m. The inspectors assumed there was difference of uranium distribution caused by aggregation and remobilization, based on this result [2].

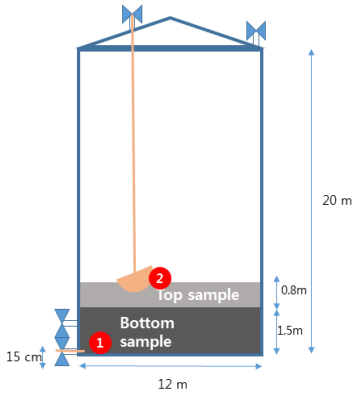

Fig. 2. Tank and sample location description.

Therefore, the inspectors collected the sample from top and bottom for expecting each sediment's representative. The samples were swiped and collected from (i) the drain nozzle which is located 15 cm off the bottom ground, (ii) the top hatch of the tank with the bucket. The type top and bottom sample was sludge with different density 1.01 and 1.06, respectively.

3. Result

The results with the TIMS (Isotopx), Alpha (Canberra) and MMXRF (ISP) are shown in Table 1. It shows that the uranium concentration of the bottom sample is about 221 to 414 times higher than top. TIMS and Alpha provided the result, 1996.6 ppm and 1366 ppm in the bottom parts. MMXRF, which is the equipment for mapping the uranium in the swipe sample, could not analyze the whole uranium concentration of each sample. But it could provide the comparison result and showed the difference between 221 to 414. It showed the top and bottom part has difference of uranium concentration.

Table 1. Analysis result of sample

Analysis Methods	Concentration [ppm]		Comparison
	Top	Bottom	
TIMS	5.69	1996.6	351
Alpha	3.34	1366 1036	310~408
MMXRF	-		221~414

Total uranium mass is calculated with the top and bottom mass assuming the values represent each sediments of the tank. Uranium mass of each part are calculated as below;

$$U = \frac{\pi D^2}{4} \mathrm{H}\ \rho\ C_U \qquad (1)$$

Where,

U = Uranium mass [kg]

D = Tank diameter [m]

H = Tank height [m]

ρ = Density [g/ml]

C_U = Uranium concentration [ppm]

TIMS results were adapted for uranium concentration as the most reliable result. Approximately 360 kg of the uranium is estimated to exist in the tank.

Only one sample would be collected from the tank, if the inspectors ignored the uranium remobilization effect of the tank. In that case, the analyzers have one sample from the top, because of the mixing concern and the easy approach to open the tank without overflow. Approximately 1.49 kg of uranium is estimated to exist in the tank, if the analyzers have one sample from the top. It showed that there is huge underestimation of the total uranium mass in the tank if the sampling procedure is ignored in the field.

4. Conclusion

The samples collected from tank without the information related to its homogeneity, axial and radial distribution of uranium in the tank. It leads to the misjudgment of the total uranium mass calculated with the concentration of the specific spot. It means the location of the sample could impact the quantity analysis. Therefore, the planning with pre-information and sampling is important as the analyze.

KINAC expected the further study, the way uranium with the flocculant remobilize in the closed system, could increase the accuracy of the quantity analysis of uranium.

REFERENCES

[1] Seungho Jeong, Heejun Chung, et al. “Management and Evaluation of Environmental Sampling 2016 Annual Report”, KINAC/RR-006/2017 (2016).

[2] International Atomic Energy Agency, “Uranium Extraction Technology”, Technical reports series No.359 (1993).