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Confirmation of Experiment Conditions for Measuring the Environmental Sample in the Site

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1. Introduction

Korea Multi-purpose Accelerator Complex (KOMAC) has been measuring and analyzing the tritium for water samples in the facility site every quarter to monitor the environmental radiation. As a low-energy beta emitter, the tritium has a low risk of the external exposure, but it is relatively dangerous from the viewpoint of the internal exposure since it can cause the radiation exposure in the body through ingestion or absorption through the skin. [1] Figure 1 shows the decay of tritium and the emission process of the beta particle.

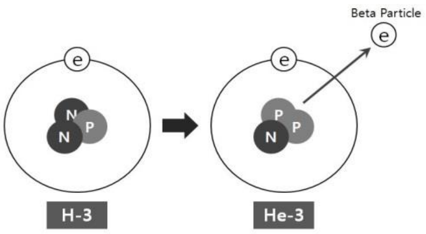

Figure 1. Decay of tritium and beta particle emission

Therefore, the tritium in the water should be derived from accurate and reliable results through appropriate measurement procedures. For this purpose, the suitable measurement conditions suitable for the surrounding environment and the sample are experimentally confirmed and the measurement procedure base on the experiment should be established.

2. Methods and Results

Generally, the low-energy beta-nuclide analysis using liquid scintillation counter (LSC) is widely used to analyze water samples and it is measured and analyzed using scintillator solution according to the sample condition. In order to analyze water samples, Ultima gold and Ultima gold (LLT) are used as scintillators. For Ultima gold is suitable for aqueous and non-aqueous sample measurement. Also it provides relatively high counting efficiency even for samples that exhibit severe quench. However, the amount of the sample is acceptable up to 2ml. For Ultima gold (LLT) the counting efficiency is lower than Ultima gold and sensitive to quenching, the range of samples suitable for measurement is limited. However the amount of acceptable samples available from 8ml to 11ml and with very low background levels. These two kinds of scintillator solution are used according to the characteristics and quantity of the samples. In the first quarter of this year, water sample has measured using two types of scintillator solutions. And MDA for two types are compared to confirm the optimal measurement the conditions.

2.1 Measurement

For sampling, certain amount of drinking water, rainwater, and reservoir water have been collected at a designated collection point in the site. Figure 2 shows the sampling points in the site. Figure 2 shows the sampling points in the site.

Figure 2. Sampling point in the site

The sample collected has been quantified with a micropipette and mixed with a scintillator solution. For Ultima gold, 2 ml of sample has been mixed with 10 ml of scintillator solution. In the case of Ultima gold (LLT), mix 8 ml of sample has been mixed with 12 ml of scintillator solution. Opaque vials are used for the color quenching in the sampling process such as polyethylene or Teflon vial. [2] Figure 3 shows the collected samples and sample vials mixed with scintillator solution

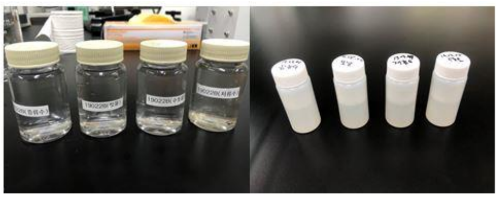

Figure 3. The collected sample (right) and the sample vials mixed with scintillator solution

The measurement time is set with reference to the minimum detectable activity (MDA) of tritium in water reported to the Nuclear Safety and Security Commission (NSSC). And in this experiment 1800 minutes are used. The sample is measured once each time. In summary, determine the amount of sample and scintillator solution that is appropriate for the type of scintillator solution should be determined and the other conditions should be kept the same and then the sample should be measured. Reliability of the measurement value is assessed through comparison with MDA. MDA is determined according to the amount of the sample, the measurement time, the geometric structure of detector, etc. The MDA equation is as follows. [3]

$$\mathrm{MDA} = \frac{2.71 + 3.29 \times \sqrt{R_b \times T_s \times \left(1 + \frac{T_s}{T_b}\right)}}{eff \times V \times T_s} \quad --- \quad eq\ 1$$

T_b is background measurement time, T_s is sample measurement time and R_b is background count rate (cpm). Generally, the longer the measurement time of the sample, the lower the MDA, however, since the measurement time is included in the numerator parameter, increasing the measurement time unconditionally dose not reduce the MDA. Therefore, it is necessary to try finding the optimal conditions for the measured variable to reduce the MDA.

2.2 Results

The MDA values reflecting the measurement conditions were used as the comparison variables because the amounts of samples and scintillators were different depending on the type of scintillator. In the MDA calculation formula, when the measurement time is the same, the value is determined according to the amount of the sample, the counting efficiency and counts per minute (CPM) of background. Table 1 shows the measurement value of two type of scintillator.

	Sample Volume	Efficiency	MDA
Ultima gold	2ml	42.59%	5.42 Bq/L
Ultima gold(LLT)	8ml	30.01%	1.71 Bq/L

Using Ultima gold (LLT), the counting efficiency was lower but the MDA was lower than Ultima gold due to the relatively high volume of sample as shown in table 1. From the view point of MDA equation, the measurement time, sample volume, counting efficiency and background level should be considered. Therefore it was confirm that sample volume is the most important condition for MDA when measurement time is same. Figure 4 shows the MDA value for two types of scintillator solutions.

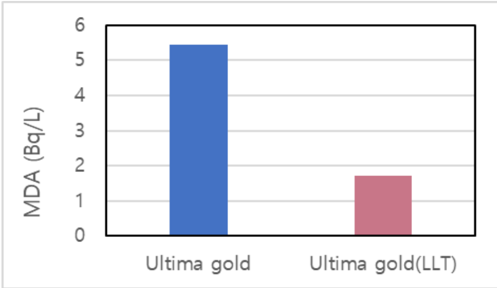

Figure 4. MDA for sample with two types of scintillator solutions

The size of the sample vial used for measurement is fixed. Therefore, amount of sample at an acceptable level has been considered, Ultima gold (LLT) is suitable for the analysis of water samples in general environment on the site in the MDA viewpoint.

3. Conclusions

KOMAC's Radiation Safety Team monitors quarterly the tritium in water by measuring water samples in the general environment on site. In water sample measurements using LSC, the tritium analysis was performed using the two most common scintillator solutions. MDA has been calculated using two types of scintillator solutions and compared with the measurement value of samples. As a result, it was confirmed that Ultima gold (LLT) is more suitable for the environmental sample analysis in the general site. In order to establish the measurement procedure for the environmental samples, the results derived from this experiment are used as the basic data.

REFERENCES

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