Design and Experimental Setup for In-situ Underwater Beta Monitoring System

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1. Introduction

Monitoring of groundwater is necessary for decommissioning of nuclear facilities because it contains the beta radioactive nuclides which include tritium. These nuclides must be managed from a health physics standpoint, but it is hard to detect because of its short range. Therefore, it is necessary to have a technique for detecting short range beta nuclides and quickly grasping the degree of contamination.

2. Methods

2.1 Concept of in-situ beta monitoring with scintillator

The detecting system was designed that directly contacts the radiation source with the scintillator for detecting short range beta ray[2]. Based on the design of detection part, detecting time can be reduced due to the increased detection efficiency. Fig. 1 shows schematic diagram for in-situ beta monitoring system.

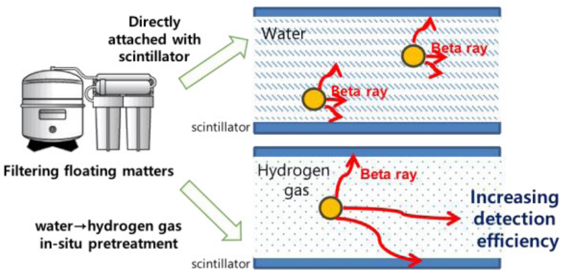

Fig. 1. Schematic diagram for in-situ beta monitoring system.

2.2 Experimental setup

The electronics are designed based on coincidence circuit for the background reduction and noise elimination. The details about each component are described at Fig. 2.

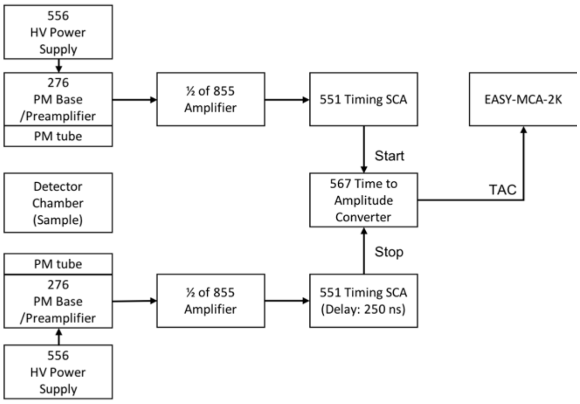

Fig. 2. Experimental setup of coincidence circuit electronics for beta detection.

2.3 Data analysis

Experiments on flow rate and amplification of electronics were carried out. The results were evaluated in relation to MDA (Minimum Detectable Activity). The MDA is defined as equation (1).

$$MDA = \frac{2.71+4.65\times\sqrt{B}}{T\times\epsilon\times/100\times V_c} \qquad (1)$$

Where,

B = Background sum (#)
ϵ = Efficiency (%)
T = Sample measurement time (sec)
V_c = Volume of sample (g/cm^3)

3. Results

The count rate measurement results according to radioactivity concentration were confirmed. The flow rate and the amplification of the electronics system are defined as parameters for the measurement and the results are described in this section.

3.1 Linearity to activity concentration

The linearity test between activity concentration and count rate was performed for checking the feasibility of the system. The linearity tests are done by the cases for radionuclides of ^{3}H and ^{90}Sr, amplification of 10, 20, 40. Fig. 3 shows the result foe linearity test in case of ^{90}Sr at 10 amplification.

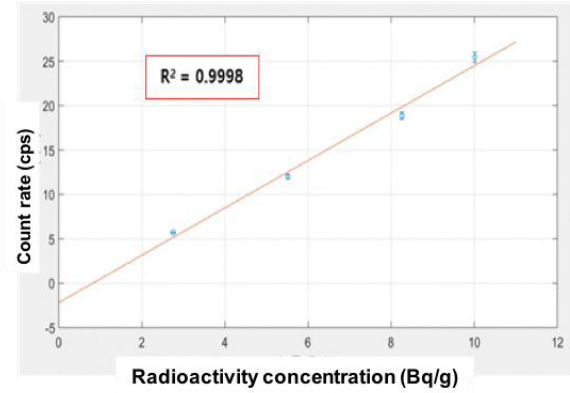

Fig. 3. The result of linearity test for radioactivity concentration to count rate (^{90}Sr, 10 amplification).

In case of ^{90}Sr, the coefficients of determination were 0.9998 at 10 amplification, 0.9992 at 20 amplification and 0.9954 at 40 amplification. In case of ^{3}H, the coefficients of determination were 0.9992 at 10 amplification, 0.9771 at 20 amplification and 0.9934 at 40 amplification. It was confirmed that all the results showed good accordance between radioactivity concentration and count rate with coefficients of determination which are bigger than 0.9.

3.2 Effect of flow rate

The flow rate was defined as 0, 600, 800, 1000 for the evaluation of the influence of the amount of water sample in the measurement part. The flow rate was varied, and the background counting rate was measured. The results were in Table 1. It was confirmed that the measured value did not change with respect to the change of the flow rate.

Table 1. Background counting rate per flow rate

0 mL/min	600 mL/min	800 mL/min	1,000 mL/min
31.12 ± 0.23 cps	31.12 ±0.17 cps	31.39 ± 0.12 cps	31.24 ± 0.19 cps

3.3 Effect of amplification

The target MDA was set to 1/10 of the initial activity concentration, and the amplification was varied to derive the required time for the measurement. The results were described at Fig. 4. It was checked that as the amplification degree increases, the required measurement time decreases.

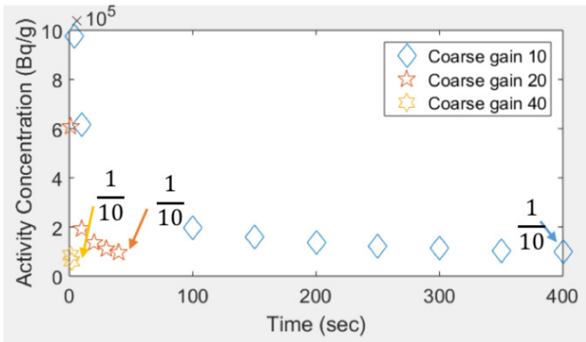

Fig. 4. Time to reach MDA by amplification difference.

4. Conclusion

The monitoring system for in-situ beta in water sample was designed and constructed. It was confirmed that the change of radioactivity concentration had a certain influence on the counting rate and the feasibility was secured to. The process for quantizing minimum detectable activity corresponding to a flow rate and amplification was performed. There was no effect on the flow rate, and it could be expected that the time for reaching the MDA could be reduced by optimizing the amplification and it can be applied to rapid monitoring system.

ACKNOWLEDGEMENT

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (Ministry of Science and ICT) NRF-2016M2B2B1945082, NRF-22A20153413555.

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[2] Thomas Theakston Alton, Stephen David Monk, and David Cheneler, “Beta particle energy spectra shift due to self-attenuation effects in environmental sources”, Nuclear Engineering and Technology ,49, 1483-1488 (2017).