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VALIDATION OF ^{32}P CHERENKOV RADIATION MEASURMENT METHOD OF URINE SAMPLES FOR LIFE SCIENCE WORKERS

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1. Introduction

Phosphorus is one of the mineral which is a structure material in environment, and accounts for much amount of naturally existing element in human body. Previously, many researchers reported that the main intake routes into body have been revealed by inhalation and ingestion. Intake by ingestion is mainly through the diet. The general compound of phosphorus is phosphate, and it can be formed as many chemical products depending on the pH. In various research fields, phosphorus has been used by using behavior characteristics as the form of radiolabelled compound in natural environment and human body.

Cherenkov counting method using LSC is also well known for beta emitting radionuclides with high energy. In particular, ^{32}P is emitting beta particles with above 263 keV which is threshold energy for Cherenkov radiation effect. Using this physical characteristic, ^{32}P measurement by Cherenkov radiation will be a good method for radiobioassay. The advantages of Cherenkov radiation counting for ^{32}P are to remove interferences of low energy beta and gamma emitters and reduce the expenses in counting sample preparation. Also, chemical quenching effect can be excluded because Cherenkov radiation is produced by physical phenomenon. In case of indirect measurement, minimum detectable activity (MDA) of counting samples can be improved by increasing sample volume without scintillation cocktail.

In this study, ^{32}P measurement and analysis procedures of urine samples were established. To apply it to radiation workers at laboratories using ^{32}P unsealed source, various factors of measurement for practical procedures were discussed. Pretreatment conditions were also discussed considering the characteristics of urine samples. And real urine samples collected from workers using ^{32}P source in the field of life sciences were measured following the practical procedure established in this study.

2. Methods and Results

2.1 Pretreatment and measurement of urine samples

For Cherenkov radiation measurement, the tendency between sample color and counting efficiency was evaluated in order to derive the accurate counting efficiency. Also, the counting efficiency was compared with Cherenkov radiation spectrum of external source in LSC. To derive the polynomial equation, ten standard samples spiked with ^{32}P standard source were made and counted.

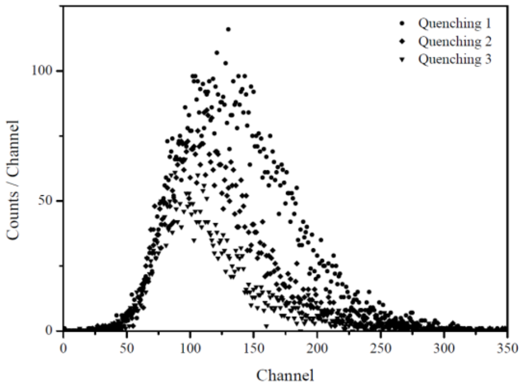

Fig. 1. Quenching spectrum of 3 color quenching standard samples.

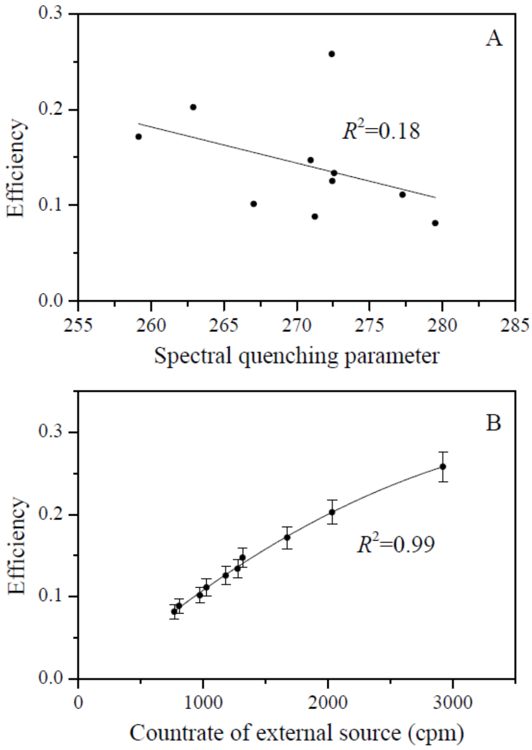

Fig. 2. The fitted curve between counting efficiency and (A) spectral quenching parameter and (B) Cherenkov radiation countrate of external source.

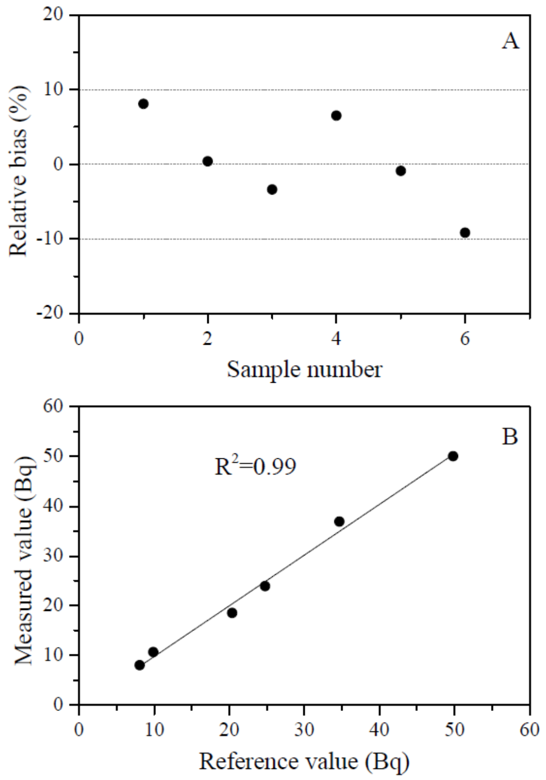

Fig. 3. (A) Relative bias distribution and (B) correlation curve between measured and reference values.

2.2 Counting efficiency

Color quenching of urine samples should be corrected to derive counting efficiency. In general, potassium dichromate and chromium trioxide were used for quenching agent as yellow in color [1]. Potassium dichromate was used as a color quencher considering the brightness of yellow color and chemical reaction. To differentiate the quenching degrees, color quencher was added by increasing 1% from 0 to 9%. All standard samples were spiked with the same amount of ^{32}P standard source (85 Bq ml^{-1}). 5 ml nitric acid was added to all standard samples for evaluation of chemical effect. Deionized water was added until 20 ml of each sample (Fig. 1).

Ten ^{32}P standard samples with the different amount of color quencher were made and detected to compare quenching degrees with counting efficiencies. Based on the comparison, the trend between spectral quenching parameter (SQP) and efficiencies was estimated. Based on the coefficient of determination, the counting efficiency did not demonstrate significant proportionality to SQP (R^2=0.18, Fig. 2(A)). In general, liquid scintillation counting method uses compton spectrum from external source such as ^{152}Eu, ^{226}Ra, etc. to determine quenching parameter of each sample. However, Cherenkov radiation is emitted in low energy range (0 - 50 keV), and conventional function of 1220 QUANTULUS LSC using compton spectrum could not be applied to Cherenkov radiation detection due to low energy Compton electrons [2]. To derive efficiency correction curve, the same standard samples were measured. Fig. 2(B) shows the decreasing trend of counting efficiencies following Cherenkov radiation countrate of external standard source. The accumulated countrate of external standard source was constantly decreased depending on volume of color quencher added to samples (R^2=0.99). Based on the fitted curve, counting efficiency equation of urine samples was derived.

2.3 Validation of measurement method

To validate the measurement method, real urine samples collected from 6 normal persons were analyzed. The activity of ^{32}P was corrected for the decay of half-life time from the mid-time of detection period to the mid-time of sampling. Relative bias between the measured values and spiked reference values ranged from -9.1 to 8.1%, which was well agreed within ± 25% recommended values for proficiency test criteria [3] (Fig. 3(A)). The influence by ^{32}P activity level could not be found and the validation results were very well agreed according to the activity (Fig. 3(B)). Based on the validation results, it is estimated that the measurement method can be applied to monitor ^{32}P activity of urine sample for workers.

3. Conclusions

In this study, ^{32}P Cherenkov radiation measurement for radiation workers in the field of life science was conducted. To evaluate ^{32}P activity of urine sample, Cherenkov radiation counting method was applied to real cases. The accuracy of measurement results were validated by using various methods. And measurement conditions for ^{32}P counting of urine samples were also discussed to establish standardized procedures. The measurement of most samples collected from workers was below MDA. Each one case of two workers was above MDA. The 2 workers did waste management in common. The overall results did not show significant level but some cases were a little high compared with background level which is needed to evaluate dose conservatively. In the future, detailed dose assessment using ^{32}P measurement results and monitoring programs for workers of other research field should be performed.

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