GROSS BETA ACTIVITY IN WATER BY CERENKOV METHOD

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Abstract

Cerenkov effect occurs when the charged particle velocity in a medium is larger than the speed of light in that medium. Cerenkov radiation is produced in water by β-emitting radionuclides of energy greater than 265 keV. The advantages of the Cerenkov method for gross beta activity determination are simplicity of sample preparation, low cost, possibility of reusing the sample, easy discard and efficiency unaffected by chemical quenching. The aim of this study is to compare the background, efficiency, Minimum Detectable Activity (MDA) and Figure Of Merit (FOM) for the determination of β-emitting radionuclides using two scintillation counters, Quantulus and Hidex. In order to evaluate these parameters, for both equipment, three standard solutions of gross beta activity were analyzed in triplicate. The performance of the determination of gross beta activity in water was evaluated by participating in a Proficiency Test organized by Instituto de Radioproteção e Dosimetria. The values obtained for the normalized standard deviation (D) was below 2, indicating a good precision and accuracy for both equipment.

Key words (bold): *Cerenkov, gross beta activity, drinking water*

1. INTRODUCTION

Water is more than a resource is also a life source. Therefore, access to safe drinking water is essential to health and a component of effective policy for health protection [1].

The process of identifying individual radioactive species in drinking water and determining their concentration requires sophisticated and expensive analysis, which is normally not justified, because the very low concentrations of radionuclides in most circumstances [1].

A more practical approach is to use a screening procedure, where the total radioactivity present in the form of alpha and beta radiation is first determined, without regard to the identity of specific radionuclides.

Screening levels for drinking-water below which no further action is required are 0.5 Bq per litre for gross alpha activity and 1 Bq per litre for gross beta activity [1, 2]. If this screening level is exceeded, then the specific radionuclides producing this activity should be identified and their individual activity concentrations measured.

With respect to screening procedure, the wide use of liquid scintillation counting (LSC) is a consequence of numerous advantages: high efficiency of detection, sample preparation techniques, automation and simultaneous analysis of different radionuclides [3].

When the sample to be analyzed consists of two radionuclides, one with energy exceeding the threshold and the other with energy within the threshold, the Cerenkov method can be used combined with LSC for the determination of gross beta activity.

When the velocity of a charged particle in a transparent medium exceeds the speed of light, the resulting radiation produced is called Cerenkov Effect. The Cerenkov radiation consists of a continuous spectrum of wavelengths extending from the ultraviolet region into the visible part of the spectrum [3].

When produced at significant levels, Cerenkov radiation can be employed for the measurement of radioactivity. Some radionuclides may be counted directly in water [3]. The advantages are: without scintillation cocktail, sample suitable for any other chemical tests; simplicity of sample preparation; low cost; easy discard and efficiency unaffected by chemical quenching [3].

The disadvantages are: the method is applicable only to beta emitters; energies above the threshold and the counting efficiency is lower when compared with LSC.

The threshold energy for the production of Cherenkov photons by electrons or beta particles is 262 keV [3].

The aim of this study is to compare the background, efficiency, Minimum Detectable Activity (MDA) and Figure Of Merit (FOM) for the

determination of ß-emitting radionuclides using Cerenkov method and two scintillation counters, Quantulus and Hidex. The equipment 1220 Quantulus™ Ultra Low Level Liquid Scintillation Spectrometer is composed by two photomultipliers and has the advantages of having an extremely low background for performing radioactivity measurements, while the Hidex equipment, model 300-SL, is composed by three photomultipliers [4,5]

2. Material and Methods

The initial step of pre-concentration of the water samples consisted of heating on a hot plate, at a temperature of 80 °C, until reduction of the volume by a factor of 32. An aliquot of 20 mL of each sample was measured in the appropriate vial.

The background was measured in triplicate with ultrapure water following the same pre-concentration procedure.

In order to evaluate these parameters, for both equipment, two standard solutions, Cs-137 with activity 2.4 Bq and Sr-90/Y-90 with activity 10.3 Bq, were analyzed in triplicate.

The performance of the determination of gross beta activity in water was evaluated by participating in a Proficiency Test organized by Instituto de Radioproteção e Dosimetria.

The channel range used for the gross beta measurement was from 5 to 350, for both equipment.

3. Results and Discussion

3.1. Background and efficiency

The results obtained for the background and the efficiency for both equipment using the Cs-137 are presented in Table 1. These results showed that the Quantulus presented a higher efficiency and lower background.

Table 1 Background and efficiency for Cs-137

	Efficiency ($cps.dps^{-1}$)	Background (BG) (cpm)
Quantulus	0.059 ± 0.002	1.74± 0.08
Hidex	0.049 ± 0.002	24.9± 0.4

The results obtained for the efficiency for both equipment using Sr-90/Y-90 are presented in Table 2. These results showed that the efficiency was slightly higher for the Quantulus.

Table 2 Efficiency for Sr-90/Y-90 for Quantulus and Hidex

Sample	Quantulus Efficiency ($cps.dps^{-1}$)	Hidex Efficiency ($cps.dps^{-1}$)
1	0.644 ± 0.002	0.607 ± 0.04
2	0.641 ± 0.002	0.600 ± 0.05
3	0.641 ± 0.002	0.599 ± 0.05

The efficiencies determined experimentally for Cs-137 and Sr- 90/Y-90 measurement are in good agreement with the literature values [3].

3.2. Performance of Quantulus and Hidex

The performance of the measurement of gross beta activity in water using Cerenkov method was evaluated by participating in the Proficiency Test organized by Instituto de Radioproteção e Dosimetria IRD/CNEN. The results obtained are presented in Table 3.

Table 3. Performance of the methodology

PT	Quantulus		Hidex	
(month/year)	Measured value[1] ($Bq.L^{-1}$)	D[2]	Measured value[1] ($Bq.L^{-1}$)	D[2]
dez/12	1.938	-0.51	1.913	-0.62
abr/13	0.817	-0.13	0.872	0.43
ago/13	2.254	0.43	2.283	-0.32
dez/13	1.827	-0,42	1.882	-0.17

[1]average value of 3 measurements

[2] D: normalized standard deviation

When D results are within the interval $-2 \leq D \leq +2$, the performance of the laboratory is considered good, data with $D \leq -3$ or $D \geq +3$ indicate that the measurement system is out of control and the performance is not acceptable. The values obtained for the normalized standard deviation (D) was below 2, indicating a good precision and accuracy for both equipment.

3.3. MDA and FOM

The results obtained for MDA and FOM for the Quantulus and Hidex equipment are presented in table 4. The MDA was determined for a counting time of 14,400 s.

Table 4 Results for MDA and FOM for Quantulus and Hidex

	MDA ($Bq.L^{-1}$)	FOM
Quantulus	0.175 ± 0.012	20
Hidex	0.798 ± 0.145	1

The results obtained show that the minimum detectable activity for Quantulus was lower than for Hidex, and the FOM also presented best results for the Quantulus.

4. Conclusion

The Cerenkov method combined with LSC was a good choice for the determination of gross beta activity measurement of samples that consist of two radionuclides, one with energy exceeding the threshold and the other with energy within the threshold.

It can be concluded from the results obtained that both equipment are suitable for the determination of gross beta activity by Cerenkov method, although the Quantulus performance was better.

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