2021 International Nuclear Atlantic Conference – INAC 2021
Virtual meeting,Brazil,November 29 – December 2, 2021

ISBN: 978-65-594-1256-3

Performance evaluation of NaI(Tl) and LaBr3(Ce) Portable Radiological Identifiers in the identification of 226-Ra and 228-Ra in scales from the petroleum industry

A. C. A. C. Izidório[1], D. F. Oliveira[1], L. S. R. Oliveira[2], and R. C. Curzio[2]

[1]*carolizidorio@hotmail.com*
davifoliveira@coppe.ufrj.br
Nuclear Instrumentation Laboratory/PEN/COPPE/UFRJ

[2]*lucianosantarita@gmail.com*
rodrigo.curzio@ime.eb.br
Instituto de Defesa Química, Biológica, Radiológica e Nuclear (IDQBRN / CTEx)
Av. das Américas, 28705
23020-470 Barra de Guaratiba, Rj

1.Introduction

Studies involving scales from the oil industry are being increasingly disseminated, due to its formation problem that promotes the reduction of production and the present radioactivity, which can lead to an increase in the dose to which workers in the oil industry are exposed during maintenance routine [1-3]. This radioactivity is due to the fact that oil wells have NORM (Naturally Occurring Radioactive Material) [4] in their composition, from the natural radioactive series, which, during the extraction process, makes the radioactive scales due to the precipitation of some radionuclides that are easily mobilized as is the case of the 226-Ra and 228-Ra, of the 238-U and 232-Th series, respectively. Therefore, the objective of this study is to evaluate the performance of the use of portable radiological identifiers (PRI) with NaI(Tl) and $LaBr_3$(Ce) scintillators [5], in order to previously analyze the dose rates of scales removed from different parts of the oil production plant and detect the presence of 226-Ra and 228-Ra by their descendants, showing whether it is possible to use it “in situ” in rapid analyzes for decision-making on the safety of radiological protection teams in critical environments of a production plant.

2.Methodology

Ten samples, six of scales and four of sludge, named A to J, collected at different points of the process plant from a FPSO (Floating Production Storage and Offloading) platform vessel, were macerated and passed through a 0.2 mm opening, ensuring the same granulometry size. Afterwards, 25 g of the sample were weighed and placed in polystyrene containers measuring 5 cm in diameter and 2 cm in height. The samples were measured with the PRI at a distance of 5 cm from the sample/detector, as shown in Figure 1. To obtain the most conservative response possible, the samples were measured after a period of 45 days, time needed to establish the secular balance of radon with the other elements of the natural radioactive series.

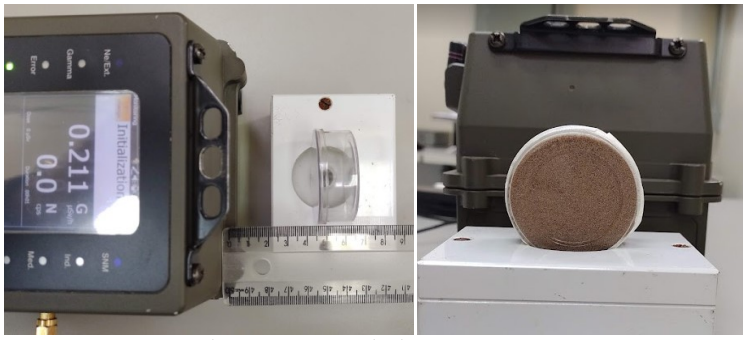

Figure 1: Correlation geometry

The PRI with scintillators of NaI(Tl) and $LaBr_3$(Ce) used in this study have 3.0"x 1.5" and 1.5"x 1.5" crystals, respectively, measuring range from 25 keV to 3000 keV and a dose rate of 0.01 µSv/h to 10 mSv/h. They were programmed for acquisition in 180 seconds, presenting energy distribution spectra in 1024 channels, and maximum dose rate measured during this acquisition time in µSv/h.

3. Results and Discussion

The dose rates obtained with $LaBr_3$(Ce) showed themselves slightly than those obtained with the NaI(Tl), as shown in Table I, but without changing its order of magnitude, presenting a maximum difference elevation of 0.07 µSv/h between the results.

Table I: Dose rates obtained with PRI.

Portable Radiologic Identifiers (µSv/h)		
Sample	NaI(Tl)	$LaBr_3$(Ce)
A	0.34	0.39
*B	0.25	0.29
C	0.32	0.39
*D	0.30	0.31
E	0.21	0.26
*F	0.31	0.32
G	0.30	0.34
H	0.31	0.36
I	0.23	0.24
*J	0.25	0.27
BG	0.20	0.23

*Sludge sample

Table II shows the energies that each PRI was able to identify, indicating the isotopes detected in each sample.

Table II: Energies identified by PRI for each sample

Isotope	Energy (keV)	PRI NaI(Tl)	PRI $LaBr_3$(Ce)
212-Pb	238.632	A,C,D,F,G,H,I	A,C,F,G,H,I,J
214-Pb	295.222	C,D,F,G,H	A,B,C,D,F,G,H
214-Pb	351.932	A,B,C,D,F,G,H	A,B,C,D,F,G,H,J
208-Tl	583.187	--	A,B,E
214-Bi	609.320	A,B,C,D,E,F,G,H,I,J	C,D,F,G,H,I,J
208-Tl	2614.511	A,B,C,D,E,F,G,H,I,J	C,H

The identification of 226-Ra, was given by its daughter nuclides 214-Pb and 214-Bi, by the energies of 295.22 keV and 351.93 keV; and 609.32 keV, respectively. And the identification of 228-Ra, by his daughter nuclides 212-Pb and 208-Tl, by the energies of 238.632 keV; and 583.187 keV and 2614.511 keV, respectively. The energy of 583.187 keV appears only in the spectra obtained with the PRI of $LaBr_3$(Ce), but it can be observed in Table II that when this energy appears, the energy of 609.32 keV does not appear. That is, as they are close energies, with only 26 keV of difference, it can be assumed that due to the efficiency of counting the equipment for medium energies, it cannot discriminate the two energies. The 2614.511 keV energy of the 208-Tl was discriminated in all spectra obtained with NaI(Tl) due to its better efficiency, even with low counting statistics.

4. Conclusions

The two identifiers are able to identify 226-Ra and 228-Ra in NORM containing scales, thus, both can be used for in situ analysis. However, the PRI of NaI(Tl) presented better performance because it has a better counting efficiency, offering a faster response, almost immediate, even with low counting statistics, mainly for well defined energies. The PRI of $LaBr_3$(Ce) despite presenting better resolution, during the measurements, it took approximately 10 seconds to give a response, that is, the crystal geometry and the low counting statistic affect the equipment response time. As they are equipments with different types and sizes of crystals, the dose rates were slightly different, but without changing their order of magnitude. It is concluded that the PRI allow fast analysis even in samples with little mass.

Acknowledgements

The authors would like to thank to the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) and Fundação de Amparo à Pesquisa do Estado do Rio de Janeiro (FAPERJ) for the financial support.

References

[1] A. T. Kan, M. B. Tomson, “Scale prediction for oil and gas production”, *Journal of Society of Petroleum Engineers - SPE*, vol.17 (2), pp. 362–378 (2012).

[2] J. M. F. Jesus, “Monitoramento de NORM na produção offshore de óleo e gás”, *X Latin American IRPA Regional Congress on Radiation Protection and Safety – IRPA, Sociedade Brasileira de Proteção*

Radiológica – SBPR, Rio de Janeiro - RJ, (2013).

[3] J. P. C. Garcia, "Análise de incrustações por técnicas atômicas/nucleares", *Tese de doutorado, Universidade Federal do Rio de Janeiro - UFRJ-COPPE*, Rio de Janeiro - RJ, (2010).

[4] S. P. Jesus, J. C. Vitorelli, A. X. Silva, "Aspectos normativos sobre ocorrência natural de material radioativo em rejeitos de petróleo", *International Nuclear Atlantic Conference – INAC*, Santos - SP; ISBN: 85-99141-01-5, (2005).

[5] L. S. R. Oliveira, A. S. Amorim, M. C. V. Balthar, P. R. T. Vilela, A. Santos; D. O. Cardoso, A. C. A. C. Izidório, S. Q. Pelegrineli, F. R. Santos, C. A. M. Ribeiro, D. C. Silva, L. B. Silva, S. L. Silva, "Análise Qualitativa de Th-232 em amostras de solo com identificadores radiológicos portáteis NaI(Tl) e LaBr3(Ce)", *International Joint Conference Rádio,* Goiânia-GO, (2017).