Determination of attenuation coefficients in aqueous saline solutions

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This report presents the simulation and modeling developed using the Monte Carlo method through MCNPX, for studying the determination of the mass attenuation coefficients of solutions with different concentrations of salts [1]. The input developed in MCNPX code has the following characteristics: a cylindrical container 5 cm high filled with a saltwater solution, a 2" × 2" cylinder representing the detector's NaI crystal and a monodirectional radioactive source with emission energy of 59.54 keV, from ^{241}Am, as shown in Figure 1. The detector's aligned.

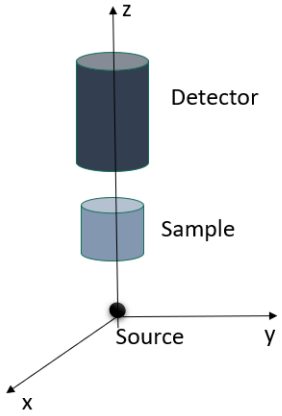

Figure 1. Detection system.

The simulation was carried out for 5 samples with different concentrations of NaCl: 1%, 3%, 5%, 7% and 10%. The tally F8 was used in the simulations. It generates a pulse height distribution (PHD), in the same way as a spectrum measurement in a standard gamma-ray detector setup. The data recorded in the simulations were treated, resulting in a pulse count graph for each sample, as identified in Figure 2. The pulse count obtained by the graphs of each sample was used to calculate the mass attenuation coefficient.

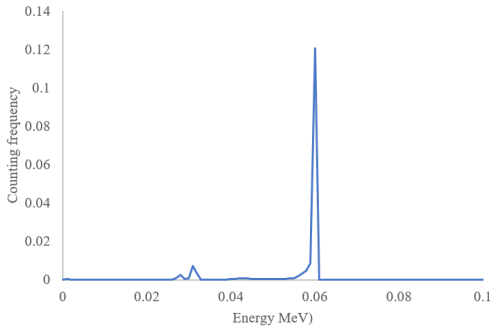

Figure 2. PHD for concentration of 5%.

The mass attenuation coefficients μ_m were calculated using the Lambert-Beer equation, $I = I_0 e^{-\mu_m \rho x}$, where I_o is the source intensity, I is the measured intensity (photopeak), ρ and x are the solution's density and thickness, respectively. For each sample, the calculated μ_m was compared with the theoretical value from the XCOM database [3]. The results are presented in Table 1.

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Table 1 – Results for each sample.

Concentration of NaCl in the solution (%)	Solution Density [g/cm^3]	Mass Attenuation Coefficient [cm^2/g]	Theoretical value (XCOM) [cm^2/g]	Relative error (%)
1	1.007	0.1798	0.2074	13
3	1.028	0.1873	0.2104	10
5	1.050	0.1954	0.2134	8
7	1.072	0.2047	0.2164	5
10	1.108	0.2169	0.2209	2

The modeling values have a relative error of up to 13%, pointing to approximate values to the theoretical values indicated by XCOM, thus being acceptable, considering that the values of the densities are close.

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