Study of mass attenuation coefficient in brine using MCNP-X

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Introduction

This report presents an elaborate model using MCNP-X code to calculate the attenuation coefficients of the saline water with different concentrations in the energy range from 59.54 keV to 600 keV. The determination of the linear attenuation coefficient of materials is of great importance in many fields of applied science [2]. The code has become a very effective tool because of its various applications in a number of areas highlighted for radiation shielding calculation, modeling of nuclear facilities, radiological protection, among others.

Computational modeling

The MCNP-X code is used to simulate similar conditions applying a narrow beam gamma source, a brine sample and a NaI(Tl) detector. Through this model, one can relate the photon attenuation coefficient to the salinity of water. However, this method shows high sensitivity, in gamma rays at low energy, in relation to the salinity content present in water, due to the high atomic number of chlorine atoms, which significantly modifies the photoelectric absorption region [2]. Using the Beer-Lambert's law, it is possible to calculate the mass attenuation coefficient (μ/ρ), as shown in Equation 1.

$$\mu/\rho = [-\ln(I/I_0).t^{-1}].\rho^{-1} \qquad \text{Eq. (1)}$$

I_0, I - incident and transmitted beam intensity;
t - thickness of the sample;
μ - linear attenuation coefficient.

Results

Simulations were carried out with a water sample and it was possible to conclude that the results of mathematical model agree with the theoretical values of National Institute of Standards and Technology (NIST) [1], as shown in the Fig. 1, thus, validating the model developed using the MCNP-X code. This modeling will contribute to save time when planning experimental tests.

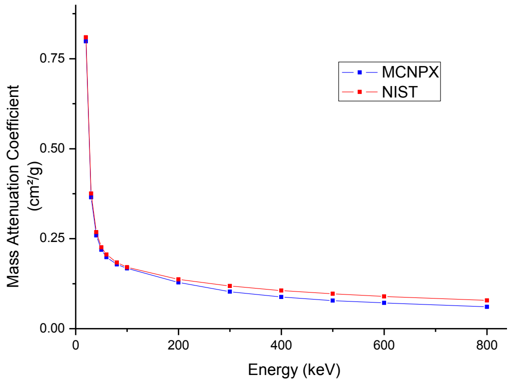

Figure 1. Comparison between NIST and MCNP-X code results.

To evaluate the interference of salinity in mass attenuation coefficient another simulation was carried out using water with different salt (NaCl) concentration and it was observed that only in the low energy region - below 100 keV - it is possible to distinguish the difference between the salinity and the measure differences in mass attenuation coefficient, as presented in Fig. 2.

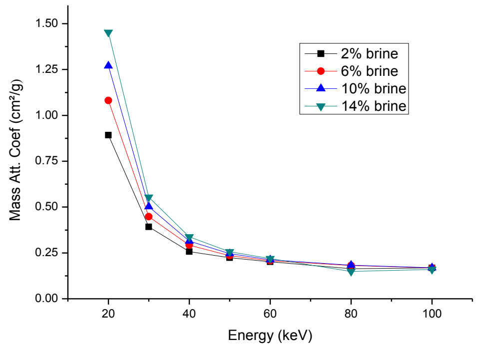

Figure 2. Mass attenuation coefficient in energy function with variations in salinity.

The results suggest that the low-energy region is the most sensitive to salinity and, thus, the use of low-energy sources allows for the distinction of the fluid inside a pipe.

References

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