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STUDY OF PHOTON ATTENUATION COEFFICIENT IN BRINE USING MCNP CODE

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ABSTRACT

In petroleum industry, multiphase flows are common and the relative salt content of the water component depends on the location of oil extraction. The salt present in the water component causes incrustations in the pipeline and may interfere in the flow measurement. This paper presents an elaborate model using MCNP code to simulate a narrow beam gamma ray source, a brine sample and a NaI(Tl) detector, with beam energies ranging from 59,54 keV to 662 keV. Through this model, we can relate the photon attenuation coefficient to the salinity of water. This model can be experimentally reproduced, and used to measure the salinity *in situ* without affecting the medium.

1. INTRODUCTION

The use of techniques for determining parameters for multiphase flows with adequate accuracy becomes necessary. By using gamma radiation sources, it is possible to determine the fraction of each component without interfering with the operating conditions. However, this method shows high sensitivity component of water has salinity content in gamma rays at low energy due to the high atomic number of chlorine atoms, which significantly modifies the photoelectric absorption region. One method to address this is to regularly measure salinity in the water and use this data to correct the output device. However, in applications where you cannot access the production line, this solution would not be feasible[1]
The MCNP-X code is used to calculate the attenuation coefficients of the saline water with different concentrations and energy ranges. The MCNP-X 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. The determination of the linear attenuation coefficient of materials is of great importance in many fields of applied science. [2]
The incidence of gamma radiation in a material, is scattered part of the beam part is absorbed and a fraction passes through the material without interacting. It is possible to quantify this process of radiation interaction with matter, checking the radiation intensity fraction attenuated through material. Through this relation gives a parameter, which is called linear attenuation coefficient which depends on the energy of the gamma radiation and the proprieties of the material. The coefficient represents the probability of suffering beam attenuation due to Compton scattering events and, photoelectric absorption and pair formation.

When a beam of gamma rays focuses on a material with thickness x, a part of this beam passes through the material without interacting, and that beam whose intensity I is associated with the incident beam I_0 through Beer- Lambert's Law, described in equation

$$I = I_0 e^{-\mu t} \quad . \tag{1}$$

Where I_0 and I are the incident and transmitted beam intensity of monoenergetic gamma-ray photons, t the thickness of the sample, and μ are the linear attenuation coefficient.
To calculate the mass attenuation coefficient, you must enter into the equation the density of the material, dividing μ by ρ , so that

$$\mu/\rho= - (I/I_0)/t/\rho \quad . \tag{2}$$

2. MATERIALS AND METHODS

2.1. Materials

It used the X-MCNP code, to the energy range of 20 keV to 800 keV, monoenergetic source, collimated located at the origin. The sample with dimensions 5x4x5 cm sample detector and the source aligned in the y axis, 2x2 detector "NaI (Tl), with a resolution of 7.5%.
Computer modeling using the MCNP-X was developed similar to the experiment data. The input files have been described geometries related to the sample and detector, as well as the type of material of each component and source energy. An input file for each energy and salinity content was prepared, and yet, for without water salinity. The levels used were 2%, 6%, 10% and 14% for NaCl.

2.2. Methods

It was drawn up MCNP-X an initially simple geometry containing a collimated monoenergetic source, aligned with NaI (Tl) detector to calculate the detector efficiency. After this step, the sample of water (H_2O) and measured in the same energy range was inserted. After generating the input file, the program simulating the simulation data obtained were used to calculate the linear attenuation coefficient (μ) and mass attenuation coefficient (μ / ρ) of water. The values obtained in the simulation were compared with the theoretical values NIST.
Below the sample become more complex, as a water solution was created with sodium chloride contents, 2%, 6%, 10% and 14% salt, a brine solution. The simulation was also made with the same energy range.

3. RESULTS

Comparing the results of MCNP with the theoretical values of NIST, a good agreement is obtained, as shown in the Fig. 1.

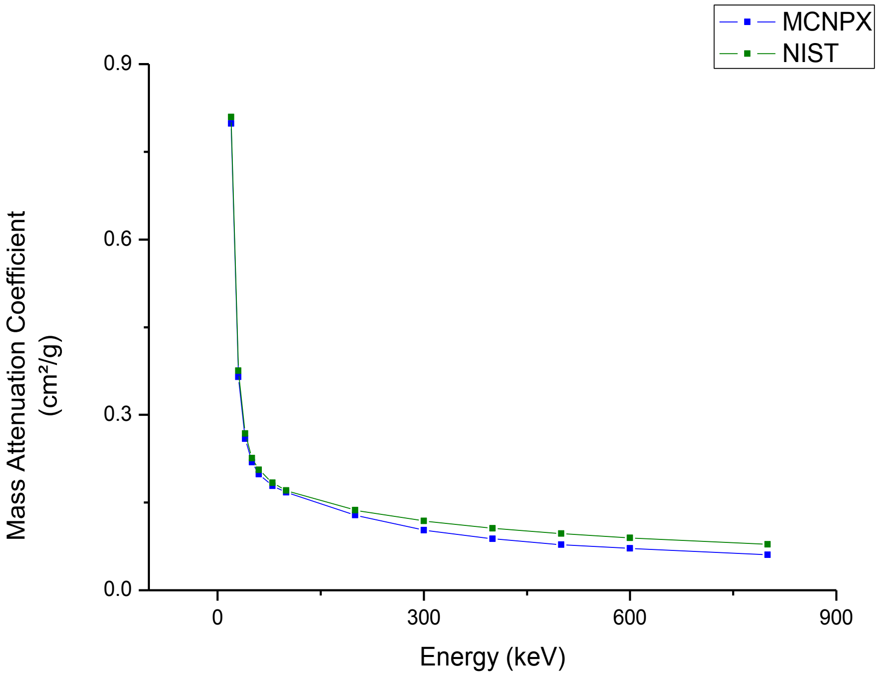

Figure 1: Comparison between NIST and MCNPX results.

Thus, we can say that the model developed in MCNPX was validated, and that the program meets the specifications of computer modeling, saving preparation time and executing a practical experiment.
In the next step, it was observed that the low energy region where there is improved sensitivity in relation to the absorber, presented in Fig. 2.

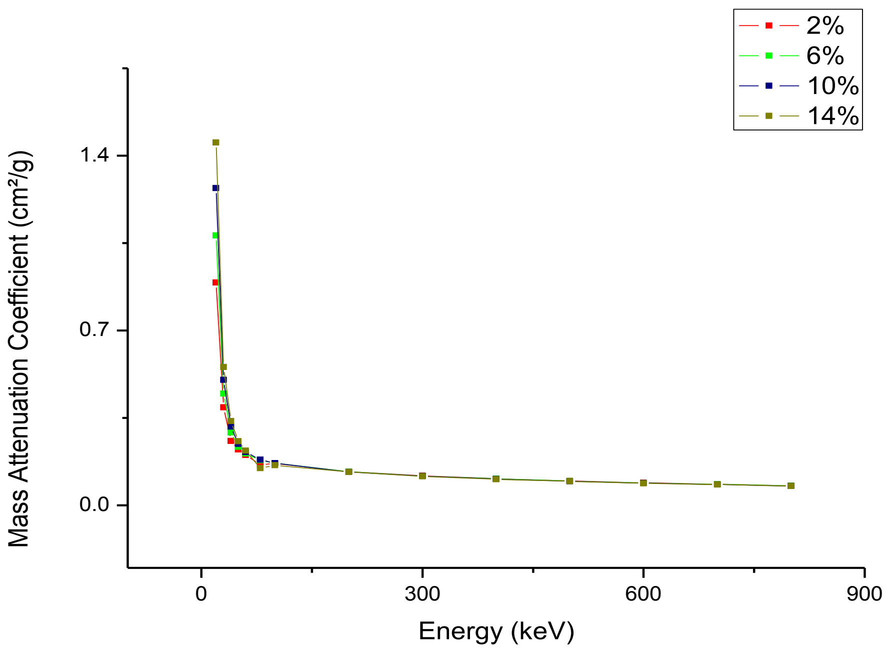

Figure 2: Mass attenuation coefficient in energy function, with variations in salinity.
It is noted that the low energy region has a greater attenuation, presented in Fig. 3.

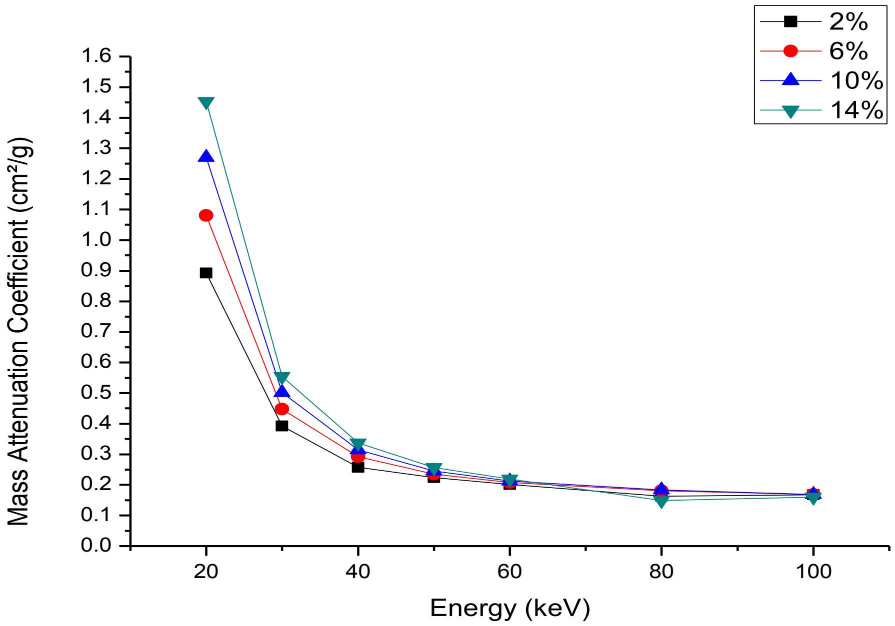

Figure 3: Zoom in the low energy region.

3. CONCLUSIONS

Johansen and Åbro [3] present a method using a source of low energy, it offers the advantages of small size due to reduced shielding requirements, compact detector and less dependent on the flow regime due to its configuration the measurement of multiple beams. With these results, it is concluded that the low-energy region is the most sensitive to salinity, and thus, the use of low-energy sources, makes it the safest measured in relation to radiological shielding.

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