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# Study of Dose Calculation of Beta-Emitting Source for Palliative Treatment of Spinal Cancer using MCNP6.2 Code

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## 1. Introduction

Brachytherapy is a highly effective radiotherapy modality involving the insertion of short-distance radioactive sources near the target volume or directly into the area to be treated. Among the various types of cancer, central nervous system (CNS) cancer poses significant challenges due to its location and complexity. CNS cancer encompasses tumors originating in the brain, spinal cord, and their meninges [1]. One of the radioactive sources used in brachytherapy is phosphorus-32 ($^{32}$P), a beta particle emitter, which has shown promise in treatment due to its ability to deliver a higher radiation dose to the tumor while minimizing exposure to healthy tissues. In comparison with gamma-emitting sources, beta emitters are suitable candidates for certain brachytherapy treatments due to the short range of electrons in tissue, resulting in rapid energy deposition with distance and a steep dose gradient [2,3]. Precise determination and delivery of the radiation dose to the tumor are directly associated with improved treatment outcomes, including enhanced tumor control and reduced post-radiotherapy complications [4,5]. In this context, the Monte Carlo method has become a crucial tool for calculating doses and other relevant parameters related to cancer treatment with radiation [6].

The aim of this study is to calculate the dose of a new $^{32}$P source using the Monte Carlo code (MCNP version 6.2) and to compare the results with previously proposed data in the literature, aiming to validate the model used and contribute to a better understanding of the application of $^{32}$P in the treatment of spinal tumors.

## 2. Methodology

In this study, Monte Carlo simulations were performed using the MCNP code version 6.2 to determine the dose values at different depths (0.0125, 1.0, 2.5, 4.0 and 7.5 mm). A water-filled phantom, sized 6.0 cm x 6.0 cm x 2.0 cm, was employed in the study. The $^{32}$P source was modeled as a plaque measuring 5.0 cm x 5.0 cm x 0.04cm, and its energy distribution was obtained from the beta spectrum available on the International Atomic Energy Agency (IAEA) website. Fig. 1 illustrates the geometry used in the simulations. The dose in water was calculated using the *F8 tally. This methodology, based on rigorous principles of modeling and simulation, aims to provide reliable and accurate results, contributing to the advancement of knowledge in dosimetry and radiological protection.

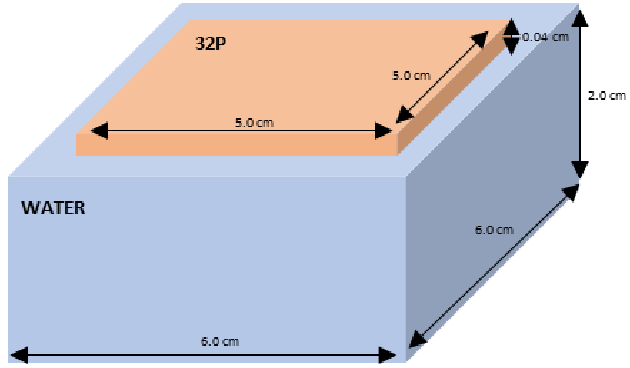


Figure 1: The geometry employed in the simulation to obtain the dose distribution.

## 3. Results and Discussion

The dose was calculated at each specified depth, presenting Gy values per unit of activity (GyBq). The results were compared with data available in the literature to validate the model and methodology used. The obtained results indicate that the dose from the $^{32}P$ source decreases exponentially with increasing depth in the water phantom. Additionally, the relative errors associated with the calculations were analyzed and found to be within an acceptable range, generally below 10%.

Table I: Dose values calculated in MCNP6.2 (dose per unit activity GyBq)

| Depth in water (mm) | $^{32}P$ source with MCNP6.2 (This Study) | $^{32}P$ Sahoo 2015 |
|---|---|---|
| 0.0125 | $4.02 \times 10^{-10}$ | $3.62 \times 10^{-10}$ |
| 1.0 | $9.16 \times 10^{-11}$ | $8.41 \times 10^{-11}$ |
| 2.5 | $6.67 \times 10^{-12}$ | - |
| 4.0 | $3.15 \times 10^{-13}$ | $2.93 \times 10^{-13}$ |
| 7.5 | $2.53 \times 10^{-15}$ | $2.74 \times 10^{-15}$ |

## 4. Conclusions

This study demonstrated that the results obtained were consistent with previously published data, indicating the validity of the model and methodology employed. The ability to accurately calculate the dose is crucial to optimize the treatment and ensure the effectiveness and safety of brachytherapy procedures for patients with spinal tumors. Future work may explore geometries and incorporate heterogeneities to further enhance the efficacy of the results.

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