atom indonesia

Exist for publishing the results of research and development in nuclear science and technology

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C o n t e n t s

EDITORIAL

Dear reader,

It is a great pleasure to provide you with the first issue of Atom Indonesia in 2024, namely Vol. 50 No. 1 (2024). The Atom Indonesia Vol. 50 No. 1 (2024) contains ten articles discussing various aspects and applications of nuclear science and technology. The contributors of those articles are not only from various national institutions and universities but also from international institutions.

"Investigation of Tissue Components Impacts on Dose Enhancement Factor Using Monte Carlo Code" was written by M. N. Al-Suhbani, N. E. H. Baghous, and C. El Mahjoub from Laboratory of Material Physics and Subatomic, Department of Physics, Faculty of Sciences, Ibn Tofail University, Kenitra, Morocco in collaboration with, S. Serag from Department of Engineering - Università degli Studi della Campania "Luigi Vanvitelli, Italy, L. Ait-Mlouk from Velindre Cancer Centre, Velindre Rd, United Kingdom, A. Zia from Faculty of Sciences, Abdelmalek Essaâdi University, Tétouan, Morocco, B. Hamid and M. Azougagh from College of Technical Education (ENSAM), Mohammed V University, Rabat, Morocco. Despite the progress of science in cancer treatments and improvements in radiotherapy, several side effects still occur during tumor treatment, particularly affecting healthy tissues surrounding tumors. New treatment methods are being explored lately, one of which is the use of nanoparticles, wherein the tumor is injected with gold nanoparticles. It aims to enhance tumor sensitivity to radiation and reduce radiation damage to healthy tissues. Tissue type may play an effective role in enhancing the dose being received under the use of nanoparticles. This study aims to find the effect of different tissue components on dose enhancement factors through MCNP6 and GATE simulations, as well as to accurately compare the simulation results of these two code packages for dose enhancement factors. A 125I brachytherapy source was simulated in phantoms for five tissues or materials (adipose tissue, breast tissue, soft tissue, water, and brain tissue). The MCNP6 simulation code was validated by comparing its results with a previous study by Cho et al. Gold nanoparticles were injected as a mixture at a concentration of 7 mg/g into tissues inside a tumor. MCNP6 and GATE simulations results were compared. It was estimated from MCNP simulations that the highest radiation dose enhancement of 2.34 occurs in adipose tissue, while the lowest dose enhancement of 1.69 is in the brain. In comparison, from GATE results, the estimates were that the highest value of dose enhancement factor also occurred in adipose tissue at 2.01, and the lowest value in the brain at 1.48. The comparison between the two codes suggests that they are compatible, with the percentage difference in all tissues being less than 15 %. This study confirms that both MCNP6 and GATE codes could calculate DEF for different tissues under irradiation from a low-energy source.

"Neutronic Design Modification of Passive Compact-Molten Salt Reactor" was explored by R. A. P. Dwijayanto from Research Centre for Nuclear Reactor Technology, Research Organisation for Nuclear Energy, National Research and Innovation Agency, BJ Habibie Science and Technology Centre, South Tangerang, Indonesia collaborating with A. W. Harto from the Department of Nuclear Engineering and Physics Engineering, Faculty of Engineering, Universitas Gadjah Mada, Yogyakarta, Indonesia. A passive compact molten salt reactor (PCMSR) is a design concept of a molten salt reactor (MSR) currently under development at Universitas Gadjah Mada, Indonesia. It is designed as a thermal breeder reactor using a thorium fuel cycle. However, our previous study shows that the original PCMSR design was incorrectly modeled, primarily overestimating its thorium breeding capability. To improve the PCMSR neutronic design, we modified the core configuration by adding radial fuel channel layers previously nonexistent in the original PCMSR core design in various configurations. Neutronic parameters of modified PCMSR geometries at the beginning of life (BOL) were simulated using MCNP6.2 radiation transport code with ENDF/B-VII.0 library. All variations of fuel layer addition show improvement in both temperature coefficient of reactivity (TCR) and breeding ratio (BR), with TCR values becoming more negative and BR values being larger than unity, ensuring proper breeding capability. The Inner Core-Outer Blanket (IC-OB) configuration achieves the largest BR and lowest doubling time (DT), whilst its TCR is an improvement

from the original design. Therefore, the IC-OB fuel layer configuration can be applied to redesign the original PCMSR and used in various design optimization scenarios.

"Differential Cross Section with Volkov-Thermal Wave Function in Coulomb Potential" was written by S. H. Dhobi and J. J. Nakarmi from S. H. Dhobi from Central Department of Physics, Tribhuvan University, Kirtipur, Nepal collaborating with S. P. Gupta and K. Yadav from S. P. Gupta from Department of Physics, Patan Multiple Campus, Tribhuvan University, Lalitpur, Nepal, J. J. Nakarmi from Innovative Ghar Nepal, Lalitpur, Nepal and, A. K. Jha from Department of Mechanical and Advance Engineering, Institute of Engineering, Pulchowk Campus, Tribhuvan University, Lalitpur, Nepal. Laser-assisted thermal electron-hydrogen atom elastic scattering was studied in the first-born approximation. The initial and final states of the projectile electron are described by the modified Volkov wavefunctions known as Volkov-Thermal wavefunctions. The laser-assisted thermal electron with energy ranges from 0.511 MeV to 4 MeV was considered to study the differential cross section (DCS) at azimuthal angles 30° and 14.7°, and laser-assisted field photon energy 1 eV to 3 eV, which is very weak at room temperature is around the room temperature 280 K to 300 K. Destructive interference was observed when a thermal electron absorbed a single photon from the laser field, but no interference was found when a thermal electron emitted an electron to the laser field at a scattering angle. The DCS with electron thermal (eT) scattering was found to be greater than a nonthermal electron in the presence of a laser field, considering the scattering angle and incidence energy of the electron.

"Monte Carlo Methods to Simulate the Propagation of the Created Atomic/Nuclear Particles from Underground Piezoelectric Rocks Through the Fractures Before the Earthquakes" was explored by A. Bahari, S. Mohammadi, N. S. Shakib, M. R. Benam, and Z. Sajjadi from Department of Physics, Payame Noor University, Tehran, Iran. Until now, many studies have been performed on particle radiations before or during earthquakes (EQs). Neutron, gamma, electron, proton, and ultra-low frequency (ULF) photons are among the particles, detected during EQs. In our previous study, with the help of piezoelectricity relationships and the elastic energy formula, the Monte Carlo N- Particle eXtended (MCNPX) simulation code was applied to find the amount of created atomic/nuclear particles, the dominant interactions; and the energy of the particles for various sizes of quartz and granite blocks. In this study, using the MCNPX simulation code, we have estimated the flux of the particles created from under-stressed granitic rocks at different distances from the EQ hypocenter inside the fractures, filled with air, water, and CO2. It was found that inside a water-filled fracture, the particles do not show the flux far from the EQ hypocenter. However, inside gases like air and CO2 with the normal density condition, different types of particles can have a flux far from the source (more than a kilometer) and they might reach themselves to the surface in the case that the EQ hypocenter is very shallow (0-5 km). However, for deep EQs, it seems that the most detected nuclear particles on the surface should pass via the vacuum-filled fractures and reach the surface. Moreover, it was concluded that the higher the density of the fracture's filling fluid, the less distance that the particles can have a flux.

"Fluka Monte Carlo for Validating Low-Energy Neutron Capture Therapy Tissue with Boron and Gadolinium" was written by T. E. Bakolia and R. Sebihi from the Faculty of Sciences, University Mohamed V, Rabat, Morocco collaborating with A. Didi from the National Energy Center of Nuclear Science and Technology (CNESTEN), Rabat, Morocco, K. Adambounou and E. Hazou from the Department of Physics, Faculty of Science, University of Lomé, Lomé, Togo. Research Gap: Neutron Capture Therapy (NCT) represents a cutting-edge neutron therapy technique for tumor treatment, but there is a gap in understanding the optimization of neutron dose deposition in tumor cells, particularly in tissues enriched with boron and gadolinium. Research Objective: This study aims to evaluate the dose deposited by thermal neutrons in adipose tissues enriched with boron and gadolinium, utilizing the Monte Carlo Fluka code. Research Methodology: The research employs Fluka, an open-source Monte Carlo simulations, to assess thermal neutron dose deposition in tissues. The focus is on boron and gadolinium-enriched tissues to understand their impact on neutron dose optimization. Results: Findings affirm the advantages of boron and gadolinium in enhancing neutron dose deposition within tissues. Fluka simulations demonstrate the strategic utilization of neutron properties, showcasing the potential for improved tumor management. The study highlights gadolinium's attractiveness, suggesting its promising application in clinical settings.

"Weighted CTDI Equation For 3D Rotational Angiography: A Monte Carlo Study" was explored by A. Azzi, R. Hidayat, A. Rosa, and L. E. Lubis from Departement of Physics, Faculty of Mathematics and Natural Sciences, Universitas Indonesia, Depok, Indonesia. This study aims to verify the weighted Computed Tomography Dose Index (CTDIw) coefficients of the 3D rotational angiography (3DRA) procedure using Monte Carlo simulation. The Monte Carlo simulation EGSnrc user code was employed for 3D dose simulations of the rotational angiography procedure. A virtual phantom resembling the head CTDI phantom was constructed, with a diameter of 16 cm and a density resembling polymethyl methacrylate (1.13 g/cm3). A series of virtual phantoms consisting of 5 images with ionization chamber detectors at the center position, 12 o'clock, 9 o'clock, 6 o'clock, and 3 o'clock were acquired. Simulations were performed with photon sources of 70 and 109 kVp for 200-degree x-ray tube rotation. The field of view was divided into narrow, wide, and full beams with diameters of 1.7 cm; 4.9 cm; and 8.6 cm, respectively. The simulated doses at the ionization chamber were processed into a weighting factor for weighted CTDI and compared with direct measurements. The dose ratio between peripheral and center positions for 360° CBCT and 200° 3DRA was 1:1 and 1:3 in this study. The weighting factors for 3DRA were determined as CTDIcenter = ¼ and CTDIperiphery = ¾. The measured average percentage difference of CTDIw between our weighted factor and conventional CTDIw was 1.75 % (-3.99 % to 6.08 %). The x-ray tube position of 3DRA impacted the accuracy of the weighting factor of CTDIw, with implications for the proposed weighting factor (Wcenter = ¼ and Wperiphery = ¾) when using a 3DRA machine.

"Radiological Risk to Inhalation of Thoron Gas from Medical Materials Samples Derived from Medical Plants in Iraq" was written by A. A. Abojassim from the Department of Physics, Faculty of Science, University of Kufa, Al-Najaf, Iraq collaborating with D. J. Lawi from Department of Laser and Optoelectronics Techniques Engineering, Engineering Technical Collage, Al-Furat Al-Awsat Technical University, Al-Najaf, Iraq and A. B. Hassan from Department of Biology, Faculty of Science, University of Kufa, Al-Najaf, Iraq. Pollution by thoron is one of the factors that is harmful to human health. Medical materials, especially those derived from plants, have natural ingredients which are a major source of natural radioactivity, thoron being one of them. Therefore, the presence of harmful radioactivity in these materials is a matter of concern. This study aimed to determine the concentrations of thoron (220Rn or radon-220) from 70 samples of medical materials derived from medical plants using a CR-39 detector. Samples are drugs (solid), skin creams, herbs, toothpaste, drugs (liquid), and cosmetic products found in Iraqi pharmacies. Also, radiological risks such as Annual Effective Dose (AED), Excessive Lifetime Cancer Risk (ELCR), and Lung Cancer Case (LCC) due to inhalation of thoron from medical materials samples in pharmacies were calculated. The results show that the results of the thoron concentrations in the samples of medical materials ranged from 1.02 Bq/m3 to 74.53 Bq/m3, with an average value of 18.21 ± 2.00 Bq/m3. The range values of AED, ELCR (×10-3), and LCC (×10-6) were 0.01-0.588 mSv/y, 0.04-2.36, and 0.18-10.58, respectively. It was also found that the thoron concentrations in samples of the present study vary from a minimum of 12.82 Bq/m3 in cosmetic products samples to a maximum of 30.29 Bq/m3 in herbs samples. Nonetheless, all thoron and radiological risk values were lower than the acceptable world limit (thoron = 200-300 Bq/m3 by ICRP and AED = 1.1-4.4 mSv/y by UNSCEAR).

"Modeling of 137Cs Dispersion in the Atlantic Ocean at Ahanta West Coast: A Hypothetical Candidate Site for Ghana's First Nuclear Power Plant" was explored by Y. A. Aggrey and M. Amo-Boateng from the Department of Civil and Environmental Engineering, University of Energy and Natural Resources, Sunyani, Ghana collaborating with D. O. Kpeglo from Radiation Protection Institute, Ghana Atomic Energy Commission, Legon, Ghana, and M. Muslim and A. T. Prasteyo from Department of Oceanography, Diponegoro University, Semarang, Indonesia. The government of Ghana has the intention of adding nuclear to its energy mix. Due to water availability for cooling, the coastal areas will be the right place for siting a nuclear power plant. This study was carried out to assess the distribution of 137Cs should liquid radioactive waste be released into coastal waters because of a non-routine event. The distribution was studied for the first month after the release. In the first week following the release, 137Cs were distributed within 16 km of the Ahanta West coastal waters with a concentration of about 9.1 Bq. L-1. On the seventh day, the distribution reached the entire coast of the Nzema East with a lower concentration with the bulk of the concentration still in the Ahanta waters. The 137Cs continued to spread into the

eastern coast until the thirty-first day with a concentration of less than 1 Bq. L-1. This study provides useful data for future monitoring along the coast.

"The Effect of I-131 Treatment on Complete Blood" was written by G. Sahutoglu and H. I. Atilgan from Hatay Mustafa Kemal University, Tayfur Ata Sokmen Faculty of Medicine, Department of Nuclear Medicine, Hatay, Turkey collaborating with S. K. Cetin from Cukurova University, Faculty of Arts and Sciences, Department of Physics, Adana, Turkey. Radioactive iodine-131 (RAI) treatment may cause suppression in the bone marrow. In this study, hemoglobin levels, leukocyte, thrombocyte, and lymphocyte counts will be compared before total thyroidectomy and 6 months after RAI treatment. 97 patients (76 females, 21 males) with a diagnosis of well-differentiated thyroid cancer who had undergone total thyroidectomy and received 50-200 mCi RAI treatment were included in the study. Hemoglobin levels, leukocyte, thrombocyte, and lymphocyte counts of the patients in the last month before the treatment and in the sixth month after the treatment were compared retrospectively. When all patients were analyzed, hemoglobin levels, leukocyte, thrombocyte, and lymphocyte counts in pretreatment were statistically lower than values after treatment. While hemoglobin levels of female patients were similar before and after treatment, lymphocyte, thrombocyte, and leukocyte counts were statistically lower before treatment. Hemoglobin levels, leukocyte, and thrombocyte counts were similar before and after treatment, while lymphocytes decreased significantly after RAI treatment. Thyroid cancer patients who received 50-200 mCi RAI treatment after total thyroidectomy exhibited bone marrow suppression, but their values remained within normal mean value ranges. This mild bone marrow suppression is more prominent in female patients than in male patients.

"The Effect of Zinc Concentration on 4 Bioaccumulation in Milkfish (Chanos chanos) Use of ^{65}Zn as a Radioactive Tracer" was explored by I. B. Wahyono from Research Center for Environmental and Clean Technology, National Research and Innovation Agency (BRIN), Tangerang Selatan 15314, 12 Indonesia and Department of Marine Science, Faculty of Fisheries and Marine Science, Diponegoro University, Semarang, Indonesia collaborating with C. A. Suryono from Department of Marine Science, Faculty of Fisheries and Marine Science, Diponegoro University, Semarang, Indonesia, Muslim from Department of Oceanography, Faculty of Fisheries and Marine Science, Diponegoro University, Semarang Indonesia and H. Suseno from Research Center for Radioisotope Technology, Radiopharmaceuticals and Biodosimetry, National Research and Innovation Agency (BRIN), Tangerang Selatan, Indonesia. Bioaccumulation studies of zinc (Zn) in milkfish (Chanos chanos) have been carried out in the laboratory using a 65Zn radiotracer. The research aimed to determine the effect of Zn concentration on the ability of Chanos chanos to accumulate and release these contaminants. Zn absorption follows the single-compartment model, and experiments were carried out until stable conditions were achieved. The research stages included biota collection, acclimatization, bioaccumulation, and elimination. Acclimatization was carried out for biota adaptation in the experimental environment. Bioaccumulation was carried out for 7 days by placing the biota in an aquarium filled with seawater added with 65Zn radiotracer contaminants. The elimination process involved releasing contaminants from the biota by placing them in contaminant-free seawater for 7 days. The results of the bioaccumulation experiment showed that the concentration factor (CF) ranged from 0.67 - 18.18 mLgr-1 at a concentration of ZnCl2 of 1.5 ppm, and the absorption constant (ku) 1.878 - 3.267d-1 and R2 was 0.0276. The release of contaminants in depuration experiments was highest at ZnCl2 2 ppm concentrations. The percentage of retention during depuration was between 14.61 - 79.91 %, the elimination constant (ke) was 8.681, and R2 was 0.7213.

On behalf of Atom Indonesia, I would like to thank you all for your contributions and endless support that have allowed Atom Indonesia to reach an outstanding performance over all the years. This outstanding achievement could not have been reached without great efforts and cooperation from the editors, reviewers, management personnel, authors, and readers.

<u>Editor in Chief</u>