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EDITORIAL

Dear reader,

It is a great pleasure to provide you with the first issue of Atom Indonesia in 2023, namely Vol. 49 No. 1 (2023). The Atom Indonesia Vol. 49 No. 1 (2023) 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.

"A Modified Method for Increasing Radiochemical Purity of I-125 for Radiopharmaceuticals" was explored by M. Maiyesni collaborating with M. Mujinah, D. Kurniasih, W. Witarti, H. Hambali, and S. Febrianti from Reseach Center for Radioisotope, Radiopharmaceutical, and Biodosimetry Technology, National Research and Innovation Agency, KST BJ Habibie, Tangerang Selatan, Indonesia and with I. Kambali from Research Center for Accelerator Technology, National Research and Innovation Agency, KST BJ Habibie, Tangerang Selatan, Indonesia. Iodine-125 (^{125}I) is one of the radioisotopes widely used in radiopharmaceuticals for diagnosis and therapy of various cancers. Recent reports indicate that there has been shortages in the world supply of this radioiodine isotope. One of the absolute requirements good radiopharmaceuticals must meet is radiochemical purity, which generally has to be above 95 %, with an efficiency of over 90 %. The previous investigation shows that the radiochemical purity is low and does not meet the radiochemical requirement. In this work, we aim at improving the previous method by modifying the Jones reductor-based method. The modified method includes reduction and uniformization of Zn particle sizes, Zn particle compaction, and the performance of reduction process in a closed process flow. The Jones reductor converted impurities into products; in this case, iodate (IO_3^-) and periodate (IO_4^-) impurities were converted into iodide (I^-), so that ^{125}I product fulfills the radiochemical purity requirements and yielded high efficiency. In this investigation, the ^{125}I previous product was, for the first time, improved with a radiochemical purity of 99.24 % and an efficiency of 97.98 %.

"Dose Planning Evaluation of Intensity-Modulated Proton Therapy (IMPT) Technique Based on In-House Dynamic Thorax Phantom" was written by V. Vernanda, A. Azzi, and S. A. Pawiro from Department of Physics, Faculty of Mathematics and Natural Science, University of Indonesia, Depok, West Java, Indonesia. One of the drawbacks of the Intensity Modulated Radiation Therapy (IMRT) technique is that the absorbed dose in healthy tissue is relatively high. Proton beam has characteristics that can compensate for these drawbacks. The Bragg peak characteristic of a proton beam allows the administration of high radiation doses to the target organ only. Non-Small Cell Lung Cancer (NSCLC) cases are located in the vicinity of many vital organs, so radiation doses that exceed a certain limit will have a significant impact on these organs. Proton is a heavy particle that exhibits interaction patterns with tissue heterogeneity that differ from that of photon. This study aims to determine the distribution of proton beam planning doses in the NSCLC cases with the Intensity Modulated Proton Therapy (IMPT) technique and compare its effectiveness with the IMRT technique. Treatment planning was done by using TPS Eclipse on the water phantom and on the in-house thorax dynamic phantom. The water phantom planning parameters used are one field at 0° and three fields at 45°, 135°, and 225°. In this study, a single, sum, and multiple field techniques on the in-house thorax dynamic phantom were used. The evaluation was performed by calculating Conformity Index (CI), Homogeneity Index (HI), and Gradient Index (GI) parameters for each treatment planning. As a result, a bit of difference in the CI the HI values are shown between IMPT and IMRT planning. The GI values of IMPT planning are in the range between 4.15-4.53, while the GI value of IMRT is 7.89. The histogram results of the planar dose distribution show that the IMPT treatment planning provides fewer off-target organ doses than the IMRT planning. Evaluation was also carried out on the IMPT treatment planning of target organs in five areas of interest and four OAR positions. The evaluation results were then compared with the IMRT measurement data. As a result, the value of the point doses at the target organ did not differ significantly. However, the absorbed dose with the IMPT technique at four OAR positions is nearly zero, which had a large difference compared to the IMRT technique.

“Simulation of Leksell Gamma Knife-4c System with Different Phantoms using PHITS and GEANT4 was explored by B. T. Hung from Vietnam Atomic Energy Institute, Hanoi, Vietnam collaborating with T. T. Duong and B. N. Ha from University of Science and Technology, Hanoi, Vietnam. This study used PHITS and Geant4 code packages to simulate a Leksell Gamma Knife system in order to determine radiation dose distribution in two types of phantoms. The results observed in the water phantom with configurations of single source and 201 sources are in good accord with the prior research, including both simulation and experiment. Several characteristics of Leksell Gamma Knife 4C, such as dose profiles, output factor, FWHM, and penumbra size, are calculated based on Monte Carlo simulations, which show the best consistency with other results. The output factors for collimators of 14 mm, 8 mm, and 4 mm are 0.984, 0.949, and 0.872, respectively. The simulation results with an adult mesh-type reference phantom reveal considerable similarities with the established radiosurgery plans. It indicates that the absorbed dose in brain tumors was highest when utilizing the 18 mm collimator and subsequently reduced with collimator size to 0.65, 0.25, and 0.5 with the 14 mm, 8 mm, and 4 mm collimators, respectively. The absorbed dose has a very low value for other essential organs and decreases with distance from the brain tumor. These findings may explain why the dose to organs decreases linearly as target distance, volume, and collimator size increase.

“Assessment of Computed Tomography Dose Index (CTDI) During CT Pelvimetry using Monte Carlo Simulation” was written by M. Aabid and A. Choukri from Ibn Tofail University, Faculty of Sciences, Department of Physics, Kenitra, Morocco collaborating with S. Semghouli from Team Health Techniques, Research Laboratory in Health and Environmental Sciences, Higher Institute of Nursing Professions and Health Techniques, Agadir, Morocco. A pelvimetry examination is sometimes prescribed to a pregnant woman at the end of her pregnancy in order to assess the dimensions of her pelvis prior to childbirth. This examination has long been performed by using X-ray, but is now increasingly being replaced by CT-scan The objective of this study is to assess the radiation doses received during a practical CT pelvimetry examination performed using a Hitashi Supria 16-slice CT scanner. The radiation doses were estimated using Monte Carlo (MC)-based simulation with GATE code to model the 16-slice CT scanner machine. The GATE code operates using GEANT4 libraries. A polyymethyl metacrylate (PMMA) acrylic phantom of 32 cm diameter was modeled to represent the patient's body. X-ray energy spectrum generated using the SRS-78 spectrum processor was used for simulation. The simulation was executed with the same exposure parameters as the practical CT pelvimetry examination with dose parameters of 1 mGy, 0.9 mGy, and 36.6 mGy.cm, respectively, for the weighted CT dose index ($CTDI_w$), the volume CT dose index ($CTDI_{vol}$), and dose-length product (DLP). The MC simulation results provide dose parameters of 1.16 mGy, 1.07 mGy, and 43.6 mGy.cm, respectively, for the $CTDI_w$, $CTDI_{vol}$, and DLP. The differences between the simulation and the practical examination were 16 %, 18 %, and 18 %, respectively. These differences are considered in a quite good agreement. The results were also consistent with other similar studies. This work proves that the Monte Carlo simulation with the GATE code is usable to assess the patient doses during a CT pelvimetry examination.

“Dose Evaluation of Head and Neck Cancer IMRT Treatment Planning Based on Gamma Index Analysis of Varian Halcyon 2.0 LINAC” was explored by W. Purwanti and S. A. Pawiro from Department of Physics, Faculty of Mathematics and Natural Sciences (FMIPA), Universitas Indonesia, Depok, Indonesia collaborating with F. Suhaimi and W. E. Wibowo from Department of Radiation Oncology, Faculty of Medicine, Universitas Indonesia, Dr. Cipto Mangunkusumo Hospital, Jakarta, Indonesia. Varian Halcyon 2.0 linear accelerator was launched and became available for clinical use in 2018. Therefore, it is necessary to evaluate the accuracy of exit fluence of the Halcyon 2.0 for quality assurance (QA) of head and neck cancer treatment planning, pretreatment, and treatment. The accuracy of the exit fluence for twenty treatment plannings has been evaluated by conducting gamma analysis for QA pretreatment and treatment in each field and composite field by using criteria for gamma index 3 %/3 mm and 2 %/2 mm. The QA pretreatment results are in the average value for each criterion for each field and composite fields on actual gantry angle and null gantry angle with gamma passing rate (GPR) of over 99 % (range 99.78 %-99.95 %)

The total treatments consisted of 2717 fractions. The analysis results of GPR for fields were 99.32 % and 97.74 % for gamma indexes of 3 %/3 mm and 2 %/2 mm, respectively. In addition, the analysis results of GPR for composites were 95.46 % and 81.38 % for gamma indexes of 3 %/3 mm and 2 %/2 mm, respectively. Based on this result, the average GPRs of QA pretreatment are ≈ 99 % of the total pixels. This means the prediction dose of Varian Halcyon 2.0 is accurate. The average GPRs of treatment is nearly > 90 %, showing that Varian Halcyon 2.0 is effective for creating treatment plans for complex cases.

"A Two-Dimensional Unsteady FDTD Model for Radon Transport With Multiple Sources Emanation From Soil Layers" was written by H. Bezzout, E. H. El Ouardy, N. Meskini, and H. El Faylali from Department of Physics and Computer Science, Faculty of Sciences, Ibn Tofail University, Kenitra, Morocco. A two-dimensional numerical model for radon transport based on the finite difference time domain (FDTD) method have been developed. The model is governed by the radon transport equation taking into account the mechanisms of diffusion, advection, and decay. The purpose of this model is to simulate the evolution of radon concentration which can be influenced by various parameters including depth and diffusion coefficient of the soil layer plus the velocity and initial concentration of radon. The obtained results were compared to an analytical solution to demonstrate the ability of this model for predicting the spatio-temporal evolution of radon transport in the porous media of soil layers.

"Assessment of Health Risk of Exposure to Alpha-Emitters in Cheese Samples Collected from Iraqi Markets" was written by R. R. Muneam and A. A. Abojassim from Department of Physics, Faculty of Science, University of Kufa, Iraq. In this research, alpha-emitter concentrations of ^{222}Rn, ^{226}Ra, and ^{228}U in Iranian, Turkish, Egyptian, Saudi Arabian, and Iraqi canned cheeses that are available in Iraqi markets were measured using the CR-39 detector. Also, the health risk parameters associated with the ingestion of alpha-emitter radionuclides, such as the annual average internal effective dose (AAIED) and the risk of an excess cancer fatality per million persons (RECFPMP), were calculated. The results show that the average values of ^{222}Rn, ^{226}Ra, and ^{228}U concentrations for all samples in the present study were 3.7±0.38 Bq/m^3, 25.24±2.63 mBq/kg, and 0.025±0.002 ppm, respectively. The average values of AAIED and RECFPMP were 0.175±0.018 μSv/y and 0.674±0.070, respectively. The results show that the highest value of alpha-emitters as well as health risk parameters were found in cheese samples produced in Saudi Arabia, while the lowest results were found in Egyptian samples. They were, nevertheless, less than the permissible value and the risk value. According to the current study, the consumption of those cheese products poses no health risks.

"Some Metal Oxide-Natural Rubber Composites for Gamma- and Low-Energy X-Ray Radiation Shielding" was explored by A. Fisli, S. G. Sukaryo and A. K. Rivai from Research Center for Radiation Detection and Nuclear Analysis Technology, National Research and Innovation Agency, KST B. J. Habibie, Serpong, Indonesia collaborating with E. Yulianti and Mashadi from Research Center for Advanced Material, National Research and Innovation Agency, KST B. J. Habibie, Serpong, Indonesia, B. Hanurajie from Directorate of Laboratory Management, Research Facilities, Science and Technology Park, National Research and Innovation Agency, KST B. J. Habibie, Serpong, Indonesia, and H. Prastanto and M. I. Fathurrohman from Research Center for Rubber Technology, Indonesia Rubber Research Institut, Bogor, Indonesia. This work studied protective material consisting of several metal oxide composites (Pb_3O_4, WO_3, SnO_2, and Bi_2O_3)-natural rubber (NR) for X-ray and gamma-ray shielding. The composites were prepared through open milling and vulcanization processes and further characterized by scanning electron microscope (SEM), X-ray diffraction (XRD), rheometry analysis, and density gauge. The attenuation coefficient of the sample was investigated using X-ray generators with voltages ranging from 50 to 140 kV and gamma-ray energies ranging and 356 to 1250 keV, respectively. The experimental results show that the linear attenuation coefficient of NR filled with metal oxides was significantly improved compared to pure NR. For gamma-ray 661 keV, the HVL of NR decreased from 9.0 cm to between 4.4 - 6.2 cm after it was filled with metal oxides. The Bi2O3-NR is the best suitable material for gamma-ray attenuation, followed by Pb_3O_4-NR, WO_3-NR, and SnO_2-NR. Meanwhile, for x-rays, the HVL of NR decreased from 2.0 cm to between 0.17 -0.31 cm after it was filled with metal oxides. The proposed metal oxide-NR composites can be appropriate as a flexible protective material for manufacturing wearable radiation shielding products such as gloves, aprons, rubber underwear, and other wearable materials.

“Patient-Specific Pre-Treatment VMAT Plan Verification Using Gamma Passing Rates” was written by M. Z. Arsalan from Medical Physics Division, Atomic Energy Medical Center, Karachi (AEMC-K), Sindh, Pakistan and Department of Physics and Applied Mathematics, Pakistan Institute of Engineering and Applied Sciences (PIEAS), Islamabad, Pakistan collaborating with M. B. Kakakhel from Department of Physics and Applied Mathematics, Pakistan Institute of Engineering and Applied Sciences (PIEAS), Islamabad, Pakistan, M. Shamshad from Danish Centre for Particle Therapy (DCPT), Denmark, and T. A. Afridi from Medical Physics Division, Atomic Energy Cancer Hospital NORIN, Nawabshah, Sindh, Pakistan. Continuous gantry motion, continuous beam modulation, and variable dose rate are used in volumetric modulated arc therapy (VMAT) to obtain highly conformal radiation therapy dose distributions. Several errors during daily radiation therapy treatment can be sources of uncertainties in dose delivery. These errors include monitor unit calculation errors and other human mistakes. Due to the uncertainties in the excessively modulated VMAT plan, the intended dose distribution is not delivered perfectly, leading to a mismatch between the measured and planned dose distributions. This necessitates an extensive and effective quality assurance (QA) program for both machine and patient. In this study, VMAT QA plan verification of 62 head and neck (H&N) and 19 prostate cases was done using Octavius 4D setup with its associating VeriSoft gamma analysis software. The plans showed a maximum 3D gamma passing rate with 4 mm/3 % gamma acceptance criteria, i.e., 99.7 % for the H&N cancer cases and 99.5 % for the prostate cancer cases. Local gamma analysis was also performed for both regions. Furthermore, 2D and volumetric gamma analyses were also carried out. Gamma analysis with respect to different axis was also carried out. It was known that the transversal axis showed the highest gamma passing rate in both H&N and prostate cases, i.e., 99.17 % and 98.3 %, respectively. The transverse axis came to be a better fit for the planned dose distribution.

“The Quantitative Effect of Noise and Object 5 Diameter on Low-Contrast Detectability of AAPM 6 CT Performance Phantom Images” was explored by E. Setiawati, C. Anam and W. Widyasari from Department of Physics, Faculty of Sciences and Mathematics, Diponegoro University, Semarang, Indonesia collaborating with G. Dougherty from Department of Applied Physics and Medical Imaging, California State University Channel Islands, Camarillo, USA. Parameters for determining computed tomography (CT) image quality include noise and low-contrast detectability. Studies on low-contrast detectability using the AAPM CT performance phantom have several limitations, such as the absence of quantitative information on the effect of noise and object size on low-contrast detectability. In this study, the quantitative effect of noise and object diameter on low-contrast detectability were investigated. Images of the American Association of Physicists in Medicine (AAPM) CT performance phantom model 610 were acquired with a tube voltage of 120 kV and tube currents of 50, 100, 150, and 200 mA. The low-contrast section of the AAPM CT performance phantom model 610 has objects with diameters between 2.5 and 7.5 mm. We analysed the mean CT number, noise level, signal-to noise ratio (SNR), and contrast-to-noise ratio (CNR), acquired using MatLab software. The results obtained indicate that noise and object size affect low-contrast detectability. The CNRs increase linearly with increasing of object diameter with R2 of 0.88, 0.67, 0.75, and 0.83 for tube currents of 50, 100, 150 and 200 mA, respectively

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>