Accreditation No.: 30/E/KPT/2018

atom indonesia

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

EDITOR IN CHIEF
Dr. Julwan Hendry Purba

MANAGING EDITOR
Drs. Budi Prasetyo, M.T.

EDITORS

Prof. Dr. Zaki Su'ud	*Nuclear Physics and Reactor Safety, Bandung Institute of Technology, Indonesia*
Prof. Dr. Terry Mart	*Theoretical Nuclear and Physics, University of Indonesia, Indonesia*
Prof. Dr. Muhayatun Santoso	*Radiochemistry; Nuclear Analytical Techniques, National Nuclear Energy Agency, Indonesia*
Dr. Hendig Winarno, M.Sc.	*Radiation; Pharmaceutical Chemistry, National Nuclear Energy Agency, Indonesia*
Dr. Abu Khalid Rivai, M.Eng	*Materials; Corrosion and Nuclear Reactor Technology, National Nuclear Energy Agency, Indonesia*
Imam Kambali, M.Phil., Ph.D.	*Radiochemistry and Radioisotopes, National Nuclear Energy Agency, Indonesia*
Edy Giri R. Putra, Ph.D.	*Neutron Scattering, Soft Condensed Matter, National Nuclear Energy Agency, Indonesia*
Dr. Darmawan Darwis	*Biomaterials, Radiation Processing of Polymers, Radiation Sterilization and Decontamination of Pharmaceuticals and Healthcare, National Nuclear Energy Agency, Indonesia*
Prof. Dr. Mukh. Syaifudin	*Biomedicine Division, Center for Technology of Radiation Safety and Metrology, National Nuclear Energy Agency, Indonesia*
Prof. Dr. Malcolm F. Collins	*Neutron Scattering; Magnetism; Glasses, McMaster University, Hamilton, Canada*
Dr. Shane J. Kennedy	*Neutron Scattering; Superconductor; Superionic Materials, Australian Nuclear Science and Technology Organization, Australia*
Prof. Dr. Philip K. Hopke	*Nuclear Analytical Methods (XRF, INAA); Environmental Analysis, Clarkson University, New York, USA*
Prof. Dr. Takashi Sakuma	*Solid State Physics, Ibaraki University, Japan*
Sugawara Takanori, Ph.D.	*Nuclear Reactor Physics, Japan Atomic Energy Agency, Japan*
Prof. Dr. T. Kamiyama	*Neutron Instrumentation and Materials Energy, High Energy Accelerator Research Organization, Japan*
Prof. Dr. Shahidan Radiman	*Nanomaterials and Their Applications, National University of Malaysia, Malaysia*
Prof. Dr. Kell Mortensen	*Head of X-Ray and Neutron Science, Niels Bohr Institute, University of Copenhagen, Denmark*
Bowen Li, Ph.D.	*Physics and Astronomy, Engineering, Lanzhou University, China*
Prof. Dr. Gerard O'Sullivan	*Quantum Mechanics, Atomic and Molecular Physics, Applied Optics, Lasers and Photonics, Low Temperature Physics: Superconductivity and Quantum Fluids, Base Einstein Condensation in Cold Gases, University College Dublin, Ireland*
Ass. Prof. Chris Ling	*Solid-state Oxide Chemistry, Magnetism, Ionic Conductivity, Neutron Scattering, Phase Transitions, Modulated Structures, University of Sydney, Australia*
Prof. Sun Ming Choi, Ph.D.	*Neutron and X-ray Scattering Studies of Molecular Self-Assemblies for Nanostructured Functional Materials, Development of Multi-Component Anisotropic Nanoparticle Superlattice and Their Applications, Structure and Dynamics of Biomembranes Interacting with Proteins, Korea Advanced Institute of Science and Technology, Republic of Korea*
Dr. Max Audeev	*Crystal and Magnetic Structural Studies of Inorganic Materials with Neutron and X-ray Scattering And Atomistic, Australian Nuclear Science and Technology Organization (ANSTO), Australian*
Prof. Ikuo Kashiwakura, Ph.D.	*Hirosaki University Graduate School of Health Sciences, Departement of Radiation Science, Japan*

PEER REVIEWERS

Prof. Dr. Evvy Kartini	*Material Science; Neutron Scattering; Condensed Matter Physics, National Nuclear Energy Agency, Indonesia*
Martalena, M.Sc. Ph.D	*Radiopharmacy, National Nuclear Energy Agency, Indonesia*
Dr. L.T. Handoko, M.Sc.	*Physics Theory, Indonesian Institute of Sciences, Indonesia*
Prof. Sunarno, Ph.D	*Nuclear Radiation; Nuclear Instrumentation, Gajah Mada University, Indonesia*
Prof. Yasushi Arano	*Environmental and Bioanalytical Sciences, Chiba University, Japan*
Prof. Dr. Michio Yamawaki	*Nuclear Fuel and Material, Nuclear Fussion Technology, University of Tokyo, Japan*
Prof. Dr. Kenji Kikuchi	*Nuclear Materials, Ibaraki University, Japan*
Prof. Dr. Fumio Yoshii	*Radiation Chemistry; Radiation Polymerization, Japan Atomic Energy Agency, Japan*
Prof. Dr. Stefan Adams	*Materials Modelling, National University of Singapore, Singapore*
Ass. Prof. Dr. Ho Jin Ryu	*Materials Science and Engineering, Korea Advanced Institute of Science and Technology, Republic of Korea*
Lucille V. Abad, Ph.D.	*Philippine Nuclear Research Institute (PNRI)*

LANGUAGE EDITOR
Jos Budi Sulistyo, Ph.D, Drs. Supria, M.Sc. (Universitas Bina Nusantara), Dr. Ratiko, M.T., Arief Sasongko Adhi, S.Si.

ADMINISTRATIVE OFFICERS
Iis Sustini, A.Md., Dra. Noer'Aida, R. Suhendani, S.IP., Moh. Zen, Heru Susanto, A.Ma., Ajie Noorseto, S.Kom., Moh. Widya, Wenseslaus Roland, Anggiana Rohandi Yusuf, A.Md.

Publisher : Center for Informatics and Nuclear Strategic Zone Utilization
Mailing Address : National Nuclear Energy Agency
Puspiptek Serpong, Tangerang 15314, Indonesia
Phone (+62 21) 7560575, 7562860 ext. 9017, Fax (021) 7560895
Web: http://aij.batan.go.id, E-mail : atomindonesia@batan.go.id

Licences : SIT No. 078/Khs/Dit.PP/II. 1a & 75; 24.5.75
SIC No. B/289-PK/VI/75; 3.6.75

Accreditation No.: 30/E/KPT/2018

atom indonesia
vol. 45 no. 1
April 2019

Contents

Editorial i

Interaction of ^{137}Cs with Sumedang Clay as Natural Barrier of Radwaste Disposal
B. Setiawan, U. Zhafirah and A. Saefumillah 1

Early Lung Cancer Detection Using Artificial Neural Network
T. Pandiangan, I. Bali and A.R.J. Silalahi 9

Experimental and Numerical Simulation Investigation of Single-Phase Natural Circulation in a Large Scale Rectangular Loop
A.R. Antariksawan, S. Widodo, M. Juarsa, S. Ismarwanti, D. Saptoadi, M.H. Kusuma, T. Ardiyati and T.M.I. Mahlia 17

Assessment of Individual Radiosensitivity in Inhabitants of Takandeang Village - A High Background Radiation Area in Indonesia
D. Ramadhani, S. Purnami, S. Nurhayati, M. Lubis, D. Teriana, W. Mailana, K.D. Purwanti, E. Pudjadi, I. Kashiwakura, R. Okazaki and M. Syaifudin 27

Occupational and Patient Doses in Interventional Cardiology in Indonesia: A Preliminary Result
E. Hiswara, K.H. Ng, H. Sofyan, D. Kartikasari and N. Nuraeni 37

A Bayesian Network Approach to Estimating Software Reliability of RSG-GAS Reactor Protection System
S. Santoso, S. Bakhri and J. Situmorang 43

Assessment of Human Milk Intake by Breastfed Infants Using Deuterium Oxide Dose-to-Mother Technique in "Tumbuh Kembang Anak" Cohort, Indonesia
E.K. Winarno, H. Winarno, Susanto, T. Fajarwati and T. Thomas 51

Investigation on Neutron Flux Effect onto Irradiated Fuel Burn-up Stored in the Reactor TRIGA PUSPATI
M.A.A. Husain, S. Hashim, D. Bradley, M.H. Rabir, N. Zakaria and M.R.M. Zin 59

Acknowledgment 67

EDITORIAL

Dear reader, with great pleasure we provide you with the first issue of Atom Indonesia in 2019, namely Vol. 45, No. 1 (2019). In this issue, we proudly announce a piece of very good news that Atom Indonesia has been indexed by Emerging Source Citation Index (ESCI) of Clarivate Analytics. Previously, Atom Indonesia has also been indexed by SCOPUS, DOAJ, Google Scholar, Crossref, ISJD, and IAEA INIS. In addition, Atom Indonesia has provided a Digital Object Identifier (DOI) for each published article, so that it can be linked to Crossref. By this indexing, it is expected that Atom Indonesia will be better known among researchers from around the world and easier to be accessed.

Based on a new policy of Government of Indonesia, currently Atom Indonesia has single scientific journal accreditation by the Ministry of Research, Technology and Higher Education of Republic of Indonesia with number 30/E/KPT/2018. Atom Indonesia was certified as the 1st rank accredited scientific journal for the period from August 2017 to April 2022. Previously, Atom Indonesia had dual accreditation with the highest rank (A) category, i.e. from the Ministry of Research, Technology and Higher Education (RISTEKDIKTI) through certificate No. 36b/E/KPT/2016 and from the Indonesian Institute of Science (LIPI) through certificate No. 767/AU3/P2MI-LIPI/08/2017. Additionally, the certificate as an international journal was awarded to Atom Indonesia by the Indonesian Institute of Science (LIPI) for the period from June 2017 to August 2022. These two accreditations were united into a single accreditation by the Government of Indonesia in October 2018.

From May 2019, Dr. Julwan Hendry Purba will be the Editor in Chief of Atom Indonesia to replace Prof. Dr. Evvy Kartini. Thank you very much to Prof. Dr. Evvy Kartini for her dedication and contribution to Atom Indonesia so that this journal becomes an internationally reputed scientific journal. Details of the editorial boards can be accessed in Atom Indonesia website.

The Atom Indonesia Vol. 45 No. 1 (2019) contains eight articles discussing various aspects and applications of nuclear science and technology.

"The Interaction of ^{137}Cs with Sumedang Clay as Natural Barrier of Radwaste Disposal" was explored by B. Setiawan from Center for Radioactive Waste Technology, National Nuclear Energy Agency of Indonesia, in collaboration with U. Zhafirah and A. Saefumillah from Department of Chemistry, Faculty of Mathematics and Natural Sciences, University of Indonesia. In this study, the interaction of ^{137}Cs with Sumedang clay as a natural barrier for radwaste disposal system was evaluated. The initial concentration of Cs was 10^{-8} M for the experiments on the contact time and the effect of Na and K concentrations on the sorption of ^{137}Cs; however, the initial concentration ranging from 10^{-8} to 10^{-3} M of CsCl in the solution for the effect of CsCl concentration. The distribution coefficient K_d is used as the indicator of ^{137}Cs sorption into samples. It was found that the K_d values decreased nonlinearly with the concentration of Na and K, and also to the effects of CsCl concentration.

"An Early Lung Cancer Detection Using Artificial Neural Network" was written by T. Pandiangan from Medical Physics Study Programme, Faculty of Science, Technology, Engineering and Mathematics, Matana University, Indonesia, in collaboration with I. Bali from Institute of Research, Science Development and Technology Study, Matana University, Indonesia and A.R.J. Silalahi from the Australian National University (Visiting research scholar), Australia. Lung carcinoma is a malignant lung tumor that is deadly and is characterized by the uncontrolled cell growth in the tissue of lung. Normally the lung cancer detection is done by visual inspection of x-ray image by medical doctor. The purpose of this study is to create a computational tool that can automatically detect early lung cancer from x-ray image. This research has two main steps, with first being to characterize cancer or cancer symptoms based on x-ray images and second step is to develop an artificial neural network (ANN).

"The Experimental and Numerical Simulation Investigation of Single-Phase Natural Circulation in a Large Scale Rectangular Loop" was explored by A.R. Antariksawan from Center for Accelerator Science and Technology, National Nuclear Energy Agency of Indonesia, in collaboration with S. Widodo, M. Juarsa and M.H. Kusuma from Center for Nuclear Reactor Technology and Safety, National Nuclear Energy Agency of Indonesia, S. Ismarwanti from Center for Nuclear Fuel Technology, National Nuclear Energy Agency of Indonesia, D. Saptoadi from Heat Transfer Laboratory, Department of Mechanical Engineering, Universitas Indonesia, T. Ardiyati from Center for Nuclear Facilities Engineering, National Nuclear Energy Agency of Indonesia, and T.M.I. Mahlia from School of Information, System and Modelling, Faculty of Engineering and Information Technology, University of Technology Sydney, Australia. In order to anticipate station blackout, the use of safety system based on passive features is highly considered in advanced nuclear power plant designs, especially after the Fukushima Dai-ichi nuclear power station accident. An example is the application of natural circulation in the emergency cooling system. To study the reliability of such an application, a research project on natural circulation was carried out. This paper describes the investigation results on the natural circulation phenomena obtained using a large rectangular experimental loop named FASSIP-01. The experiments were conducted at two different heat source powers. The experimental results are analyzed using existing correlation and numerical model simulation.

"An Assessment of Individual Radio sensitivity in Inhabitants of Takandeang Village - a High Background Radiation Area in Indonesia" was studied by D. Ramadhani, S. Purnami, S. Nurhayati, S. Nurhayati, D. Teriana, W. Mailana, K.D. Purwanti, E. Pudjadi, and M. Syaifudin from Center for Radiation Safety Technology and Metrology, National Nuclear Energy Agency of Indonesia, in collaboration with I. Kashiwakura from Department of Radiological Life Sciences, Hirosaki University Graduate School of Health Sciences, Japan and R. Okazaki from Department of Radiological Health Science, Institute of Industrial Ecological Sciences, University of Occupational and Environmental Health, Japan. People living in high background radiation areas (HBRAs) possibly develop the radio adaptive response (RAR) phenomenon. The Mamuju area in West Sulawesi Indonesia is known as an HBRA in Indonesia due to its high natural uranium contents. It is possible that RAR has developed in Mamuju inhabitants. To prove this hypothesis, here in this study, evaluation of the individual radio sensitivity in the inhabitants of Takandeang Village, Mamuju, was conducted using G_2 micronucleus (MN) assay. Association between blood groups and TP53 Arg72Pro polymorphism with individual radio sensitivity was also evaluated in this study. Using G_2 MN assay, we assessed the individual radio sensitivity of Takandeang Village inhabitants and control samples.

"The Occupational and Patient Doses in Interventional Cardiology in Indonesia: A Preliminary Result" was explored by E. Hiswara, H. Sofyan, D. Kartikasari and N. Nuraeni from Center for Radiation Safety Technology and Metrology, National Nuclear Energy Agency of Indonesia, in collaboration with K.H. Ng from Department of Biomedical Imaging, Faculty of Medicine, University of Malaya, Malaysia. Interventional cardiology is a branch of cardiology that manages the catheter based treatment of structural heart illnesses. These minimally invasive procedures involve inserting catheters and other devices through superficial arterial and venous access sites. Due to increased reliability and advancing technology, the number and complexity of interventional cardiology procedures haves increased in recent years. The increasing complexity of the procedures, however, require longer fluoroscopic duration, leading to increased exposure time to ionizing radiation for the patient and also for the medical staff since they need to remain close to the patient throughout the procedure. This study attempts to investigate the occupational and patient doses during the course of several interventional cardiology procedures in Indonesia, i.e. CA, PCI, cat scan, PA, PTCA, TACE, PAC and peripheral vascular.

"A Bayesian Network Approach to Estimating Software Reliability of RSG-GAS Reactor Protection System" was written by S. Santoso, S. Bakhri and J. Situmorang from Center for Nuclear Reactor Technology and Safety, National Nuclear Energy Agency of Indonesia. Reliability represents one of the most important attributes of software quality. Assessing the reliability of software embedded in the safety of highly critical systems is essential. Unfortunately, there are many factors influencing software reliability that

cannot be measured directly. Furthermore, the existing models and approaches for assessing software reliability have assumptions and limitations, which are not directly acceptable for all systems, such as reactor protection systems. This paper presents the result of a study, which aims to conduct quantitative assessment of the software reliability at the reactor protection system (RPS) of RSG-GAS based on software development life cycle. A Bayesian network (BN) is applied in this research and used to predict the software defect in the operation, which represents the software reliability.

"An Assessment of Human Milk Intake by Breastfed Infants Using Deuterium Oxide Dose-to-Mother Technique in "Tumbuh Kembang Anak" Cohort, Indonesia" was explored by E.K. Winarno, H. Winarno, and Susanto from Center for Isotopes and Radiation Application, National Nuclear Energy Agency of Indonesia, in collaboration with T. Fajarwati from Center for Research and Development of Health, National Institute of *Health Research* and Development, The Ministry of Health, Indonesia and T. Thomas from St. John's Research Institute, India. Indonesia government has done the WHO recommendation that the infants should be exclusively breastfed for the first six months of life to achieve optimum growth, development and health. Nevertheless, the percentage of exclusive breastfed infants has not achieved the target yet and has not been scientifically quantified. The objective of the study is to measure the intake of human milk of Indonesian infants during first 6 months and to record the breastfeeding practices of mothers. Thirty healthy mother-infant pairs were recruited randomly for the cross-sectional study at "*Tumbuh Kembang Anak*" cohort in Bogor.

"The Investigation on Neutron Flux Effect onto Irradiated Fuel Burn-up Stored in the Reactor TRIGA PUSPATI" was written by M.A.A. Husain and S. Hashim from Department of Physics, Faculty of Science, Universiti Teknologi Malaysia, in collaboration with D. Bradley from Department of Physics, Faculty of Engineering and Physical Sciences, University of Surrey, United Kingdom, M.H. Rabir, N. Zakaria and M.R.M. Zin from Malaysia Nuclear Agency. An investigation on the out-core neutron flux in the Reactor TRIGA PUSPATI is carried out in this work to determine whether the thermal and/or fast neutron from the core would cause burn-up of the irradiated fuel stored in the same vicinity of the reactor core. The storage rack is positioned at 1 m from the central thimble. MCNPX code is used to calculate the fast and thermal neutron flux at 750 kW reactor power using 10 cm × 10 cm × 10 cm mesh while MATLAB model on 20 cm × 20 cm mesh model is used to plot the axial and radial distribution of the neutron flux density.

On behalf of Atom Indonesia, I would like to thank you all for all of your contributions and endless support that have allowed Atom Indonesia to reach an outstanding performance for 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.

Editor in Chief