P03

A REVIEW ON UNMANNED GROUND VEHICLE ARCHITECTURE FOR RADIATION OR NUCLEAR SAFETY AND SECURITY APPLICATIONS

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Abstract

Unmanned Ground Vehicles (UGVs) are robotic systems designed for terrestrial operation without human drivers, controlled either remotely or autonomously. They are increasingly deployed for critical tasks including surveillance, reconnaissance, inspection, and transportation across various industries. This paper reviews the architecture of UGVs specifically tailored for radiation or nuclear safety and security applications. Drawing on lessons learned from the Fukushima nuclear disaster, we present several recommendations for UGV deployment in hazardous environments. The architecture of UGVs is dissected into key components: the chassis, controller, sensor and vision systems, controller software, communication mediums, and user interfaces. Each component's role and integration are discussed in detail to enhance the effectiveness and reliability of UGVs in nuclear safety and security operations.

P04

NET ZERO EMISSIONS 2050: NUCLEAR POWER IS A VALID AND SENSIBLE OPTION FOR RELIABLE AND SUSTAINABLE ELECTRICITY GENERATION.

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Abstract

This paper presents a case study on Malaysia's 2050 net zero emissions pathway, which is a vital step for ensuring a sustainable world. Electricity affordability, reliability and security are the key success factors that transformed the economy of Malaysia from commodity-based economy to manufacturing and services in the 1980s. Recognizing the intricacy of achieving the net zero emissions aspiration, this study acknowledges that there is no singular approach or energy source that can exclusively meet this target. The key lies in a strategic fusion of diverse fuels, cutting-edge technologies and effectively addressing the energy trilemma encompassing security, sustainability, and affordability. Developing an optimal future power-generating mix necessitates consideration of several key elements, as well as country-specific constraints. Benchmarking with other countries, particularly ASEAN states such as Indonesia, Thailand, Vietnam, Singapore, and the Philippines, is critical to ensuring that the projected generation is comprehensive and fits within the context of the energy trilemma. The advancement of nuclear power architecture, especially the state-of-the-art Small Modular Reactors (SMRs) and advanced large power reactors, presents a sensible justification for achieving the net zero emissions target. It provides clean, dispatchable, reliable, and affordable electricity generation. Nuclear power technology offers diverse options for generating a cost-effective baseload of electricity, industrial heat, water desalination, and hydrogen production.

Keywords: Small modular reactors (SMRs), energy trilemma, generation mix, nuclear hydrogen hybrid system

Acknowledgment: The authors thank Yayasan Canselor Universiti Tenaga Nasional and Tenaga Nasional Berhad for financing the PhD research program, for which this study reports on the first author's studies.

P05

ENHANCING CYBER AND INFORMATION SECURITY PREPAREDNESS THROUGH RECOVERY TESTING AND VALIDATION SIMULATIONS

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Abstract

This paper discusses and identifies issues and success factors in the Cyber Incident Management of the Malaysian Nuclear Agency (Nuklear Malaysia) through the implementation of simulation exercises using a "walkthrough" approach for disaster recovery testing of Information and Communication Technology (ICT). Cyber incident management is a critical requirement for compliance and monitoring of ICT governance through the certification of the Information Technology Management System (ISMS, ISO/IEC 27001) and the Business Continuity Management System (BCMS, ISO 22301). These certifications strengthen and improves the cybersecurity and ICT readiness of Nuklear Malaysia. The Information Technology and Applications Unit (PTM) has taken proactive initiatives to conduct simulation exercises for walkthrough recovery testing to test the readiness and effectiveness of response measures in recovering from a cyber incident. The objective of these simulation exercises is to verify the achievement level of disaster recovery objectives that have been set and also to identify improvements in ICT disaster recovery strategies at Nuklear Malaysia. These simulation exercises successfully identified the critical achievement level of PTM incident management based on Business Impact Analysis (BIA) objectives through detailed flowcharts of ICT incident management simulation workflows. In conclusion, these simulation exercises optimize the verification of BIA objectives achievement levels, ensuring that Nuklear Malaysia's cybersecurity and ICT management can be guaranteed through smooth normalization of ICT governance and operations. Additionally, it also identifies vulnerabilities and weaknesses in our security controls and operational systems. Therefore, PTM planning for ICT incident management at Nuklear Malaysia can be improved continuously. Keywords: preparedness, security, incident management, disaster recovery plan, business continuity plan.

P06

AXS: EFFICIENT TOOL FOR GRAPHENE CHARACTERIZATION

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Abstract

This study introduces an efficient way of characterizing particulate nanosheet graphene. Our method delivers an outstanding result, yielding number of graphene layers. Thus the technique could be used to determine singe layer, bilayer or few layer graphene. The result was confirmed by Raman scatter-ing. The success of this efficient technique opens up possibilities for leveraging a cost-effective and uncomplicated process to attain high quality graphene.

P07

OPTIMIZING EDXRF METHODS FOR ACCURATE GOLD ALLOY PURITY ASSESSMENT

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Abstract

There has been a growth in demand for gold-based transaction products that are more rapid and efficient. The enduring appeal of gold can be attributed to its inherent value, potential for investment, and cultural significance. Accurately determining gold purity in alloys is essential for various industries, including jewellery. Traditional methods of gold purity measurement, such as fire assay and inductively coupled plasma mass spectrometry (ICPMS), are highly accurate but can be time-consuming, costly, and require complex sample preparation. Energy Dispersive X-ray Fluorescence (EDXRF) offers a non-destructive, rapid, and cost-effective alternative for gold alloy analysis. However, the accuracy of EDXRF can be influenced by several factors, including instrumental parameters, sample homogeneity, and matrix effects. This study explores methods to enhance the accuracy of EDXRF for gold alloy purity measurements. The research focuses on optimizing instrumental parameters, including X-ray tube voltage, acquisition time, filter and collimator to improve signal-to-noise ratio and peak resolution. Additionally, the study evaluates the impact of sample preparation techniques and the usage of calibration standards on measurement accuracy and precision. A comprehensive analysis of matrix effects is conducted, exploring the influence of common alloying elements in yellow gold such as silver and copper on EDXRF measurements. This study combined standardless Fundamental Parameter (FP) with empirical calibration using matrix-specific materials, which are applied to mitigate these effects. The research also assesses the feasibility of correction factors to predict and correct for complex matrix interactions. The EDXRF procedures' reliability was then conducted through cross-validation with fire assay towards sets of gold matrix samples designed similarly to the commercial gold materials. The findings demonstrate that with proper tuning and calibration, EDXRF can achieve accuracy comparable to traditional methods for gold purity determination in alloys. This study contributes to the field by providing a comprehensive framework for the precious metals industry. The optimized EDXRF method offers a reliable, efficient, and non-destructive solution for industrial applications, significantly reducing the time and cost associated with gold alloy analysis. Hence, it will support the gold industry through high confidence in the accuracy of equipment and fair trade in their transaction.

Keywords: EDXRF, Gold Purity Measurement, Accuracy, Non-Destructive, Matrix Effect

P09

CHARACTERIZATION OF POLYVINYL ALCOHOL DOSIMETER BASED ON SILVER NITRATE AND SILVER BROMIDE USING UV-Vis SPECTROPHOTOMETER

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Abstract

Recent advances in radiotherapy techniques have made it possible to deliver highly conformal radiation to the tumour inside the body for cancer treatment. A three-dimensional (3D) dosimetry system is required to verify the accuracy of the complex treatment delivery. The polyvinyl alcohol (PVA) dosimeter is a 3D dosimeter based on the radiochromic reaction of a polymer to ionising radiation. The PVA-based dosimeter matrix is combined with a leuco-dye and a free radical initiator, whose colour changes in proportion to the radiation dose. In the last decade, PVA dosimeter achieved refinement and augmentation as a 3D dosimeter. PVA dosimeter, in particular, overcomes the limitations of its predecessors, the Fricke gel, which are difficult to fabricate and read, sensitive to oxygen, and sensitive to diffusion. This study aims to review the characteristics of the PVA radiochromic dosimeter using UV-Vis spectrophotometer. The formulation of PVA dosimeter displays a complex balance between the quantity of radical initiators, metal compounds, and catalysts to ensure stability, optimum sensitivity, and water equivalency.

Keyword: radiation dosimeter, polymer, radiotherapy, polyvinyl-alcohol, 3D dosimetry

P10

A PRELIMINARY STUDY OF CELLULOSE NANO FIBRILS INCORPORATING METAL OXIDE NANOPARTICLES IN ENHANCING CERAMIC COMPOSITE FOR POTENTIAL NON-TOXIC RADIATION SHIELDING MATERIALS

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Abstract

In workplaces with radiation-generating devices and radioisotopes, such as an accelerator and X-ray resources, radiation dose must be controlled properly to prevent hazards caused by exposure to radiation. Any shielding material (portable or fixed) that absorbs radiation is indispensable to protect personnel from ionising radiation. Ordinary concrete (density of ~2.3 g/cm3) with adequate thickness is commonly used for irradiation facilities especially for high energy beams due to its stable mechanical strength and promising radiation attenuation properties. Meanwhile, lead is used for portable or fixed radiation shielding especially for low and medium energies due to its higher density (11.29 g/cm3). However, lead is toxic to human body whereas the cost for producing concrete has increased and needs large space installation according to the required thickness for high beam photons (MeV). Incorporating cellulose nanofibrils (CNF) as matrix and stabilizing the highest density metal oxide nanoparticles (NPs) in composite materials as potential radiation materials might solve the toxicity and space problems to attenuate various energies of radiations in any radiation instrument facilities including medical and industries. In this research, we studied the mechanical and physical properties of fabricated ceramic materials incorporated with CNF and metal oxide NPs as an alternative for promising shielding materials. The CNF was synthesized from coconut husk using combination of chemical hydrolysis and sonication process, whereas the tin NPs was synthesized using chemicals process. The CNF, tin NPs and their distribution in ceramic materials was characterized using Fourier Transformed Infrared (FTIR) spectroscopy, Field Emission Scanning Electron Microscopy (FESEM) and UV-Vis spectroscopy. Mechanical strength of the ceramic materials with various ratio of CNF and tin NPs was tested using Universal Testing Machine (UTM). 2:2:3:4 ratio of CNF, NPs, feldspar (KAlSi3O8) and clay shows the best results in terms of particles uniformity and mechanical strength.

Keywords: Cellulose nanofibrils, nanomaterials, radiation shielding, ceramic, Gamma/X-rays

P15

DEPTH DOSE MEASUREMENT BY USING AL_2O_3 OSL DOSIMETERS IN THE PRESENCE OF AIR CAVITY AND DENSITY INHOMOGENEITY IN HIGH ENERGY ELECTRONS

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Abstract

Air cavities and tissue density inhomogeneity significantly affects the distribution of radiation doses, potentially resulting in adverse consequences such as cancer recurrence. This research aims to assess the accuracy of Al_2O_3 optically stimulated luminescence (OSL) dosimeters in measuring doses within varying thicknesses of air cavities and tissue inhomogeneities. An expanded polystyrene (EPS) was used to simulate the air cavity within the solid water phantoms. The low and high density mediums are simulated by the cork simulating the lungs (5 cm) and bone phantoms (3 cm). The percentage depth-dose (PDD) curves at 9 and 15 MeV electrons were obtained in both presence of air cavity and density inhomogeneities and compared to that in the EBT3 radiochromic film dosimeters and treatment planning system (TPS). The results indicated that the presence of an air cavity and tissue inhomogeneities affected the depth dose measured in OSL dosimeters, EBT3 films and TPS. OSLD and TPS showed good agreement at the centre of the cavity, which is within ±5% but could not estimate scattered radiation to the distal and proximal surfaces of the air cavity. The obtained *p*-values showed no significant differences of dose measured in OSL dosimeters compared to those in EBT3 films and TPS. The overall results indicated the suitability of OSL dosimeters as indirect dosimeters for the measurements of depth dose in the presence of air cavity and tissue density inhomogeneities.

Keywords: OSL dosimeters, electrons, air cavity, density inhomogeneity

P16

THE VARIATION OF KOTA BELUD INDIGENOUS RICE BASED ON ORGANIC ELEMENTAL AND STABLE ISOTOPE PROPERTIES

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Abstract

Indigenous rice cultivated in Kota Belud accounted for numerous varieties with varying colors and physical characteristics. The surge in demand for premium rice underscores the imperative of ensuring its authenticity, a matter of paramount importance to both consumers and producers. Consequently, the necessity for analytical methodologies capable of accurately tracing and verifying the variety of rice has become increasingly pronounced. The primary objectives of the study were to characterize the organic elemental composition of carbon (C), nitrogen (N), hydrogen (H), and sulfur (S) and isotopic composition of indigenous rice and to model the classification of rice varieties using a chemometric approach. Four varieties, namely *beras wangi keladi putih*, *beras wangi keladi merah*, *beras wangi keladi hitam*, and *beras keladi putih*, were obtained from local farmers. The analysis revealed significant differences ($p<0.05$) in C, N, and S among rice varieties. Additionally, isotopic data for oxygen (O) and hydrogen (H) also exhibited significant differences ($p<0.05$) between rice varieties. A clear separation among rice varieties was achieved through linear discriminant analysis (LDA), resulting in an overall correct classification rate of 90%. Ultimately, this research contributes to the preservation and promotion of indigenous rice varieties, which play a significant role in the cultural heritage and agricultural diversity of the region.

P17

STATISTICAL ANALYSIS OF DISUSED SEALED RADIOACTIVE SOURCES (DSRS) FROM RADIOACTIVE WASTE INVENTORY IN MALAYSIA

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Abstract

A Disused Sealed Radioactive Source (DSRS) is a type of sealed radioactive material that is no longer in use or has been removed from service. These sources may have become outdated due to the end of their operational life, advancements in technology, or changes in regulations. If not properly managed and disposed of, DSRS can pose significant risks. Improper storage and handling can lead to deterioration over time, potentially resulting in leaks or accidental radiation exposure. Maintaining a comprehensive inventory of radioactive waste is essential for effective waste management, regulatory compliance, and ensuring overall safety. Such an inventory allows organizations and authorities to monitor and control radioactive waste from its creation to its final disposal. Conducting statistical analysis on the radioactive waste inventory provides valuable insights for waste management planning, regulatory compliance, and decision-making. This analysis can help identify areas needing improvement, develop effective waste management strategies, and ensure the safe and efficient handling of radioactive waste.

Keywords: Disused Sealed Radioactive Sources (DSRS), statistical analysis, decision-making

P18

EXPLORING DOMESTIC CAPABILITIES FOR NUCLEAR POWER SUPPLY CHAIN PARTICIPATION IN MALAYSIA

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Abstract.

A desktop assessment was conducted to evaluate Malaysia's industrial potential for participation in the nuclear power supply chain. By analysing existing manufacturing capabilities, engineering expertise and human capital development, this research seeks to identify opportunities for domestic industries to contribute to the development and operation of nuclear power plant. Preliminary findings serves as an initial indicator of the alignment of Malaysia's industrial base with the specific requirements of nuclear power supply chain.

P19

PERFORMANCE QUALIFICATION DOSE MAPPING OF GLOVE STERILISATION USING ELECTRON BEAM IRRADIATION

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Abstract

Electron beam (e-beam) irradiation is an emerging technology in Malaysia, offering applications mostly in medical device sterilisation, polymer cross-linking, and electronic properties enhancement of semiconductor. The need for consistent and reliable EB dose measurement is essential to ensure precise control of irradiation doses. Dose mapping helps identify the Dmin and Dmax locations within the product, ensuring that all parts receive adequate absorbed dose without exceeding material tolerance levels. This study presents dose mapping activities carried out on a box of gloves to perform performance qualification for product sterilisation using electron beam (EB) irradiation. The main objective is to determine the location of the minimum (Dmin) and maximum (Dmax) doses, as well as the dose uniformity ratio (DUR). Three full dose mappings were carried out using radiochromic FWT dosimeters to accurately measure the doses. The EPS-3000 EB machine was set at 3MeV accelerator voltage, 2 mA beam current, and a conveyor speed of 0.89 m/min. These parameters were optimized to achieve the desired dose distribution within the glove boxes. The Dmin and Dmax were determined to be 15 kGy and 41 kGy, respectively, resulting in a DUR of 2.73. The Dmin locations were identified at the top and bottom corners of the box, while the Dmax was located at the center of the box. The study confirmed the zones of minimum and maximum dose distribution within the product box and specified the EB appropriate process parameters for sterilising gloves, highlighting its effectiveness in maintaining product quality and safety.

Keywords/Kata kunci: EB machine, sterilisation, dose mapping, dosimeter

P20

ASSESSMENTS OF NATURAL RADIONUCLIDES CONCENTRATION AND RADIOLOGICAL HAZARD INDICES IN UNIVERSITI TEKNOLOGI MALAYSIA (UTM)

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Abstract

Terrestrial gamma radiation arises from the decay of naturally occurring radionuclides, known as primordial radionuclides. The radiological hazard associated with these radionuclides can be quantified using radiological hazard indices. This study aims to (1) determine the average Terrestrial Gamma Radiation Dose (TGRD) rate at Universiti Teknologi Malaysia (UTM), (2) assess the average concentrations of radionuclides ^{238}U, ^{232}Th, and ^{40}K in UTM soil, and (3) evaluate the corresponding radiological hazard indices. The mean TGRD rate, measured at 30 locations across UTM, was found to be 100.11 ± 16.22 nGy/h, which exceeds both the national average of 92 nGy/h and the global average of 59 nGy/h. Gamma spectra of soil samples from five locations with the highest TGRD readings were analyzed using a high-purity germanium (HPGe) detector. The mean activity concentrations of ^{238}U, ^{232}Th, and ^{40}K were 71.29 ± 33.11 Bq/kg, 74.09 ± 27.72 Bq/kg, and 343.03 ± 226.52 Bq/kg, respectively. The calculated radiological hazard indices—annual effective dose equivalent, radium equivalent activity, external hazard index, and internal hazard index—were all below international safety limits, indicating that the radiation hazard levels in UTM are within safe bounds.

P21

TOMOGRAPHY DESKTOP SCANNER USING VISIBLE LIGHT FOR EXPERIMENTAL LEARNING AND IN EDUCATIONAL SETTING

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Abstract

Computed tomography (CT) has emerged as a powerful non-destructive imaging technique, utilizing X-rays or neutrons to reveal the internal structures of objects. However, incorporating hands-on lab activities with imaging equipment that employs radiation poses challenges such as radiation exposure and limited access. This study presents the development a simple and portable imaging scanner designed to illustrate the principles of a computed tomography system within an educational environment. It can be used as a demonstration tool. The developed CT scanner utilizes a light source instead of X-rays, addressing concerns related to radiation exposure. By incorporating a rotating stage, test phantoms, a computer camera, a paper screen, and a custom control program, an affordable yet effective CT scanner can be developed. Transparent phantoms, easily fabricated, leverage the visibility of light, allowing students to directly observe the formation of images. Objects are rotated incrementally, with a 1° angle per step, enabling a complete 360° rotation for comprehensive scanning.

Keywords: Computed tomography, light source, transparent phantom, projections, image reconstruction

P27

ANALYSIS OF CYCLE LENGTH FOR HIGH-FISSILE-DENSITY FUEL IN SELECTED SMR AND MMR

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Abstract

Small Modular Reactors (SMRs) and Micro Modular Reactors (MMRs) are gaining significant interest in the nuclear power industry due to their compactness and mobility. However, they face challenges with neutron economy, necessitating the development of advanced fuels to extend their cycle lengths. This paper presents simulations of high-fissile-density fuel in selected SMR and MMR designs. One SMR and one MMR were chosen as reference reactors, and core models were developed and verified against published data. Various case studies were conducted using different high-fissile-density fuels, and the reactor neutronics, including cycle length, were analyzed. The results indicate that high-fissile-density fuels can significantly extend the cycle length of these reactors. Achievable burnup, power distribution, nuclide inventory, delayed neutron fraction, and fuel temperature reactivity coefficient were evaluated, demonstrating improvements in reactor performance and efficiency. This study provides critical insights into the potential of advanced fuels to enhance the operational capabilities of SMRs and MMRs, supporting their role in the future of nuclear energy.

Keywords: Neutronics, Cycle length, High density fuel, SMR reactor

P28

COMPARISON OF THE POTENTIAL RISK ASSOCIATED WITH VARIOUS SMR DESIGNS

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Abstract

Each SMR design presents a distinct array of risks due to its specialized technology and systems. The Probability of Safety Assessment (PSA) Level 1 is a technique used to evaluate the safety risks of nuclear power plants, focusing on the probability of reactor core damage. Current research mainly emphasizes the advantages and safety features of a particular SMR design. However, there is a deficiency in the available information and data needed for a thorough comparative analysis of the potential risks associated with various SMR designs, particularly in terms of the identification systems and design technologies that are most critical to safety and present the highest risks. As a result, this study was done to identify and compare the potential risk associated with various SMR designs. A rigorous risk evaluation can help regulatory agencies set safety criteria for SMRs. This study conducts a comparison of Stage-1 PSA data for the ACP 100, NuScale, and BWRX-300 reactors. The research method consisted of gathering and analysing data from available reports and technical documentation for each type of SMR design. Key risk factors and event scenarios are identified and assessed to estimate the potential risks associated with each design. Furthermore, the risk profile of SMRs is compared to typical large-scale nuclear reactors to determine variations in safety. Findings of this study indicates that the ACP 100's direct vessel injection line brake contributed 66.3% to the core damage frequency (CDF), the NuScale's loss of the auxiliary power supply system contributed 33.6% to the CDF, and the BWRX-300's boron injection system contributed 95.6% to the CDF. Furthermore, SMR has a lower CDF value than typical reactors, which range from 1E-04 to 1.42E-07 and 1E-5 to 1E-6 reactors annually. The findings of the study can inform future design choices for SMR.

Keywords: SMR; safety; risk; design

P29

INFLUENCING FACTORS FOR SPENT NUCLEAR FUEL FROM RESEARCH REACTOR ON RADIOACTIVE WASTE MANAGEMENT PLAN

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Abstract

Research reactors have various functions in the development of nuclear technology, especially for countries that support nuclear energy for peaceful purposes. Much of the high-level spent nuclear fuel generated from research reactors currently does not have a good disposal plan. This has caused debate from the public. However, ongoing efforts in research and development in producing more strategic management of spent nuclear fuel (SNF) to help nuclear power and the environment are growing rapidly. Spent nuclear fuel management is defined as the efficient and safe handling, storage and disposal of SNF, and radioactive waste generated by nuclear power plants or other nuclear reactors. This study aims to look in detail at the management method of spent nuclear fuel from research reactors and identify the factors that influence the disposal plan in Malaysia. In addition, this research also uses a qualitative method where a combination of two approaches will be used, which is an analysis of international and national legal documents and a focused cross-check method with related documents. Therefore, a review of the strategy for the disposal of spent nuclear fuel from research reactors in Malaysia should be emphasized to ensure that the country's radioactive waste management is more strategic and optimal in order to increase confidence and subsequently change the public's perception of nuclear energy.

P30

NATURAL RADIOACTIVITY LEVEL IN COAL ASHES AND RADIOLOGICAL RISKS OF TOPSOIL AROUND A COAL-FIRED THERMAL POWER PLANT IN MALAYSIA

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Abstract

Coal is a dominant fossil fuel for power generation in Malaysia. Combustion of coal releases substantial amounts of ash by-products, including bottom (CBA) and fly ash (CFA) which can be radioactive. Depending on power plants' stack emission control performance, significant quantities of ash may be emitted into the atmosphere and subsequently deposited into the surrounding areas. This paper investigates the radioactivity level of coal ashes and topsoil near Tuanku Mukhriz Power Station, Port Dickson. It was found that concentrations of ^{238}U, ^{232}Th, and ^{40}K in the ashes were ranging 19.7 – 139.2 Bq/kg, 18.9 – 114.7 Bq/kg and 124.9 – 601.1 Bq/kg, respectively. The concentrations of ^{238}U, ^{232}Th and ^{40}K within 1 km to 10 km distance from the plant were 12.54 – 85.83 Bq/kg, 12.80 – 167.90 Bq/kg and 231.94 – 1384.05 Bq/kg, respectively. In addition, annual effective doses (AED) were substantially below the national regulation limit (1 mSv/y). It can be reasonably concluded that the coal ashes may be safely reused or recycled for other applications, and there are negligible radiological risks from the plant operation on the local population and plant operators.

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SELF-ATTENUATION CORRECTION IN ENVIRONMENTAL BULK SAMPLES: A STUDY ON ENHANCING GAMMA-RAY ACTIVITY MEASUREMENT USING HPGE DETECTOR WITH SOIL SAMPLES IN VARIED GEOMETRIES

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Abstract

Gamma-ray spectrometry is a vital technique for identifying and measuring radioactivity in environmental samples, offering high energy resolution. However, the accuracy of measurements in bulk samples is often compromised due to geometric and compositional variations from reference samples, leading to self-attenuation effects. This study aims to enhance the accuracy of gamma-ray activity measurements in soil samples by applying a self-attenuation correction across various geometric shapes and sample matrices. The proposed correction methodology was experimentally verified using High Purity Germanium (HPGe) detectors, resulting in an improvement of activity concentration measurements by 4.04 % to 8.66 %. The self-attenuation correction reduced measurement discrepancies by 6.27%, particularly in samples with significant density variations. These results highlight the critical importance of accurate self-attenuation corrections for reliable environmental monitoring. This advancement in measurement precision is expected to contribute to more effective environmental and nuclear safety protocols.

Keywords: HPGe detector, Bulk samples, Self-attenuation, Geometric shape, Activity concentration.