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Isodose mapping of terrestrial gamma radiation in Sarawak-Borneo: Insights from surface-weathered soil analysis

H.N. Idris [a,b], M.S.M. Sanusi [b,*], A.T. Ramli [a], M.R.M. Solleh [c], F. Yahaya [d], M.Z. Ya'cob [c], W.B. Siong [e]

[a] Waste Technology & Environment, Division, Malaysian Nuclear Agency, 43000, Kajang, Bangi, Malaysia
[b] Department of Physics, Faculty of Science, University Teknologi Malaysia, Skudai, Johor, Malaysia
[c] Faculty of Engineering and Life Sciences, Department of Science and Biotechnology, University of Selangor, Malaysia
[d] Faculty of Education and Social Sciences, Departmnet of Social Sciences, University of Selangor, Malaysia
[e] Faculty of Resource Science and Technology Universiti Malaysia Sarawak, Kota Samarahan, Sarawak, Malaysia

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ABSTRACT

Presentation of baseline data on terrestrial gamma radiation (TGR) levels is crucial for assessing the annual effective dose received by the public due to natural radiation exposure. Cumulative doses from various sources can become significant, warranting a spatial understanding of TGR distribution. Few countries have comprehensively mapped TGR on a national scale, often facing challenges due to remote or inaccessible regions. This study investigated the influence of weathered soil groups on TGR dose rates in Sarawak-Borneo, Malaysia, to facilitate insights for TGR projection and isodose mapping. A total of 1044 TGR dose rate measurements were collected using NaI (Tl) scintillation detector survey meters, with a mean of 100 nGy h^{-1} and a range of 8–375 nGy h^{-1}. Non-parametric statistical analyses of variance using Welch's ANOVA, Brown-Forsythe, and Kruskal-Wallis validated (P-sig.=.000) notable dissimilarities among six categories of superficial-weathered soil. Graphical analysis using Sinclair's cumulative plot revealed deviations at intervals of 50, 80, 100, 120, 175, and 205 nGy h^{-1}. These deviations indicate distinct lithological influences. Skeletal soil (entisols) and podzolic soils had high mean dose rates (148 and 113 nGy h^{-1}, respectively) due to limited development, thus preserving abundant uranium (U) and thorium (Th). Meanwhile, gleysols and thionic soils exhibited compatible means (90 and 82 nGy h^{-1}, respectively), while alluvial (or transported soils) and organic soils displayed lower dose rate ranges (mean of 76 and 47 nGy h^{-1}, respectively), reflecting rapid hydrolysis weathering processes. Simple linear regression analysis revealed a strong relationship between TGR dose rate and mean value of weathered soil groups ($y = 0.851x + 0.141$ nGy h^{-1}), signifying the significance and magnitude of weathered soil groups' impact on TGR dose rates. The obtained R-value is 0.704, indicating a strong linear correlation among soil group variables, and a Durbin-Watson statistic of 1.41, suggesting positive autocorrelation among residuals, thus positive relationships. An isodose map was successfully developed using the Kriging technique, aligning with lithological features of the study area. Semivariogram analysis reveals spatial dependence within a range of 1.47°, supporting the Kriging technique's suitability for spatial inference. In conclusion, this study has successfully revealed the relationship between TGR dose rates and superficial-weathered soil in Sarawak-Borneo. While the linear relationship is applicable to the Sundaland-Borneo tectonic block, it has potential to be used as a valuable tool for spatial inference of TGR dose rates in isodose development with similar lithologial characteristics, aiding in radiation exposure assessment and environmental monitoring.

1. Introduction

Baseline data pertaining to regional terrestrial gamma radiation (TGR) levels is vital for estimating the annual effective dose accrued by the public due to natural radiation exposure. Although TGR-induced radiation exposure is typically low, the cumulative dose from various sources, such as medical radiation procedures, impacting the public can be substantial. In this context, the development of a spatial

* Corresponding author.
E-mail address: mohamadsyazwan@utm.my (M.S.M. Sanusi).

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