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Radiological study of Mersing District, Johor, Malaysia

Muneer Aziz Saleh [a,b,*], Ahmad Termizi Ramli [a], Yasser Alajerami [a], Abubakar Sadiq Aliyu [a], Nor Afifah Bt Basri [a]

[a] Department of Physics, Faculty of Science, Universiti Teknologi Malaysia, 81310 Skudai, Johore Bahru, Johore, Malaysia
[b] National Atomic Energy Commission (NATEC), Sana'a, Yemen

HIGHLIGHTS

- ► A station in Mersing District has been identified as a possible site for nuclear power plant.
- ► The average dose rate found to be two times higher than the world average.
- ► The activity concentration of ^{232}Th is four times world average.
- ► The activity concentration of ^{238}U is two times and ^{40}K is lower than world average.
- ► A digital map plotted for isodose, ^{232}Th, ^{238}U, ^{40}K, gross alpha, gross beta activities.

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ABSTRACT

A potential site has been selected for a nuclear power plant (NPP) in Mersing District of Malaysia. This study aims at providing the base line data of this district for the first time, in line with the International Atomic Energy Agency (IAEA) for NPP sitting criteria. The mean dose rate, mean population weighted dose rate and annual effective dose are found to be 140 nGy h^{-1}, 0.836 mSv y^{-1} and 0.857 mSv, respectively. A hyper Purity Germanium Detector (HPGe) is used in determining the activity concentrations of ^{232}Th, ^{226}Ra and ^{40}K. The activity concentration ranges from 16 ± 1 to 410 ± 15 Bq kg^{-1} for ^{232}Th, 17 ± 1 to 271 ± 8 Bq kg^{-1} for ^{226}Ra and 13 ± 3 to 1434 ± 57 Bq kg^{-1} for ^{40}K. In addition, a Low Background Alpha Beta Series 5 XLB Automatic was used in the determination of gross alpha and gross beta activity. The result ranges from 202 ± 50 to 2325 ± 466 Bq kg^{-1} for gross alpha and 164 ± 17 to 2447 ± 103 Bq kg^{-1} for gross beta. Contour maps were produced for isodose, activity concentration of ^{232}Th, ^{226}Ra, ^{40}K, gross alpha and gross beta for the study area. The results are compared with UNSCEAR (2000).

1. Introduction

Natural radiation sources have always existed on earth, and all living organisms are continually being exposed to it. Gamma radiation emitted from primordial radioisotopes is one of the main external sources of radiation on earth (UNSCEAR, 1993, 2000). Terrestrial radioactivity and the associated external exposure due to gamma radiation depend primarily on the geological background and soil types. The geological background and soil type factors greatly influence the dose distribution of natural terrestrial gamma radiation. Since natural radiation is the largest contributor of external dose to the world population, an assessment of gamma radiation from natural sources is of particular importance. The concentrations of ^{232}Th, ^{226}Ra and ^{40}K vary widely depending on the geographical location (UNSCEAR, 2000).

The measurement and monitoring of terrestrial gamma radiation dose as well as the determination of the concentration of radionuclides in soil are important information in NPP site assessment. The Mersing District has been proposed as a potential site for Malaysia pioneer NPP (Basri and Ramli, 2012).

In this study, 460 gamma measurements were conducted at different data locations and 65 soil samples were collected from locations. The data obtained would be used in determining the radioactivity levels in the surface soil of the Mersing District and the corresponding health hazard.

2. Materials and methods

2.1. The study area

Mersing District is located between 2° 04′ and 2° 39′ N, and longitudes 103° 17′ and 104° 03′ E. It is located in the east of the

* Corresponding author at: Department of Physics, Faculty of Science, Universiti Teknologi Malaysia, 81310 Skudai, Johore Bahru, Johore, Malaysia.
Tel.: +60 9671245453.
E-mail addresses: mouneersaleh@yahoo.com, mouneersaleh@gmail.com (M.A. Saleh).

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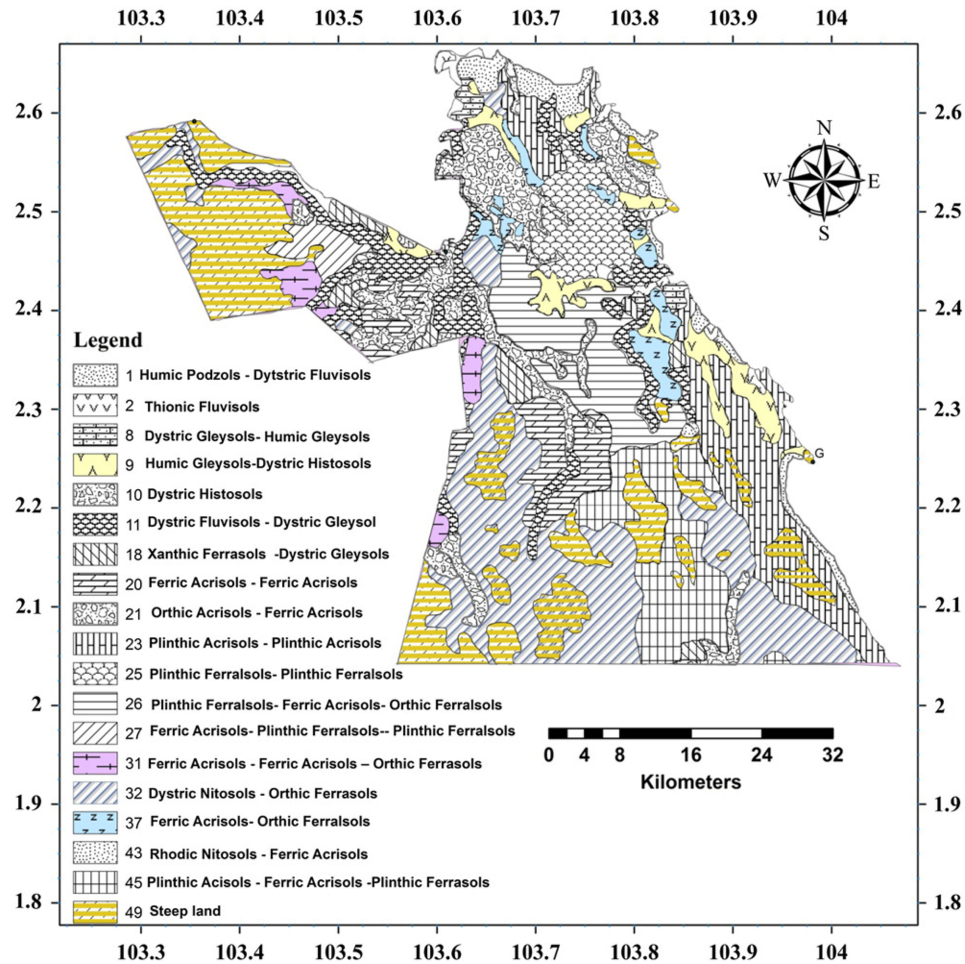

Fig. 1. Map of soil type in Mersing District of Johor, Malaysia.

State of Johor, Malaysia, with a total land area of 2838.6 km^2, and a population of 69,028 as of 2010 (Department of Statistical Malaysia, 2010). Mersing District is overlain by 19 soil types as classified by FAO/UNESCO (Director General of Agriculture Peninsular Malaysia, 1973) as shown in Fig. 1 and Table 1.

Mersing District also has eight underlying geological formations underlying soils (Ramli et al., 2000) as followings:

(1) Quaternary (1): It is composed of continental and marine deposits with unconsolidated sand (mainly marine).
(2) Quaternary (2): It is composed of continental and marine deposits with unconsolidated silt and clay (marine).
(3) Quaternary (3): It is composed of continental and marine deposits with unconsolidated humic clay, peat and silt.
(4) Quaternary (4): It is composed of continental and marine deposits with unconsolidated clay, sand, silt and gravel-undifferentiated.
(5) Cretaceous-Jurassic (10): It is composed of thick, cross-bedded sandstone with metamorphic and sedimentary rocks of sandstone/metastone.
(6) Permian (20): It is consists of shale, slate, and phyllite with subordinate schist and sandstone. It developed of limestone through the succession. Rhyolitic, volcanic, to andersitic in composition, widespread.
(7) Permian (21): It consists of Permian (20) with unconsolidated deposits of ignimbrit.
(8) Acid Intrusive (38): It is consists of undifferentiated igneous rock (Director General of Geological Survey, 1982).

Fig. 2 shows the geological formations of Mersing District, Johor, Malaysia.

2.2. Measurements of gamma dose rates

The measurements of absorbed dose rates in air were conducted in the study area at the crossing points of the latitudinal and longitudinal lines as far as possible. Dose measurements were performed at each location using two survey meters manufactured by Ludlum Measurement, USA. Fig. 3 shows the locations where the data were obtained. Dose rate measurements were made until the readings were stable (Ramli, 1997) at least two measurements were taken around the measuring point for each detector. The mean results were calculated in micro roentgen per hour ($\mu R\, h^{-1}$). The readings were converted from $\mu R\, h^{-1}$ to $nGy\, h^{-1}$ ($1\ \mu R\, h^{-1} \approx 8.7\ nGy\, h^{-1}$). The uncertainty was calculated using the standard division formula. The instrument has a linear energy response to gamma radiation dose between 0.04 and 1.2 MeV (Knoll, 1989). This range covers the majority of gamma radiations emitted from natural radiation sources. The detector response to cosmic gamma rays from is very low due to the detector's low response to high energy cosmic gamma radiation (Ramli, 1997). The instrument was calibrated at higher dose rates by Malaysian Nuclear Agency, which is a recognized as a Secondary Standards Dosimetry Laboratory (SSDL) by the IAEA.