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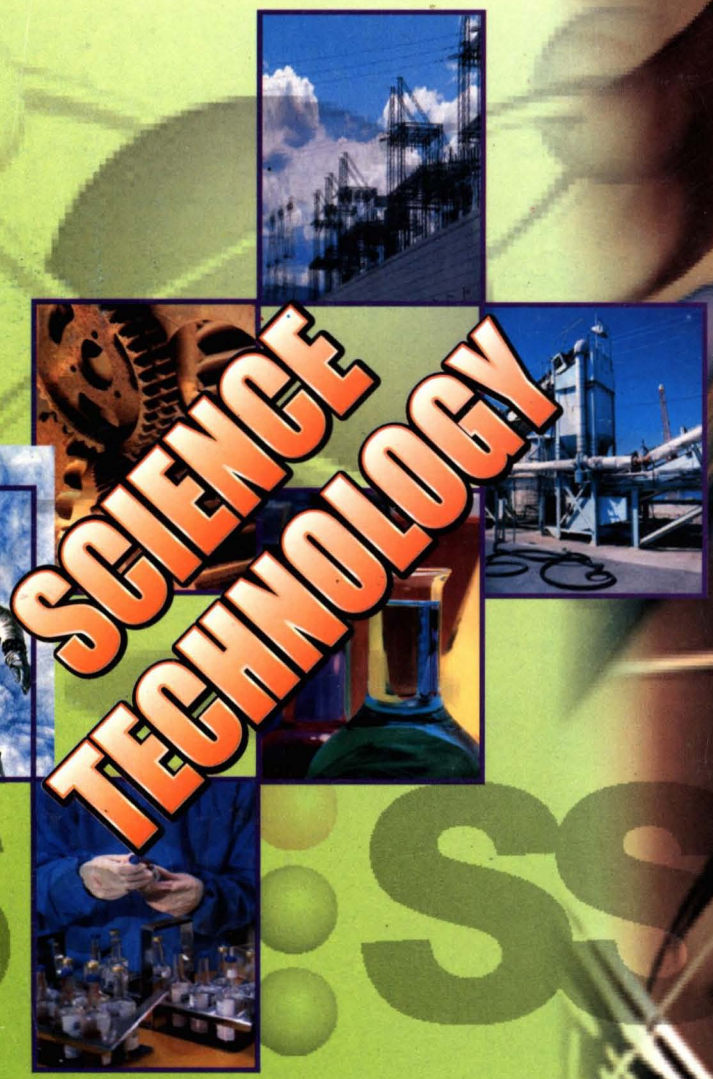

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Environmental Survey of Natural Gamma Background Radiation Dose Rates in Rembau District, Malaysia

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ABSTRACT

Universiti Teknologi MARA Negeri Sembilan (UiTM NS) has conducted an environmental survey of natural background gamma radiation dose rates in Rembau district, Malaysia. The natural radiation sources have always existed on earth and all living organisms are continually exposed. The doses to human beings from natural radiation are important, beccuse they contribute the largest component of equivalent dose received by the world population. About 74 % of area was carried out to map the distribution of terrestrial gamma radiation dose rates in Rembau district. The highest terrestrial gamma radiation dose rate measured is 857±14 nGy h^{-1}. The lowest terrestrial gamma radiation dose rate measured is 114±14 nGy h^{-1}. The average terrestrial gamma radiation dose rate measured in Rembau district is 383±18 nGy h^{-1}. These data are presented as terrestrial gamma radiation dose rates map of Rembau district, Malaysia. This map provides a usable regional picture of environmental gamma background radiation dose rates excluding cosmic radiation in Rembau district.

Keywords: *Terrestrial gamma radiation dose rate, Environmental radiology, Soil and Geology.*

Introduction

The terrestrial gamma radiation dose rates were measured at 93 locations in the district of Rembau, Malaysia. One of the main goals of radiation protection is to measure the amount of radiation to which a person's body is subjected. It is very important when radiation interacts with tissue some or all of the radiation energy is imparted to that tissue. Since radiation of natural origin is responsible for most of the total radiation exposure, knowledge of the dose received from natural sources is very important in the discussion not only of its effects on health but also of the incidence of other radiation from man made sources (UNSCEAR 2000).

The current study examines relationship between terrestrial gamma radiation dose rates, soil types and underlying geological formations in district of Rembau, Malaysia (Quindos et al. 1994; Ramli et al. 2003; Abdul Rahman et al. 2004; Abdul Rahman et al. 2005). Rembau district is located between latitudes 2° 25' and 2° 43' North and longitudes 102°00' and 102°113' East. It has an area approximately 440 km^2 and a population of about 41,000. Seventy per cent of the area is covered by forest and the main land use is for agriculture.

Rembau district can be divided into three major geological formations of different geological age (Director General of Geological Survey, 1982) as shown in Table 1. The geological formations overlaid are, (a) Devonian, (b) Silurian and (c) Acid Intrusive Rock. Devonian (G5) and Acid Intrusive Rock (G7) are most abundant in Rembau district, about 60 per cent of the area.

Rembau district is overlaid by six group of soil types as classified by FAO/UNESCO (Director General of Agriculture Peninsular Malaysia 1973) as shown in Table 2. The soil types are;

(a) Nitosols

Nitosols is a soil of shiny pad surfaces. There are three types of *Nitosols*, namely *Dystric Nitosols (Renggam)*, *Rhodic Nitosols (Tavy)* and *Haplic Nitosols (Serdang)*. *Dystric Nitosols* is the most abundant soil type in Rembau district.

(b) Ferrasols

Ferralsols is a soil with high content of sesquioxides. There are two types found in the Rembau district. These soil types are characterised as *Orthic Ferrasols* and *Plinthinc Ferrasols*. It is also called *Munchong* and *Malacca*.

(c) Acrisols

Acrisols is an acidic soil of low base saturation. Two types are found in the southern part of Rembau district. They are characterised, as *Orthic Acrisols* and *Plinthinc Acrisols*, and the local names are *Batu Anam* and *Durian* respectively

(d) Fluvisols

Fluvisols; this group consists of flood plains and alluvial soils. There is one type of *Fluvisols*, namely *Thionic Fluvisols*, and the local names is *Kranji*. Most of this group are found on the coastal plain, mostly in tidal swamps covered by mangrove.

(e) Leptosols

This group consists of clay in all horizons to a dept of 100cm or more. There is only one type of this group in Rembau district, *Dystric Leptosols* or local name called *Seremban Series*.

(f) Miscellaneous soils, (i) Steep Land. (ii) Local Alluvium.

Most of Rembau district is steep land with forested area above 30 m in height (Yaacob & Jusop 1982).

Table 1: Geological formations of Rembau district, Malaysia.

Geological Label	Geological Name	Composition
G5	Devonian	Phyllite, schist and slate, limestone and sandstone, locally prominent. Some interbeds of conglomerate, chert and rare volcanic.
G6	Silurian	Schist, phyllite, slate and limestone. Minor intercalations of sandstone and volcanic.
G7	Acid Intrusive	Undifferentiated of granite and intrusives rock.

Experimental Methods

By aligning the grid along latitudinal and longitudinal, Rembau district was divided into 126 squares of area around 1.85 km ′ 1.85 km (1' ′ 1') (Abdul Rahman et al. 2004). Soil types and underlying geological features for each crossing point was determined. Measurements of the actual terrestrial gamma radiation dose rate were done with gamma ray detectors manufactured by Ludlum (Model 19 Micro R Meter, USA). The equipment uses a 2.54 ′ 2.54 cm NaI crystal doped with thallium [NaI(Tl)]. The instrument had almost flat energy response to gamma radiation between 40 keV and 1.2 MeV (Knoll 1989). It is suitable for environmental gamma radiation measurements. It covers the majority of significant gamma radiation emitted from terrestrial sources (Abdul Rahman et al. 2005). The location for each sampling point was established by a global positioning system (GPS) (Sejkora & Most 1993; Abdul Rahman et al. 2005). Dose measurements were taken at the sampling points away from sites of developments such as roads, buildings and foundation soils. The measurement was done on the ground, with considering of soil types and geological formations information in Rembau area.

Table 2: Soil types of Rembau district, Malaysia

Soil types label	FAO units	Local name
S2	*Dystric Nitosols*	*Renggam*
S12	*Orthic Acrisols-Plinthic Acrisols-Plinthic Ferrasols*	*Batu Anam-Durian-Malacca*
S14	*Plinthic Acrisols-Plinthic Ferrasols*	*Durian-Malacca*
S16	*Plinthic Acrisols-Dystric Leptosols*	*Durian Seremban*
S19	*Plinthic Ferrasols-Rhodic Nitosols-Orthic Ferrasols*	*Malacca-Tavy-Munchong*
S26	*Orthic Ferrasols-Plinthic Ferrasols*	*Munchong-Malacca*
S29	*Haplic Nitosols-Orthic Ferrasols-Rhodic Nitosols*	*Serdang-Munchong-Tavy*
S36	*Thionics Fluvisols*	*Kranji*
S43	*Local Alluvium*	*Local Alluvium*
S48	*Steep Land*	*Steep Land*

Results and Discussions

The terrestrial gamma radiation dose-rate at each location measured was plotted using the GIS Arc View version 3.1 program by ESRI (Goddard 2002; Abdul Rahman *et. al.* 2004) as shown in Appendix 1. The figure clearly shows map the isodose contour lines follow some of the soil types and geological features boundaries in Rembau district. It shows close relationship between terrestrial gamma dose-rates, geological features and soil type's distribution in Rembau district.

The mean terrestrial gamma radiation dose-rate measured for each geological features and each soil types are presented in Table 3 and Table 4. The average terrestrial gamma radiation dose rates measured in Rembau district is 383±18 nGy h^{-1}. The highest terrestrial gamma radiation dose rates measured in Rembau district is 857±14 nGy h^{-1}. It was found in area covered by soil type Dystric Nitosols (S2) and Local Alluvium (S43) with underlying geological features Acid Intrusives (G7). The lowest terrestrial gamma radiation dose rates measured in Rembau district is 114±14 nGy h^{-1}. It was found in area covered by *Haplic Nitosols-Orthic Ferrasols-Rhodic Nitosols* (S29) with underlying geological features Devonian (G5).

Table 3: Mean terrestrial gamma radiation dose rate measured for each different geological features covering the Rembau district, Malaysia

Geological features	Gamma ray dose-rate (nGy h^{-1})					95% confidence interval for mean	
	Mean	Standard deviation	Minimum	Maximum	Standard error	Lower bound	Upper bound
G5	274	114	114	629	15	244	304
G6	400	149	300	571	86	30	770
G7	536	19	214	857	19	498	674

Table 4: Mean terrestrial gamma radiation dose rate measured for each different soil types covering the Rembau district, Malaysia

Soil types	Gamma ray dose-rate (nGy h^{-1})					95% confidence interval for mean	
	Mean	Standard deviation	Minimum	Maximum	Standard error	Lower bound	Upper bound
S2	493	106	257	686	23	446	540
S12	264	71	214	314	50	294	234
S14	245	82	157	629	14	216	274
S16	288	90	214	486	34	205	371
S19	229	40	200	257	29	199	259
S26	295	71	214	243	41	245	345
S29	221	214	114	543	107	181	261
S43	506	169	214	857	51	392	620
S48	547	130	214	714	30	484	610

Tables 3 and Table 4 show mean terrestrial gamma radiation dose rate for each different geological features and for each different soil types. Acid Intrusives Rock (G7) gives the highest mean terrestrial gamma radiation dose rate, which is 536 nGy h^{-1}. *Dystric Nitosols* (S2), *Local Alluvium* (S43) and *Steep Land* (S48) were the most abundant soil types covering of Rembau district. They give the highest mean terrestrial gamma radiation dose-rate measured that is 493 nGy h^{-1}, 506 nGy h^{-1} and 547 nGy h^{-1} respectively.

These soil type of high environmental gamma dose rate levels is abundant in granitic areas, which are extensively intruded by schist, shale, quartzite and siltstone. Granites usually have U, Th and K contents higher than other crustal rocks (Narayana et al. 2001). Dystric Nitosols or locally named Rengam also has 43% clay content and the highest K concentration in 0 - 8 cm depth from surface (Yaacob & Jusop 1982). Both of these soil type are found in area with underlying of *Acid Intrusive Rock* (G7). Acid Intrusive Rock is rock that has crystallized from molten rock material called magma. These rocks contain higher monazite, basalt and rhyolite (Voutileinen *et. al.* 1988). Therefore the highest terrestrial gamma radiation dose rate was found in the area covered by those soil types and geological features.

The lower mean terrestrial gamma radiation dose-rate were found in the areas covered by soil types *Haplic Nitosols-Orthic Ferrasols-Rhodic Nitosols* (S29) and *Plinthic Ferrasols-Rhodic Nitosols-Orthic Ferrasols* (S19), that is 221 nGy h^{-1} and 229 nGy h^{-1} respectively. The area in Rembau district covered by *Devonian* geological features show the lowest mean terrestrial gamma radiation dose rate measured, which is 274 nGy h^{-1}.

Lower dose-rates were registered on *Haplic Nitosols-Orthic Ferrasols-Rhodic Nitosols* (S29) and *Plinthic Ferrasols-Rhodic Nitosols-Orthic Ferrasols* (S19) with underlying of geological features *Devonian* (G5) in certain location along the river. These soil types was overlaid by Devonian geological structure, which was formed from Phyllite, schist and slate, limestone and sandstone, locally prominent as peat, humic clay and silt. Gamma dose-rates generally are lower in Devonian area than in other geological areas. This result is similar to the previous study at Kota Tinggi district (Abdul Rahman et al. 2004), Pontian district (Ramli 1997), Segamat district (Ramli et al. 2005) and Ulu Tiram district (Abdul Rahman et al. 2005).

Conclusion

Outdoor terrestrial gamma radiation dose-rate measured throughout of Rembau district was conducted in this study. Isodose map of gamma radiation dose rate measured was drawn to present environmental terrestrial gamma radiation dose rate distribution in Rembau district. A comprehensive understanding of spatial distribution of gamma dose rate is essential in assessing potential human risk associated with surface soil contamination by radionuclide. It is important for determining radiation detriment to the population as a whole.

About 74 % of area was carried out to map the distribution of terrestrial gamma radiation dose rates in Rembau district. The highest terrestrial gamma radiation dose rates measured is 857±14 nGy h^{-1} and it was found in area covered by *Dystric Nitosols* (S2), *Local Alluvium* (S43) and *Steep Land* (S48) with underlying geological feature *Acid Intrusives Rock* (G7). The lowest terrestrial gamma radiation dose rates measured is 114±14 nGy h^{-1} and it was found in area covered by *Haplic Nitosols-Orthic Ferrasols-Rhodic Nitosols* (S29) and *Plinthic Ferrasols-Rhodic Nitosols-Orthic Ferrasols* (S19) with underlying of geological features *Devonian* (G5).

The average terrestrial gamma radiation dose rates measured in Rembau district is 383±18 nGy h^{-1} and the population weighted mean dose rate Kota Tinggi is 316 nGy h^{-1}. The Malaysian average is 92 nGy h^{-1} and world average is 59 nGy h^{-1} (UNCEAR 2000). Using the conversion factor of 0.7 Sv Gy^{-1} (UNSCEAR 2000) the average dose from such terrestrial gamma radiation dose rate to an individual assuming a tropical rural setting is estimated to be 0.58 mSv per year, which is considered to be within the normal range for doses from natural sources. It is not expected to cause statistical significance radiology health impact.

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References

Abdul Rahman A.T., Jaafar M.Z., Ramli A.T., Hasan M.N., (2005). A Statistical Modelling Of Radionuclide Concentrations In Soil And Its Effect To Gamma Ray Contribution To The Ambient Dose Rate In The District Of Kota Tinggi, Malaysia. *The International Nuclear Chemistry Congress 2005 (1st INCC);. 22 May – 30 May 2005*, Kusadasi Turkey.

Abdul Rahman A.T., Ramli A.T. (2005). A Study of Radioactivity Level of Uranium and Thorium and The Activity of Alpha and Beta Particle and Associated Dose Rates From Soil Surface In Ulu Tiram, Malaysia. *The International Nuclear Chemistry Congress 2005 (1st INCC);. 22 May – 30 May 2005*, Kusadasi Turkey.

Abdul Rahman A.T., Ramli A.T., Abd. Khalik Wood, (2004). Analysis of the Concentrations of Natural Radionuclide in Rivers in Kota Tinggi District, Malaysia. *Journal of Nuclear and Related Technology*. Vol. 1 (1).

Abdul Rahman A.T., Ramli A.T., Abdul Rahman A.L., (2004). Environmental Terrestrial Gama Radiation Dose-Rate and Its Relationship with Soil Type and Underlying Geological Formations in Kota Tinggi District, Malaysia. *The Proceeding of National Seminar of Science Technology and Social Sciences 2004 (STSS 04);.31 May – 1st June 2004*, Kuantan.

Director General of Agriculture Peninsular Malaysia (1973) *Map of Soil Types in Peninsular Malaysia L-40A series 1st ed.* Kuala Lumpur, Malaysia.

Director General of Geological Survey (1985) *Map of Geological Features in Peninsular Malaysia.* Ipoh, Malaysia.

Director of National Mapping Malaysia (1989) *Map of Johore State, Malaysia c type 2nd ed.* Kuala Lumpur, Malaysia.

Goddard C. C., (2002) Measurement of Outdoors Terrestrial Gamma Radiation in the Sultanate of Oman. *Health Physics*. 82. 869-874.

Knoll and Glein F. (1989) Radiation Detection and Measurements, 2nd ed. New York: Wiley and Sons.

Narayana Y., Somashekarappan H. M., Karunakara. N., Avadhani D.N., Mahesh H.M. and Siddhappa K. (2001) Natural Radioactivity In The Soils Sample Of Coastal Karnataka Of South India. *Health Physics* 80. 24-33.

Quindos L.S., Fernandez P.L., Soto J., Rodenas c. and Gomez J. (1994) Natural Radioactivity in Spanish Soil. *Health Physics*. 66. 194-200.

Ramli A.T. (1997) Environmental Terrestrial Gamma Ray Dose and Its Relationship with Soil Type and Underlying Geological Formations in Pontian District, Malaysia. *Applied Radiation and Isotopes* 48. 407-412.

Ramli A.T., Abdel Wahab M.A.,Abd. Khalik Wood (2005) Environmental ^{238}U and ^{232}Th concentration measurements in an area of high level natural background radiation at Palong, Johor, Malaysia. *Journal of Environmental Radioactivity*. 80: 287-304.

Ramli A.T., Abdul Rahman A.T., Abd. Khalik Wood, (2003). Natural Soil Gama Radioactivity Level and Resultant Population Dose in the District of Kota Tinggi, Malaysia. *The Proceeding of Annual Fundamental Science Seminar 2003*: 247-256.

Ramli A.T., Abdul Rahman A.T., Lee, M.H., (2003). Statistical Prediction of Terrestrial Gama Radiation Dose-Rate Based on Geological Features and Soil Types in Kota Tinggi District, Malaysia. *Applied Radiation and Isotopes*. 59: 393-405.

Sejkora K.J. and Most M.L. (1993) Use of Global Positioning System in Radiological Environmental Monitoring. *Proceeding 26th Midyear Topical Meeting, Health Physics Society*: 423-431.

UNSCEAR. (2000). Sources and Effect of Ionising Radiation, *United Nation Scientific Committee Of The Effect Atomic Radiation Report on The General Assembly*. New York: United Nation.

Voutileinen A., Castren o., Makelainen I, Winqvisk K. and Arvela H. (1988) Radiological Characteristics of a Village on Uraniferoud Granitic Ground in Finland. *Radiation Protection Dosim.* 24: 333-337.

Yaacob and Jusop. (1982). *Soil Science*. Kuala Lumpur: Dewan Bahasa and Pustaka.

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APPENDIX 1

ISODOSE MAP OF TERRESTRIAL GAMMA RADIATION DOSE RATE IN REMBAU DISTRICT, MALAYSIA