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Distribution of Natural Radionuclides in Songkhla Beach Sands

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ABSTRACT

Specific activities and distribution of natural radionuclide γ-ray activities, produced by ^{40}K, ^{226}Ra and ^{232}Th, were determined in 80 sand samples collected along the Chalatat and the Samila beaches in Songkhla province. The derivation of ^{40}K, ^{226}Ra and ^{232}Th γ-ray specific activities of sand samples was performed by using the high-purity germanium (HPGe) detector and gamma spectroscopy analysis system and the Eu-152 radioactive standard source at the Office of Atoms for Peace (OAP) laboratory. The beach sand specific activity ranges from 89 – 963 Bq/kg for ^{40}K, 0 – 120 Bq/kg for ^{226}Ra and 0 – 319 Bq/kg for ^{232}Th with mean values of 248 ± 44 Bq/kg, 41 ± 5 Bq/kg and 64 ± 7 Bq/kg, respectively. The specific activities of these radionuclides were compared with the OAP results and other global radioactivity measurements and evaluations. Moreover, gamma–absorbed dose rates and radium equivalent activities were calculated for the analyzed samples to assess the radiation hazards arising. All the beach sand samples had the mean value of radium equivalent activities lower than the limit set in the Organization for Economic Cooperation and Development (OECD) report.

Key words: radioactivity, radionuclide, activity, specific activity, beach sand, gamma -absorbed dose rate, radium equivalent activity, high-purity Germanium (HPGe) detector.

INTRODUCTION

Human beings have always been exposed to natural radiations arising from within and outside the earth. The exposure to ionizing radiation from natural sources occurs because of the naturally occurring radioactive elements in the soil, sand and rocks, cosmic rays entering the earth's atmosphere from outer space and the internal exposure from radioactive elements through food, water and air. Natural radioactivity is wide spread in the earth's environment and it exists in various geological formations in soil, sand, rocks, plants, water and air. (Selvasekarapandian *et al*., 2000; Freitas *et al*., 2004; Alencar *et al*., 2005; Singh *et al*., 2005; Veiga *et al*., 2005). The natural radioactivity in soil or sand comes from U and Th series and natural K. Artificial radionuclides can also be presented such as ^{137}Cs, resulting from the fallout from weapons testing. The radiological implication of these radionuclides is due to the gamma ray exposure of the body and irradiation of lung tissue from inhalation of radon and its daughters. Therefore, the assessment of gamma radiation dose from natural sources is of particular importance as natural radiation is the largest contributor to the external dose of the world population (UNSCEAR, 1988). The measurement of natural radioactivity due to gamma rays from the dose rate is needed to

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implement precautionary measures whenever the dose is found to be above the recommended limits.

Songkhla, one of Thailand's important ports and coastal provinces, is located 950 kilometers from Bangkok. Occupying an area of 7,393 square kilometers on the eastern side of the Malaysian Peninsula, the province is bordered by the States of Kedah (Sai Buri) and Perlis of Malaysia to the south and the Gulf of Thailand to the east. In addition, Songkhla borders on Nakhon Si Thammarat and Phatthalung Provinces to the north, Yala and Pattani Provinces to the south, and Satun and Phatthalung Provinces to the west. An undeniably historic town endowed with ancient ruins, arts, and places of cultural importance. Songkhla, a melting pot of Thais, Chinese and Malays, charms visitors with its unique traditions, dialect, and folk entertainment. These characteristics are reflections of the provinces rich cultural heritage, which has been preserved and passed down from generations to generations. Over the last few decades, Songkhla has been rapidly developed and is currently a unique attraction worth visiting. Blessed with natural resources such as fine beaches (the Chalatat and the Samila beaches), enchanting waterfalls, and a tranquil lake, the province has an abundance of tourist attractions and an amazing range of seaside resort towns. Moreover, the old section of Songkhla still maintains its unique identity of ancient and historical flavors through local architecture and cuisine. While Songkhla is noted as a fishing community set in a peaceful atmosphere, Hat Yai, on the other hand, serves as a transportation and communications hub of the south with links to various destinations in the neighboring provinces and Malaysia. Despite being only 30 kilometers apart, Songkhla and Hat Yai have uniquely contrasting characteristics and are ideal places to visit. Therefore, a lot of food, drinking water, napkin and many kinds of food container are brought to all attractive places in Songkhla provinces such as the Chalatat and the Samila beachs, and then some parts of them will be left behind on these areas by thousands of tourist. Year after year, many kinds of organic and inorganic materials from these food and containers are accumulated and distributed to the beach sands. Moreover, the level of natural radioactivity in environment might be increased by the fallout from nuclear weapon testing of some Asian neighborhood countries. For this reason, the measurement of natural radioactivity due to gamma rays from some popular and attractive natural resources in Songkhla, e.g. the Chalatat and the Samila beaches, should be regularly examined and reported.

The objective of this study was focused on determining the distribution of natural radioactivity and the γ-ray specific activities of ^{40}K, ^{226}Ra and ^{232}Th in beach sands samples collected from the Chalatat and the Samila beaches in Songkhla province. The specific activities of ^{40}K, ^{226}Ra and ^{232}Th in collected beach sand samples were estimated by using the high-purity germanium (HPGe) detector and gamma spectroscopy analysis system and the Eu-152 radioactive standard source at Office of Atoms for Peace (OAP) laboratory. These results have been also compared with the OAP data (OAP, 1994-2002) and other global radioactivity measurements and evaluations. Gamma-absorbed dose rates and radium equivalent activities were evaluated for the analyzed samples to assess the radiation hazards arising and also compared the Radium equivalent activities to the limit set in the Organization for Economic Cooperation and Development (OECD) report.

EXPERIMENTAL PROCEDURE

Measurement of natural radioactivity level by gamma spectroscopy technique

In order to measure natural radioactivity in beach sands, 80 surface beach sand samples of the Chalatat (40 samples) and the Samila beaches

(40 samples) were collected from different sites at each location. Figure 1 shows the geographic of the down town of Songkhla province in the map of Thailand, as well as the sampling sites.

After remove the stone and organic materials, the samples were dried in room temperature for 1 week to remove the moisture content and sieved with the 2 mm mesh sieve to homogenize it. Then, a sample of 200-300 grams was weighed and finally, a spilt of prepared sample was packed in a standard plastic container (7.5 cm × 8.2 cm. diam.) and after properly tightening the threatened lid, the container were taken in a light zip-lock bag. And left for at least 4 weeks (> 7 half-lives of ^{222}Rn and ^{224}Ra) before counting by gamma spectroscopy in order to ensure that the daughter products of ^{226}Ra up to ^{210}Pb and of ^{228}Th up to ^{208}Pb achieve equilibrium with their respective parent radionuclides. The Eu-152 radioactive standard source at OAP laboratory was used to be a known activity contents for measuring the specific activity of all those desired natural

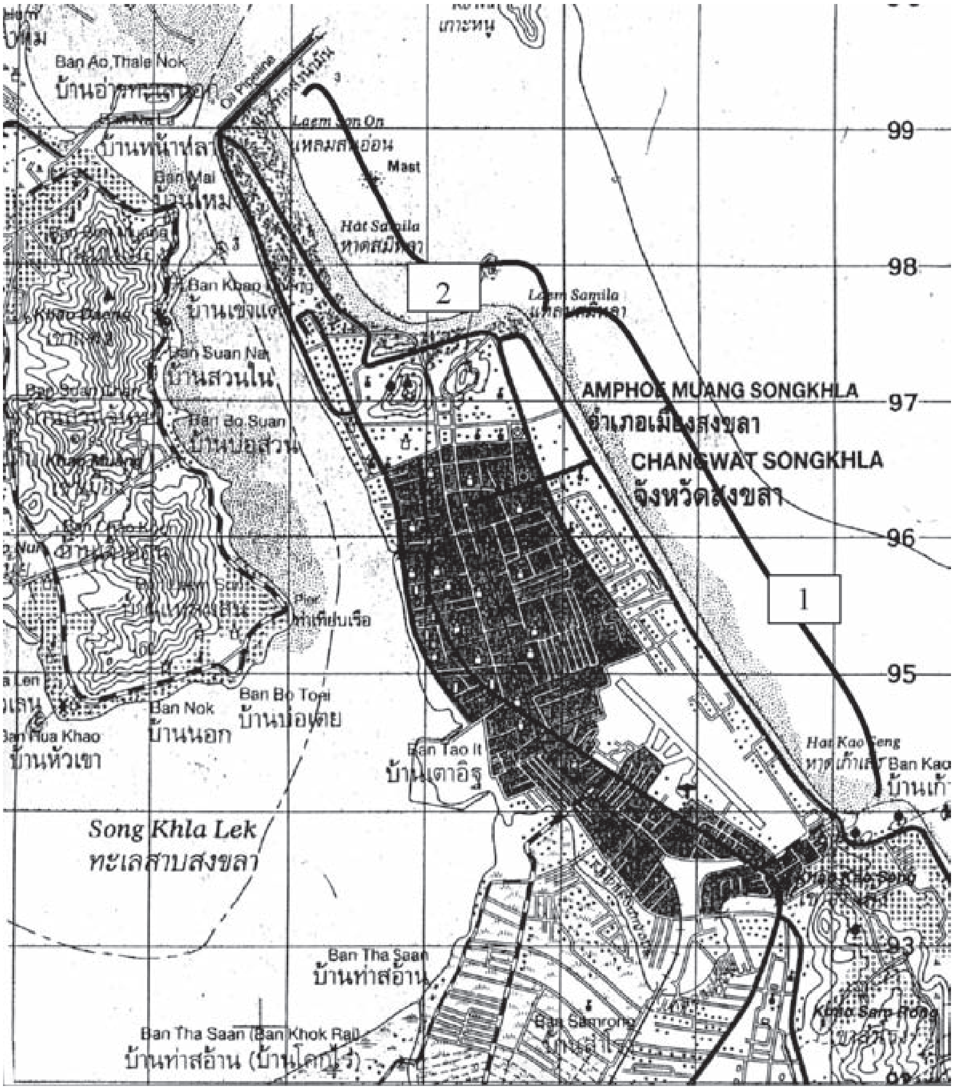

Figure 1 The map showing sampling locations in (1) the Chalatat beach and (2) the Samila beach.

radionuclides. The radioactivities ^{40}K, ^{226}Ra and ^{232}Th contents have been estimated using the low background gamma spectroscopy system, which makes used of a high-purify germanium (HPGe). The detector is enclosed in a massive 10 cm thick lead shielding. Using different radioactive standard sources of OAP (Cs-137 and Co-60), the gamma ray spectroscopy system and the detectors is calibrated up to about 2 MeV. The counting time for each beach sand sample was 10,000 s to get a statistically small error. With appropriate corrections for laboratory background, the activity of ^{226}Ra was evaluated, in all cases, from the 0.610 MeV peak of ^{214}Bi, while the ^{232}Th activity was determined from 0.239 MeV peak of ^{212}Pb, and the ^{40}K peak at 1.46 MeV.

Determination of the distribution of natural radionuclide γ-ray activities, produced by ^{40}K, ^{226}Ra and ^{232}Th

The specific activities of ^{40}K, ^{226}Ra and ^{232}Th derived from gamma spectroscopy technique in section 1, were plotted into the frequency distributions graphs. (Figure 2, 3 and 4)

Evaluation of the gamma-absorbed dose rate (D) and radium equivalent activities (Ra_{eq})

The gamma-absorbed dose rate in outdoor at 1 m above the ground is calculated using the specific activities of ^{40}K, ^{226}Ra and ^{232}Th. The conversion factor used to calculated the absorbed dose rates is given as (UNSCEAR, 1993) :

$$D(nGyh^{-1}) = 0.0414C_K + 0.461C_{Ra} + 0.623\ C_{Th}$$

The distribution of ^{40}K, ^{226}Ra and ^{232}Th in beach sands is not uniform. Uniformity with respect to exposure to radiation has been defined in terms of radium equivalent activity in Bq/kg to compare the specific activity of materials containing different amounts of ^{40}K, ^{226}Ra and ^{232}Th. It is calculated through the following relation :

$$Ra_{eq} = 0.077C_k + C_{Ra} + 1.43C_{Th},$$

where C_k , C_{Ra} and C_{Th} are the specific activities of ^{40}K, ^{226}Ra and ^{232}Th, respectively.

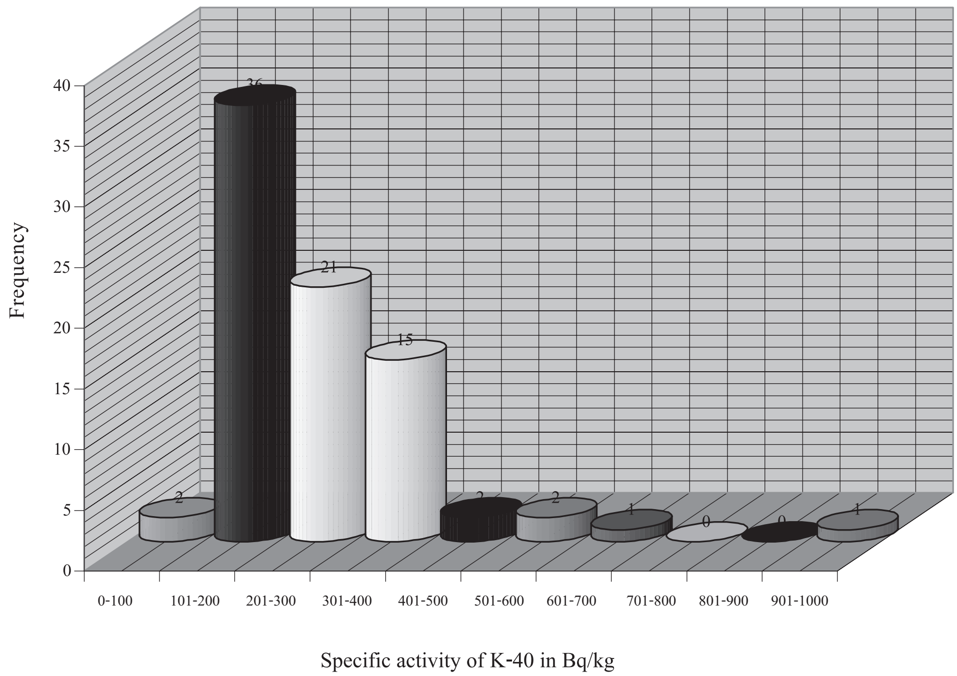

Figure 2 Frequency distributions of the specific activities of K-40 in Bq/kg.

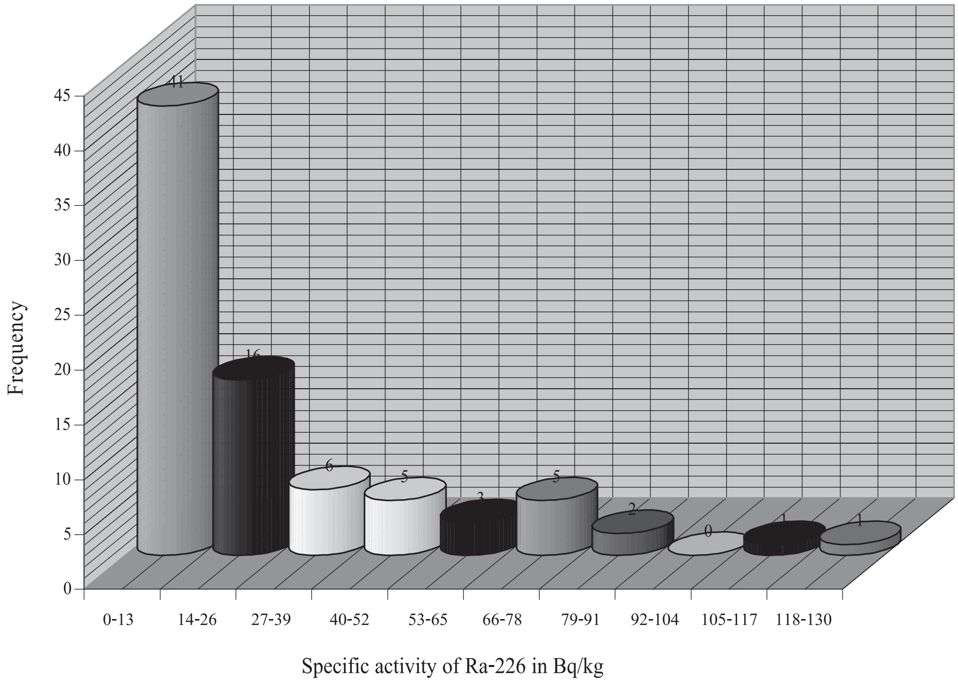

Figure 3 Frequency distributions of the specific activities of Ra-226 in Bq/kg.

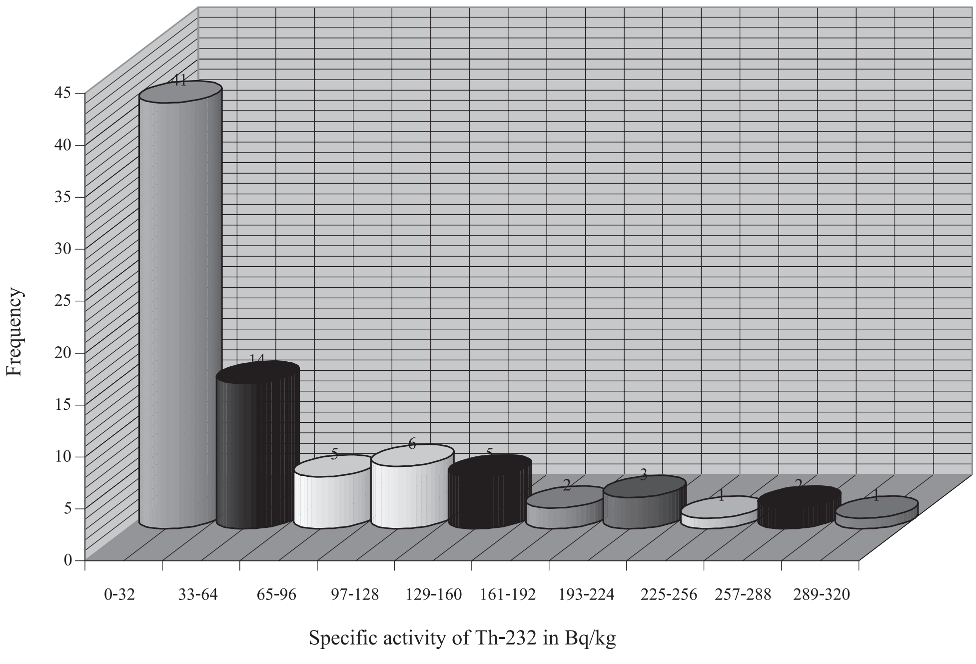

Figure 4 Frequency distributions of the specific activities of Th-232 in Bq/kg.

RESULTS

The frequency distributions of the activities of ^{40}K, ^{226}Ra and ^{232}Th were shown in Figure 2, Figure 3 and Figure 4, respectively.

The beach sand specific activity ranges from 89 – 963 Bq/kg for ^{40}K, 0 – 120 Bq/kg for ^{226}Ra and 0 – 319 Bq/kg for ^{232}Th with mean values of 248 ± 44 Bq/kg, 41 ± 5 Bq/kg and 64 ± 7 Bq/kg, respectively. The specific activities mean values of ^{40}K, ^{226}Ra and ^{232}Th , the gamma-absorbed dose rate and radium equivalent activity have been compared with other global radioactivity measurements and evaluations as shown in Table 1.

DISCUSSION

The measured specific activity mean value of terrestrial gamma ray emitters are compared with the worldwide mean values and OAP data. For ^{40}K the specific activity mean value is *lower than* the worldwide mean values and OAP data ; for ^{226}Ra the specific activity mean value is higher than the worldwide mean value but *lower than* the OAP data ; and for ^{232}Th the mean value

Table 1 Comparison of specific activity, gamma-absorbed dose rate and radium equivalent activity in 80 beach sand samples collected along the Chalatat and the Samila beaches in Songkhla province with those in other countries as given in UNSCEAR (2000).

Region/country	Specific activity in soil (Bq/kg)			Gamma-absorbed dose rate (nGy/h)	Radium equivalent activity (Bq/kg)
	K-40	Ra-226	Th-232		
Egypt	320	17	18	32	67
United States	370	40	35	56	119
Argentina	650	-	-	-	-
Bangladesh	350	34	-	-	-
China	440	32	41	59	125
Hong Kong SAR	530	59	95	108	236
India	400	29	64	70	151
Japan	310	33	28	45	97
Korea, Rep. of	670	-	-	-	-
Iran(Islamic Rep. of)	640	28	22	53	109
Denmark	460	17	19	39	80
Belgium	380	26	27	45	94
Luxemburg	620	35	50	73	154
Switzerland	370	40	25	49	104
Bulgaria	400	45	30	56	119
Poland	410	26	21	42	88
Romania	490	32	38	59	124
Greece	360	25	21	40	83
Portugal	840	44	51	87	182
Spain	470	32	33	55	115
Worldwide mean	*474*	*33*	*36*	*57*	*121*
OAP (Thailand)	*511 ± 7*	*172 ± 3*	*211 ± 2*	*231 ± 3*	*513 ± 6*
Present study	*248 ± 44*	*41 ± 5*	*64 ±7*	*69 ± 8*	*152 ± 18*

of specific activity is *higher than* the worldwide mean value and OAP data. Table 1 gives the gamma-absorbed dose (D) rate in air at a height of about 1 m above the ground level due to terrestrial gamma radiation and the radium equivalent activity (Ra_{eq}). These gamma-absorbed dose rate and radium equivalent activity were calculated from the measured specific activity of radionuclides of ^{40}K, ^{226}Ra and ^{232}Th which have mean values 248 ± 44 Bq/kg, 41 ± 5 Bq/kg and 64 ± 7 Bq/kg, respectively. The mean values of the gamma-absorbed dose rate (69 ± 8 nGy/h) and the radium equivalent activity (152 ± 18 Bq/kg) are *higher than* the worldwide mean but *lower than* the OAP data.

CONCLUSIONS

The measured specific activity mean values of terrestrial gamma ray emitters are compared with the worldwide mean values and OAP data. For ^{40}K the specific activity mean values are 48% and 51% *lower than* the worldwide mean values and OAP data, respectively. For ^{226}Ra the specific activity mean values are 24% *higher than* the worldwide mean and 76% *lower than* the OAP data, respectively. And for ^{232}Th the mean values of specific activity are 78% *higher than* the worldwide mean and 70% *lower than* the OAP data, respectively.

The mean values of the gamma-absorbed dose rate evaluated from the measured specific activity of radionuclides of ^{40}K, ^{226}Ra and ^{232}Th are 21% *higher than* the worldwide mean but 70% *lower than* the OAP data.

The radium equivalent activity calculated from the measured specific activity of radionuclides of ^{40}K, ^{226}Ra and ^{232}Th are 25% *higher than* the worldwide mean but 70% *lower than* the OAP data.

The mean value of the radium equivalent activity calculated from the measured specific activity of radionuclides of ^{40}K, ^{226}Ra and ^{232}Th in 80 beach sand samples collected along the Chalatat and the Samila beaches in Songkhla province is *152 Bq/kg*. This value is less than *370 Bq/kg* which is the maximum admissible value set in the OECD report (OECD, 1979).

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