อัตราปริมาณรังสีแกมมาดูดกลืนและการแจกแจงของนิวไคลด์กัมมันตรังสีในธรรมชาติในทรายชายหาดจังหวัดสงขลา

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บทคัดย่อ

ได้ทำการตรวจวัดค่ากัมมันตภาพจำเพาะและการแจกแจงของนิวไคลด์รังสีเริ่มต้น ^{40}K, ^{226}Ra และ ^{232}Th ในตัวอย่างทรายชายหาดจำนวน 80 ตัวอย่างที่เก็บจากบริเวณชายหาดชลาทัศน์และชายหาดสมิหลาในจังหวัดสงขลาโดยใช้หัววัดรังสีแบบเจอร์มาเนียมบริสุทธิ์และระบบวิเคราะห์แบบแกมมาสเปกโตรสโกปี และใช้ต้นกำเนิดรังสีแกมมามาตรฐาน Eu-152 ของสำนักงานปรมาณูเพื่อสันติ ในการเปรียบเทียบเพื่อการคำนวณค่ากัมมันตภาพจำเพาะที่ต้องการ ค่ากัมมันตภาพจำเพาะที่คำนวณได้นี้มีค่าพิสัยอยู่ระหว่าง 89 – 963 Bq/kg สำหรับ ^{40}K, 0 - 120 Bq/kg สำหรับ ^{226}Ra และ 0 – 319 Bq/kg สำหรับ ^{232}Th และมีค่าเฉลี่ยเป็น 248 ± 44 Bq/kg, 41 ± 5 Bq/kg และ 64 ± 7 Bq/kg ตามลำดับ ได้นำผลการตรวจวัดค่ากัมมันตภาพจำเพาะที่ได้นี้ไปเปรียบเทียบกับข้อมูลจากการรายงานผลการตรวจวัดและการประเมินค่ากัมมันตภาพรังสีในทรายชายหาดหลายๆประเทศทั่วโลก นอกจากนี้ ยังได้นำผลของค่ากัมมันตภาพจำเพาะที่ตรวจวัดได้นี้ไปคำนวณหาค่าอัตราปริมาณรังสีแกมมาดูดกลืน และพร้อมกันนี้ได้คำนวณค่ากัมมันตภาพรังสีสมมูลของเรเดียม เพื่อประเมินค่าการเพิ่มขึ้นของความเป็นอันตรายจากรังสีในธรรมชาติอีกด้วย พบว่าค่าเฉลี่ยของค่ากัมมันตภาพรังสีสมมูลของเรเดียมที่วัดได้ในตัวอย่างทรายทั้งหมดมีค่าต่ำกว่าค่าที่กำหนดโดยองค์กรความร่วมมือทางเศรษฐศาสตร์และการพัฒนา

คำสำคัญ: กัมมันตภาพจำเพาะ รังสีแกมมา กัมมันตภาพรังสีสมมูล เรเดียม เจอร์มาเนียม

Gamma-Absorbed Dose Rate and 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 Chalatat and Samila beaches in Songkhla province. The derivation of ^{40}K, ^{226}Ra and ^{232}Th γ-ray specific activities of sand samples was performed using the high-purity germanium (HPGe) detector, 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 some 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 370 Bq/kg, which is the limit set by OECD.

Keywords : Specific Activity, Gamma Ray, Equivalent Activity, Radium, Germanium

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. The natural radioactivity in soil or sand comes from U and Th series and natural K. Artificial radionuclides can also be present 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 ray from the dose rate is needed to implement precautionary measures whenever the dose is found to be above the recommended limits.

Around the world, several authors have been studying radionuclide concentrations in sand beaches in Kerala and Tamil Nadu coastal regions of India (Radhakrishna et al., 1993), in Bangladesh (Alam et. al., 1999) and in the southwestern Australia (de Meijer et. al., 2001). Also in India, Kannan et. al., (2002) analysed the distribution of natural and anthropogenic radionuclides in beach sand and soil from Kalpakkam area using gamma ray spectrometry. Freitas and Alencar (2004) investigated the variability in time of the concentrations of primordial radionuclides ^{40}K and the elements from series of ^{232}Th and ^{238}U in two island beach sand samples in southeastern Brazil and the consequent variability of the absorbed dose rate. El-Aabi (2004) identified and determined activity levels in selected radionuclides (^{40}K, ^{226}Ra and ^{232}Th concentrations) in sand samples of the Red Sea beach, to estimate doses for patients treated from Psoriasis and Rheumatoid Arthritis. Moreover, the annual effective dose rates (obtained from measurements of ^{40}K, ^{226}Ra and ^{232}Th concentrations of some Brazilian beach sand samples) were evaluated using simple calculations and the results can be used as reference values by Veiga et. al., (2005). In spite of the high number of works carried out around the world, there is a lack of studies about radionuclides in some tourist attraction places of Thailand (e.g. the Phuket beaches, the Samui Island beaches and the Songkhla beaches).

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. 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 have been 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 ray 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 were compared with some 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 compared the Radium equivalent activities to the limit set in the Organization for Economic Cooperation and Development (OECD) report.

Experimental Procedure

1. 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.

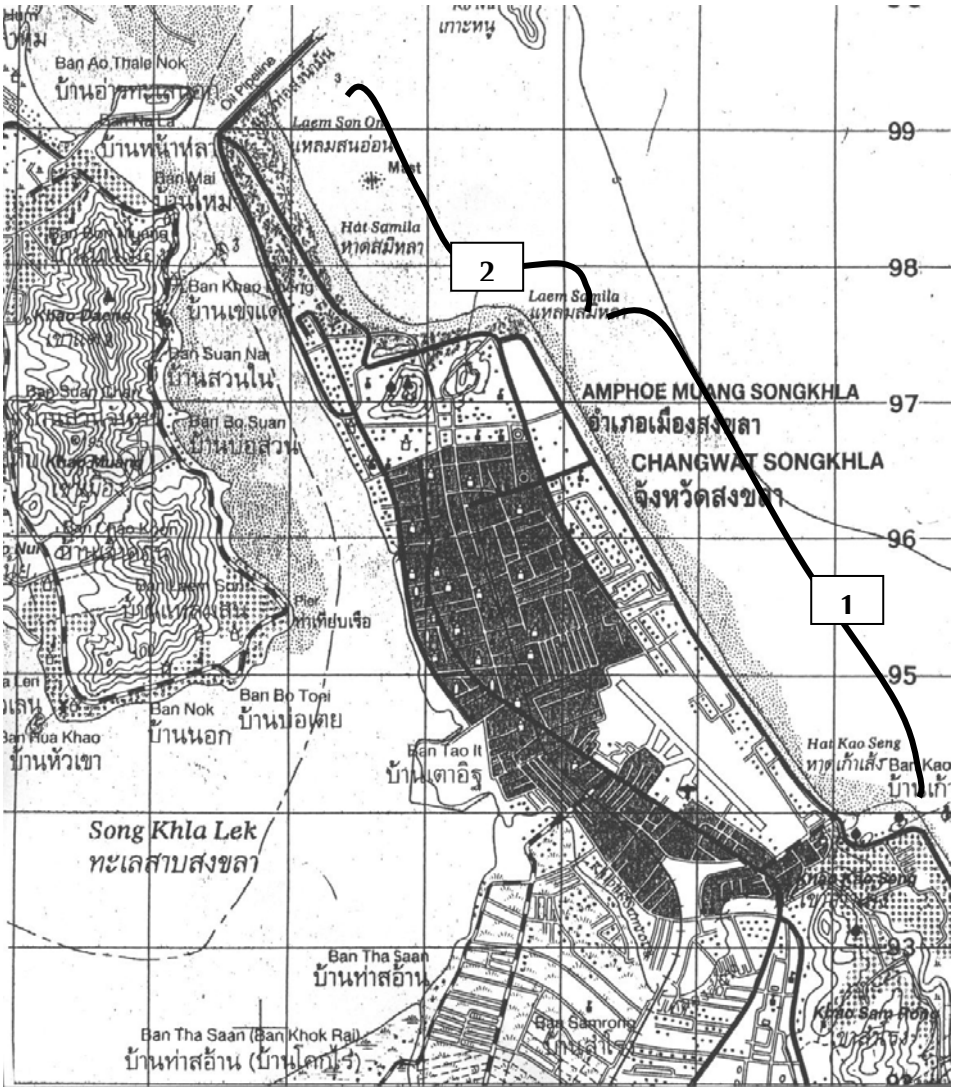

Figure 1 The map showing sampling locations in (1) the Chalatat beach and (2) the Samila beach.

After removing 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 packed in a standard plastic container (7.5 cm × 8.2 cm). The container was then put into a light zip-lock bag and left for at least 4 weeks (> 7 half-lives of ^{222}Rn (3.82 d) and ^{224}Ra (3.66 d)) before counting by gamma spectroscopy in order to ensure that the daughter products of ^{226}Rn 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 was used for determining the specific activity of all those desired natural radionuclides. The radioactivities ^{40}K, ^{226}Ra and ^{232}Th contents were estimated using the low

background gamma spectroscopy system of a high-purify germanium (HPGe). 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 sample was 10,000 s to get a statistically small error. With appropriate corrections for laboratory background, the activity of ^{226}Ra was evaluated, from its peak at 0.610 MeV, while the ^{232}Th activity was determined from 0.239 MeV peak of ^{212}Pb, and the ^{40}K peak was determined at 1.46 MeV.

2. 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 in the frequency distributions graphs. (see Figures 2-4).

3. 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.

Results

The frequency distributions of the activities of ^{40}K, ^{226}Ra and ^{232}Th was shown in Figures 2-4, 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 ranges of ^{40}K, ^{226}Ra and ^{232}Th in 80 beach sand samples collected along the Chalatat and the Samila beaches in Songkhla province have been compared with other global radioactivity measurements and evaluations as shown in Table 1. Furthermore, the specific activities mean values of ^{40}K, ^{226}Ra and ^{232}Th in 80 beach sand samples

collected along the Chalatat and the Samila beaches in Songkhla province, the gamma-absorbed dose rate and radium equivalent activity have been also evaluated and compared to some standard values as shown in Table 2.

Discussion

The measured specific activity ranges and mean values of terrestrial gamma ray emitters were compared with some global radioactivity measurements and evaluations ranges and mean values. It was found that, the specific activity ranges of ^{40}K, ^{226}Ra and ^{232}Th were in the same range of the global radioactivity measurements and evaluations (see Table 1). From Table 2, the specific activity mean values of ^{40}K, ^{226}Ra and ^{232}Th were lower than some standard values. The gamma-absorbed dose (D) rate in air at a height of about 1 m above the ground level due to terrestrial gamma radiation(^{40}K, ^{226}Ra and ^{232}Th) was evaluated and found lower than the standard values. Moreover, the radium equivalent activity (Ra_{eq}) was also calculated using the measured specific activity mean values of radionuclides of ^{40}K, ^{226}Ra and ^{232}Th and found lower than standard values.

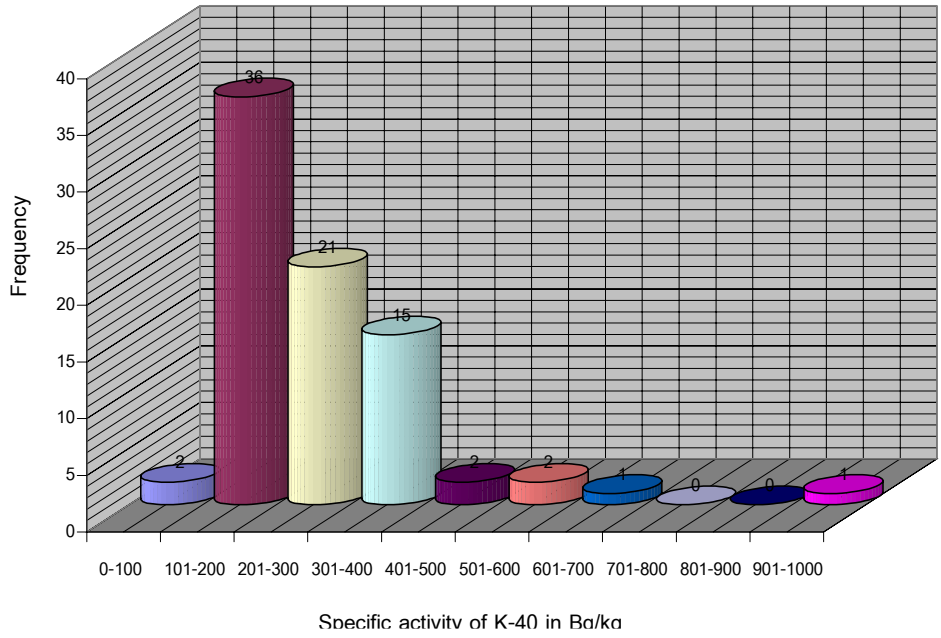

Figure 2 Frequency distributions of the specific activities of K-40 in Bq/kg.

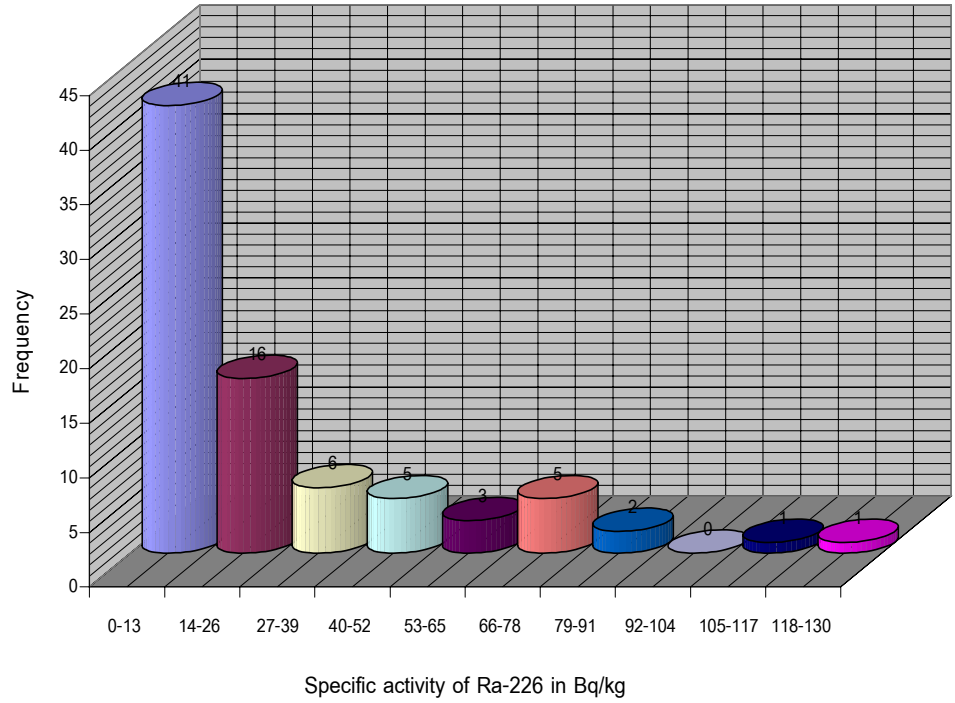

Figure 3 Frequency distributions of the specific activities of Ra-226 in Bq/kg.

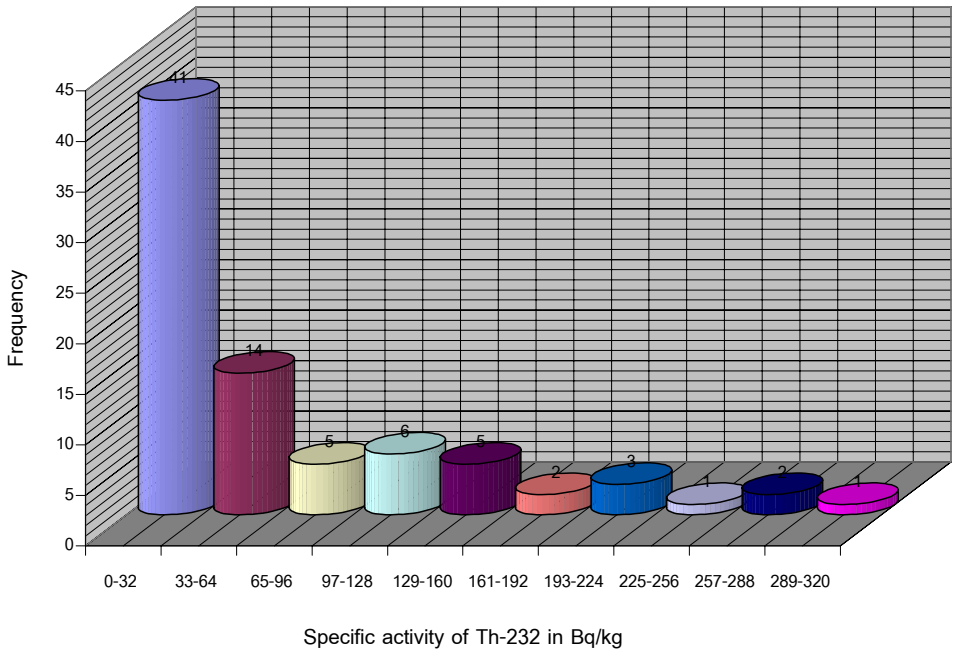

Figure 4 Frequency distributions of the specific activities of Th-232 in Bq/kg.

Table 1 Specific activity ranges of ^{40}K, ^{226}Ra and ^{232}Th (Bq/kg) in 80 beach sand samples collected the Chalatat and the Samila beaches in Songkhla province and other studies in different beaches of the world

Locations/Country	Specific activity in beach sand samples (Bq/kg)			Reference
	^{40}K	^{226}Ra	^{232}Th	
Visakhapatnam, India	-	-	300 - 600	Kalyani et. al (1990)
Northeast Coast, Spain	136 - 1087	-	5 - 44	Rosell et. al. (1991)
Ullal, India	158	-	1842	Radhakrishna et. al. (1993)
Valencia, Spain	30 - 253	-	1 - 11	Navaro and Roldan (1994)
Kalpakkam, India	324 - 405	-	352 - 3872	Kannan et. al. (2002)
Preta beach, Brazil	47 - 283	-	128 - 349	Freitas and Alencar (2004)
Dois Rios beach, Brazil	269 - 527	-	12 - 87	Freitas and Alencar (2004)
Safaga, Egypt	421 - 965	10 - 64	9 - 37	El-Arabi (2005)
Hurgada, Egypt	423 - 652	16 - 25	18 - 27	El-Arabi (2005)
Sao Paulo (SP), Brazil	444 - 888	36 -51	23 - 49	Veiga et. al. (2005)
Rio de Janeiro (RJ), Brazil	32 - 888	5 - 286	7 - 963	Veiga et. al. (2005)
Espirito Santo (ES), Brazil	27 - 412	5 - 4043	7 - 55537	Veiga et. al. (2005)
Bahia (BA), Brazil	25 - 62	10 - 572	14 - 1735	Veiga et. al. (2005)
Songkhla, Thailand	**89 – 963**	**0 – 120**	**0 – 319**	**Present study**

Table 2 Specific activity mean values of ^{40}K, ^{226}Ra and ^{232}Th (Bq/kg) in 80 beach sand samples collected along the Chalatat and the Samila beaches in Songkhla province the gamma-absorbed dose rate and radium equivalent activity have been also evaluated and compared to some standard values

References	Specific activity in beach sand samples (Bq/kg)			gamma-absorbed dose rate (nGy/h)	radium equivalent activity (Bq/kg)
	^{40}K	^{226}Ra	^{232}Th		
OECD, 1979 (Singh et. al., 2005)	-	-	-	-	370
Beretka and Mathew, 1995	4810	370	259	< 163 (< 1.0 mSv/y)	-
UNSCEAR, 2000 (Veiga et. al., 2005)	-	-	-	391 (2.4 mSv/y)	-
Present study	**248 ± 44**	**41 ± 5**	**64 ± 7**	**69 ± 8**	**152 ± 18**

Conclusions

The measured specific activity ranges and mean values of terrestrial gamma ray emitters were calculated and compared with some global radioactivity measurements and evaluations, as well as standard values. The specific activity ranges of ^{40}K, ^{226}Ra and ^{232}Th in sand samples collected along the Chalatat and the Samila beaches in Songkhla province were in the same range of some global radioactivity measurements and evaluations. For ^{40}K the specific activity mean value was 95 % lower than the standard value. For ^{226}Ra the specific activity mean value was 89 % lower than the standard value. And for ^{232}Th the mean value of specific activity was 75% lower than the standard value.

The gamma-absorbed dose (D) rate in air at a height of about 1 m above the ground level due to the measured specific activity mean values of ^{40}K, ^{226}Ra and ^{232}Th were 58% and 82 % lower than the value of Beretka and Mathew(1995) and UNSCEAR (2000), respectively.

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 was 152 Bq/kg. This value was less than 370 Bq/kg which is the maximum admissible value set in the OECD report (OECD, 1979).

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