

# Specific Activities of Natural Radionuclides in Beach Sand Samples from Samila Beach in Songkhla Province (Thailand) after Nuclear Power Plant Accident in Japan

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**Abstract**—Specific activities of natural radionuclides ( $^{40}\text{K}$ ,  $^{226}\text{Ra}$  and  $^{232}\text{Th}$ ) in 30 beach sand samples collected from Samila beach of Songkhla province in southern region of Thailand, have been measured and evaluated. Experimental results were obtained by using a high-purity germanium (HPGe) detector and gamma spectrometry analysis system. The frequency distribution of specific activities of measured natural radionuclides ( $^{40}\text{K}$ ,  $^{226}\text{Ra}$  and  $^{232}\text{Th}$ ) in all beach sand samples, have been also studied and analyzed. It was found that the frequency distribution of specific activities of  $^{40}\text{K}$ ,  $^{226}\text{Ra}$  and  $^{232}\text{Th}$  were asymmetrical distribution with the skewness of 2.50, 4.28 and 4.11, respectively. The median values of  $^{40}\text{K}$ ,  $^{226}\text{Ra}$  and  $^{232}\text{Th}$  were  $868.51 \pm 118.42$  Bq/kg,  $30.50 \pm 4.22$  Bq/kg and  $23.31 \pm 2.22$  Bq/kg, respectively. Furthermore, four radiological hazard indices which are gamma-absorbed dose rate (D), radium equivalent activity ( $\text{Ra}_{\text{eq}}$ ), external hazard index ( $\text{H}_{\text{ex}}$ ) and annual external effective dose rate ( $\text{AED}_{\text{out}}$ ), were evaluated for Samila beach by using the median values of specific activities of  $^{40}\text{K}$ ,  $^{226}\text{Ra}$  and  $^{232}\text{Th}$ . Moreover, the results were also compared with the Office of Atoms for Peace (OAP) annual report data, Thailand and global radioactivity measurement and evaluations. From this study, the corresponding annual external effective dose rate ( $\text{AED}_{\text{out}}$ ) was equal to  $0.08 \pm 0.01$  mSv/y, significantly lower than the worldwide average as reported by United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR).

**Index Terms**—Beach sand, gamma spectrometry, natural radionuclide, radiological hazard index, specific activity.

## I. INTRODUCTION

During the late 20<sup>th</sup> and early 21<sup>st</sup> century, one of the major interests in studies of natural background radiation is the requirement to set up reference levels, especially in areas

where the risk of radioactive material being released to environment is high e.g. in European countries and Japan after Chernobyl (1986) and Fukushima Dai-ichi (2011) nuclear power plant accidents, respectively. Furthermore, there is also a worldwide interest in identifying new areas with high natural radiation around the world. There are many scientists and researchers in several countries have studied the levels of natural background radiation by in situ measurements or by analysis of specific activities of natural radionuclides in soil or beach sand samples [1]-[7]. Moreover, radiological hazard studies have been made in beach sand samples in some famous beach locations, mainly in India and Brazil, because along their coastline there are quite a few monazite sand bearing placer deposits causing natural high background radiation areas [5], [8]-[11]. In Thailand, the levels of natural background radiation and radiological hazard assessment have been also studied in beach sand samples in different locations around the kingdom by some group of researchers [7], [12]-[14]. The present work was carried out in the Samila beach which is one of the most famous beaches in Songkhla province in the southern region of Thailand. The objective of this study was focused on studying the frequency distribution of specific activity of natural radionuclides ( $^{40}\text{K}$ ,  $^{226}\text{Ra}$  and  $^{232}\text{Th}$ ) in beach sands samples collected from the Samila beach in Songkhla province. Furthermore, radiological hazard were also studied and evaluated for the investigated area. Moreover, the results were also compared with the Office of Atoms for Peace (OAP) annual report data, Thailand and global radioactivity measurement and evaluations.

## II. METHODOLOGY

### A. Collection and Preparation of Beach Sand Samples

30 Beach sand samples were collected along the Samila beach of Songkhla province in the south of Thailand. After collection, each sample was dried up at room temperature and sieved through a 2 mm mesh-sized sieve to remove stone, pebbles and other macro-impurities. All samples were oven dried at a temperature of 100 °C for 3 hours, before the analysis for removing moisture. The homogenized sample was placed in a PVC containers. The container was sealed hermitically and externally using a cellophane tape and kept aside for about a month to ensure equilibrium between  $^{226}\text{Ra}$  and its daughters and  $^{228}\text{Ra}$  and its daughters before being taken for gamma spectrometric measurement and analysis.

Manuscript received August 5, 2014; revised December 5, 2014. This work was fully supported by Office of the National Research Council of Thailand (NRCT) and Research and Development Institute Thaksin University (RDITSU).

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**B. Measurement and Analysis the Specific Activity in Beach Sand Samples**

The specific activities of natural radionuclides ( $^{40}\text{K}$ ,  $^{226}\text{Ra}$  and  $^{232}\text{Th}$ ) in all beach sand samples were determined by employing a high-purity germanium detector (HPGe, CANBERRA Model GC 2018) and gamma spectrometry analysis system at Nuclear and Material Physics Research Unit (NuMPRU), Department of Physics, Faculty of Science, Thaksin University, Songkhla Campus. The detector was enclosed in a massive 10 cm thick lead shielding. Geometric efficiency for beach sand matrices in the container was determined by the KCL, IAEA/RGU-1 and IAEA/RGTh-1 reference materials (International Atomic Energy Agency IAEA, Vienna, Austria). The spectra were analyzed using the program GENIE 2000. The specific activity of  $^{40}\text{K}$  was determined from its 1460 keV  $\gamma$ -line. The specific activities of  $^{226}\text{Ra}$  and  $^{232}\text{Th}$  were determined by their decay products  $^{214}\text{Pb}$  (351.9 keV) and  $^{208}\text{Tl}$  (583.2 keV), respectively. The specific activity of  $^{137}\text{Cs}$  was also determined from its 661.7 keV  $\gamma$ -line. The statistic computer program was employed to analyze the frequency distribution of specific activities of natural radionuclides ( $^{40}\text{K}$ ,  $^{226}\text{Ra}$  and  $^{232}\text{Th}$ ) in all beach sand samples for the Samila beach of Songkhla province (Thailand). Four radiological hazard indices in these two beaches were also evaluated by using the appropriate medium values of the frequency distribution and the equations published in [9] and [11].

**III. RESULTS**

**A. Frequency Distribution of Specific Activity of  $^{40}\text{K}$ ,  $^{226}\text{Ra}$  and  $^{232}\text{Th}$  in 30 Beach Sand Samples Collected from Samila Beach**

By using the statistics computer program, the frequency distribution of specific activities of  $^{40}\text{K}$ ,  $^{226}\text{Ra}$  and  $^{232}\text{Th}$  in 30 beach sand samples collected from Samila beach in Songkhla province (Thailand), were studied, analyzed and presented in the following Fig. 1 to Fig. 3.

**B. Statistic Values of the Frequency Distribution of Specific Activities of  $^{40}\text{K}$ ,  $^{226}\text{Ra}$  and  $^{232}\text{Th}$  in 30 Beach Sand Samples**

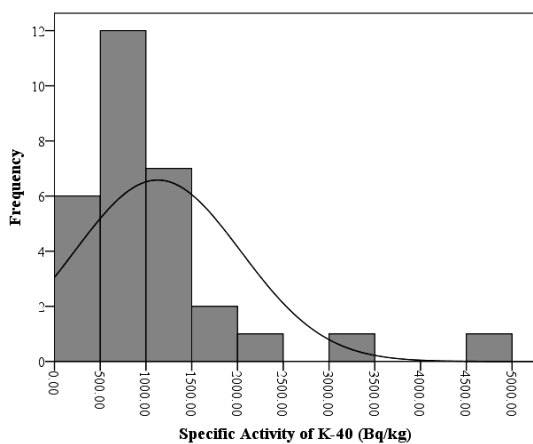


Fig. 1. Frequency distribution of specific activity of  $^{40}\text{K}$ .

From Fig. 1 to Fig. 3 and all calculated statistic values, it

was found that the frequency distribution of specific activities of  $^{40}\text{K}$ ,  $^{226}\text{Ra}$  and  $^{232}\text{Th}$  in 30 beach sand samples collected from Samila beach in Songkhla province, were asymmetrical distribution with the skewness of 2.50, 4.28 and 4.11, respectively. For this reason, the median values of  $^{40}\text{K}$ ,  $^{226}\text{Ra}$  and  $^{232}\text{Th}$  which were  $868.51 \pm 118.42$  Bq/kg,  $30.50 \pm 4.22$  Bq/kg and  $23.21 \pm 2.22$  Bq/kg, for Samila beach, should be selected for calculation the corresponding radiological hazard evaluation in this area. The results were also compared with the Office of Atoms for Peace (OAP) annual report data, Thailand and global radioactivity measurement and evaluations as shown in Table I.

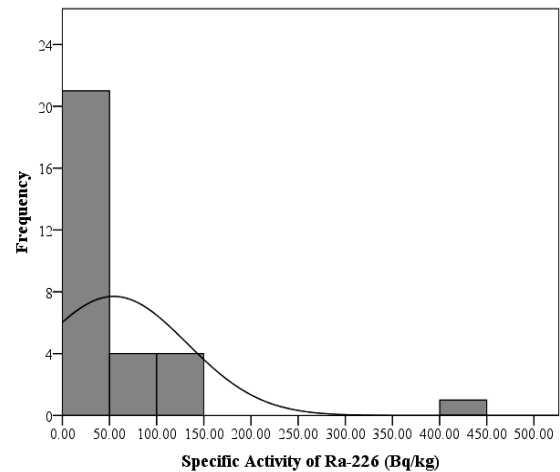


Fig. 2. Frequency distribution of specific activity of  $^{226}\text{Ra}$ .

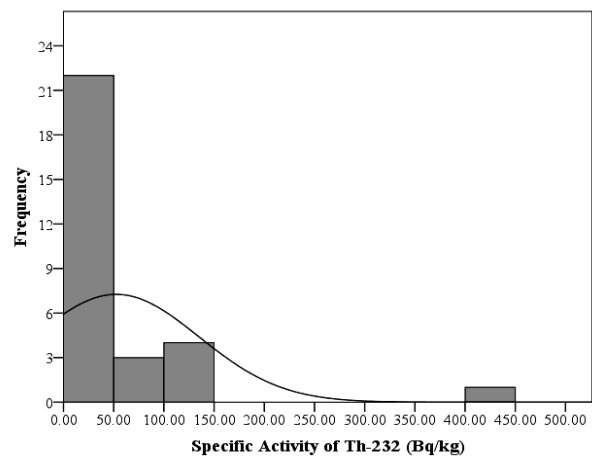


Fig. 3. Frequency distribution of specific activity of  $^{232}\text{Th}$ .

**C. Radiological Hazard Assessment**

Furthermore, four radiological hazard indices which are gamma absorbed dose rate (D), radium equivalent activity ( $\text{Ra}_{\text{eq}}$ ), external hazard index ( $H_{\text{ex}}$ ) and annual external effective dose rate ( $\text{AED}_{\text{out}}$ ), were evaluated and presented in Table II for Samila beach by using the median values of specific activities of  $^{40}\text{K}$ ,  $^{226}\text{Ra}$  and  $^{232}\text{Th}$ . Moreover, the results were also compared with some research data in Thailand and UNSCEAR as shown in the same table.

**IV. DISCUSSIONS**

According to Songkhla province is one of the province which is located in the eastern coast of Thailand, Samila

beach certainly have the experiences of Naturally Occurring Radioactive Material (NORM) and Technologically Enhanced Naturally Occurring Radioactive Material (TENORM) activities e.g. phosphate fertilizers that are commonly used, oil and gas industry wastes and Fukushima Dai-ichi nuclear power plant accident. For this reason, the values of gamma absorbed dose rate in Samila beach were higher than about 1.2 – 3.7 times to some research data in Thailand and UNSCEAR but lower than in Patong and Naiyang beaches in Phuket province. The values of radium

equivalent activity in Samila beach were higher than about 1.6 – 3.6 times to some research data in Thailand but lower than in Patong and Naiyang beaches in Phuket province which is less than 370 Bq/kg, which are the acceptable value for safe use. The values of external hazard index obtained in this study were found to be  $0.35 \pm 0.04$  for Samila beach which were less than unity. The calculated annual effective dose with average values  $0.08 \pm 0.01$  mSv/y for Samila beach were lower than the worldwide average value of 0.48 mSv/y as reported by UNSCEAR.

TABLE I: COMPARISON OF MEDIAN VALUES OF  $^{40}\text{K}$ ,  $^{226}\text{Ra}$ , AND  $^{232}\text{Th}$  IN BQ/KG FOR SAMILA BEACH WITH THE OFFICE OF ATOMS FOR PEACE (OAP) ANNUAL REPORT DATA, THAILAND AND GLOBAL RADIOACTIVITY MEASUREMENT AND EVALUATIONS

Locations	Specific Activity (Bq/kg)		
	$^{40}\text{K}$	$^{226}\text{Ra}$	$^{232}\text{Th}$
Patong beach (Phuket province)	3538.09 ± 959.56	29.72 ± 11.48	32.71 ± 7.51
Naiyang beach (Phuket province)	1648.27 ± 702.98	14.62 ± 6.54	18.10 ± 4.22
Ao Nang Beach (Krabi province)	330.73	4.60	5.78
Noppharat Thara beach (Krabi province)	307.60	5.31	5.28
Pakmeng beach (Trang province)	57.3	23.1	6.9
Chaweng beach (Surat Thani province)	373.30	18.85	23.53
<b>Samila beach (Songkhla province)</b>	<b>868.51 ± 118.42</b>	<b>30.50 ± 4.22</b>	<b>23.31 ± 2.22</b>
OAP (Southern region of Thailand)	511.04 ± 7.04	171.55 ± 3.13	211.19 ± 1.98
Worldwide mean [17]	400	35	30

TABLE II: COMPARISON BETWEEN THE CORRESPONDING RADIOLOGICAL HAZARD IN SAMILA BEACH WITH SOME RESEARCH DATA IN THAILAND AND UNITED NATIONS SCIENTIFIC COMMITTEE ON THE EFFECTS OF ATOMIC RADIATION (UNSCEAR)

Locations	D (nGy/h)	Ra <sub>eq</sub> (Bq/kg)	H <sub>ex</sub>	ADE <sub>out</sub> (mSv/y)
Patong beach (Phuket province)	180.56 ± 49.70	348.93 ± 96.11	0.94 ± 0.26	0.22 ± 0.06
Naiyang beach (Phuket province)	86.25 ± 34.75	167.42 ± 66.70	0.45 ± 0.18	0.11 ± 0.04
Ao Nang beach (Krabi province)	19.41	38.33	0.10	0.02
Noppharat Thara beach (Krabi province)	18.47	36.55	0.10	0.02
Pakmeng beach (Trang province)	17.32	37.38	0.10	0.02
Chaweng beach (Surat Thani province)	38.80	81.24	0.22	0.05
<b>Samila beach (Songkhla province)</b>	<b>64.54 ± 8.23</b>	<b>130.71 ± 16.51</b>	<b>0.35 ± 0.04</b>	<b>0.08 ± 0.01</b>
UNSCEAR [15]-[17]	55	370	1	0.48

### V. CONCLUSIONS

We can conclude that the monitored area (Samila beach) is at the typical level of radioactivity from natural background radiation after the Fukushima Dai-ichi nuclear power plant accident. Therefore, the radiological hazard is insignificant for the population living and spending sometimes in the investigated area.

### ACKNOWLEDGMENT

The investigation is a part of research project which was fully supported by Office of the National Research Council of Thailand (NRCT) and Research and Development Institute Thaksin University (RDITSU). The authors wish to thank Assoc. Prof. Dr. Tripop Bhongsuwan, Department of Physics, Faculty of Science, Prince of Songkhla University (PSU), Hat Yai Campus for his generous permission to us to use all of standard reference materials for calculation and analysis in this research. The authors are particularly indebted to some of undergraduate and graduate students for their works and patience in samples collection, preparation, measurement and analysis some parts of these data.

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