Radioactivity Levels in Beach Sand from Hambantota to Dondra, Sri Lanka

WMRC Bandara and P Mahawatte#
Department of Nuclear Science, University of Colombo, Colombo 3, Sri Lanka
#palee_m@yahoo.com

***Abstract*—** *This study aims to evaluate the activity concentrations of ^{232}Th, ^{238}U and ^{40}K in beach sand along the southern coastal strip from Hambantota to Dondra, Sri Lanka. The results of this study serve as a database for radioactivity levels of the mineral sand deposits in the selected strip. It will also provide information about unidentified locations having sand with high radioactive mineral content. This is an extended study of an ongoing project to determine the above three radionuclides in the coast line of Sri Lanka. Sand samples collected from 38 locations along the beach from Hambantota to Dondra were analyzed for ^{232}Th, ^{238}U and ^{40}K radionuclide content using high resolution gamma ray spectrometry. The resulting concentrations for ^{232}Th, ^{238}U and ^{40}K ranged from 1.4±0.7 – 10752±203, 4±0.6 – 1726±41, and 54±5 – 852±57 Bq kg^{-1} respectively. The minimum detection limits of the system for the three radionuclides were 0.9, 0.3 and 5.4 Bq kg^{-1} respectively. The percentages of samples having the activity concentration below the worldwide average for ^{232}Th, ^{238}U and ^{40}K in soil were 34%, 47% and 92%. Thorium to uranium ratio in sand samples collected in this study ranged from 0.17 to 7.88. The activity level measured in this study is comparable with the activity levels measured in previous studies done in other areas of the coastal line of Sri Lanka. Four new locations (Nilwella, Polgahamulla, Unukuruwella and Wellamadama) with sand having high radionuclide content were identified in this study.*

***Keywords*—** *Sri Lanka, Beach Sand, Radioactivity*

I. INTRODUCTION

Some naturally occurring minerals contain primordial radionuclides. Those radioactive minerals originate from the sedimentary, metamorphic and igneous rocks. As a result of the chemical and physical disintegration process (weathering) they split into small particles. These products which are transported to sea by rivers and streams are brought back to beach side by wave action. The sea waves make the light particles to be washed out and heavy grains remain in the beach. Ocean currents also bring minerals from the sea bed to the beach. This has happened for millions of years and has created large mineral deposits in the coastline.

According to Ramli (1997) preparing a reference background radiation level is a major research area in natural background radiation studies. It is especially important for areas close to where radioactive elements are released to the environment and in areas rich in radioactive minerals. Since the coastline is a place where large natural mineral deposits can be found many countries have measured the primordial radionuclides in beach sand.

Radiation level of shore sediments along the coast of Greater Accra, Ghana was measured by Radiation Protection Institute, of the Atomic Energy Commission of Ghana in 2011. They used High Purity Germanium (HPGe) detector to measure the activity level of ^{232}Th, ^{238}U and ^{40}K (Amekudzie *et al.*, 2011). A similar research project was done in Brazil. In that study both HPGe and NaI(Tl) detectors were used to obtain the gamma ray spectra and the concentration of natural radionuclides in Atlantic coast of Brazil was determined (Veiga *et al*., 2006). Beach sand from different sites of Tripoli Region and Northwest Libya were analysed using the same method. Samples were collected at 5-10 cm and 50-70 cm. Element concentration of ^{226}Ra, ^{232}Th, ^{40}K, and ^{210}Pb were measured (El-Kameesy *et al*., 2008). Radioactivity of sand from several renowned public beaches and assessment of the corresponding environmental risks in Serbia was analysed by Mirjana *et al.* (2009). Shukla *et al.* in 2001 measured the Natural radioactivity levels in soils from high radiation background areas of Kerala, India. High resolution gamma spectrometric technique was used and activity concentrations for ^{232}Th and ^{238}U were obtained.

In Sri Lanka, large heavy mineral deposits rich in U and Th can be found in Pulmoddeai and Kokilai. Other than those large deposits, such mineral rich areas can be seen as small pockets scattered along many parts of coastline of Sri Lanka (Herath, 2008).

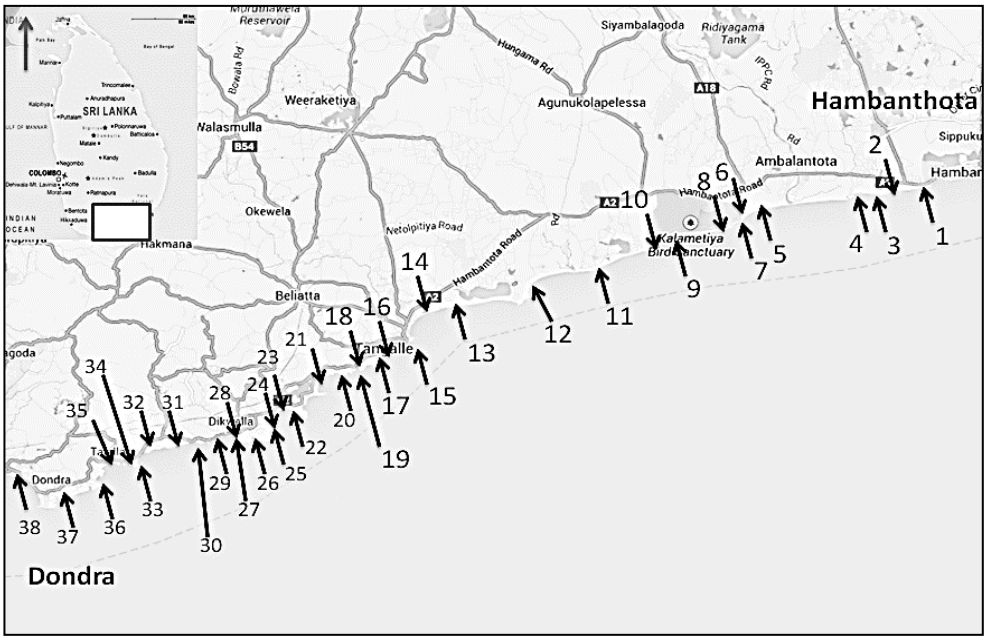


Figure 1**.** Sampling locations

The aim of this study was to determine the activity concentrations of three primordial radionuclides ^{232}Th, ^{238}U and ^{40}K in sand samples collected along the coastal strip from Hambantota to Dondra. This is an extension of an ongoing project to determine the radionuclides content in beach sand in the entire coastal strip of Sri Lanka.

II. METHODOLOGY

A Preparation of samples

Thirty eight sand samples were collected along the coastal stretch from Hambantota (6°06'48.6"N 81°05'15.3"E) to Dondra (5°55'53.6"N 80°34'56.0"E) within an approximate distance of 5 m from the water line. Sand from Hambantota to Tangalle was collected on 29th of April 2014 and Tangalle to Dondra on 28th of July 2014. The sampling area covered is shown in Figure 1.

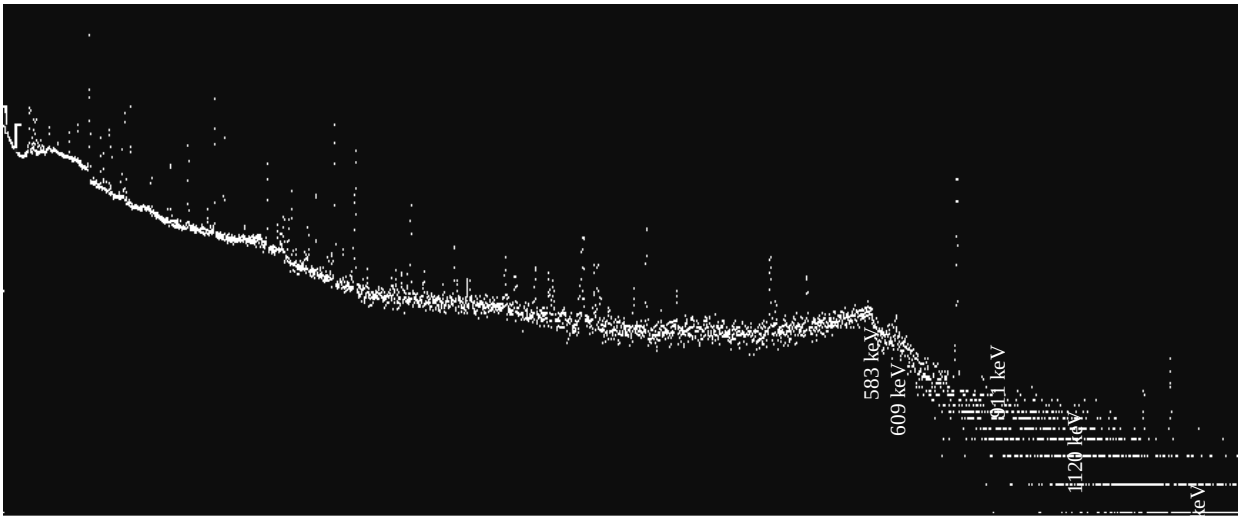
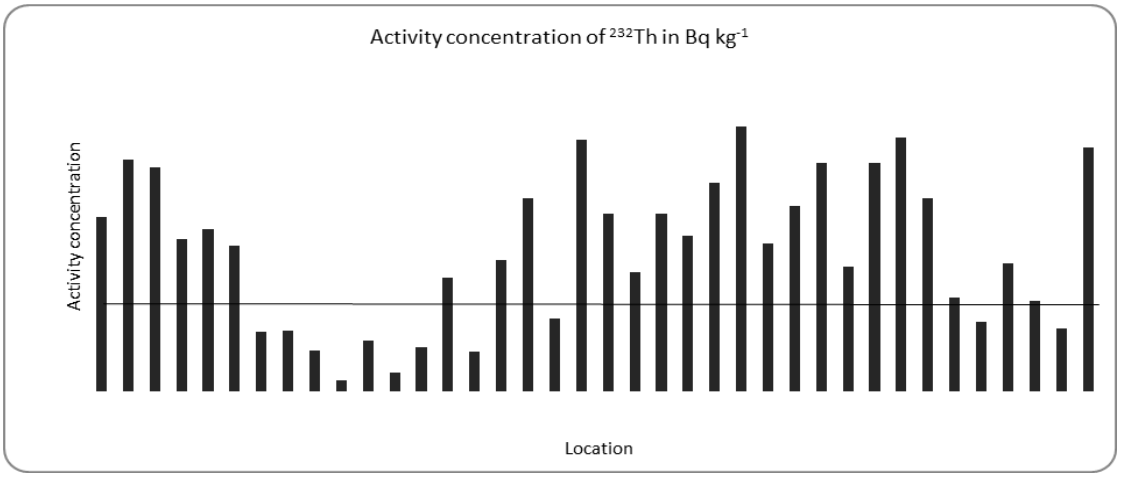
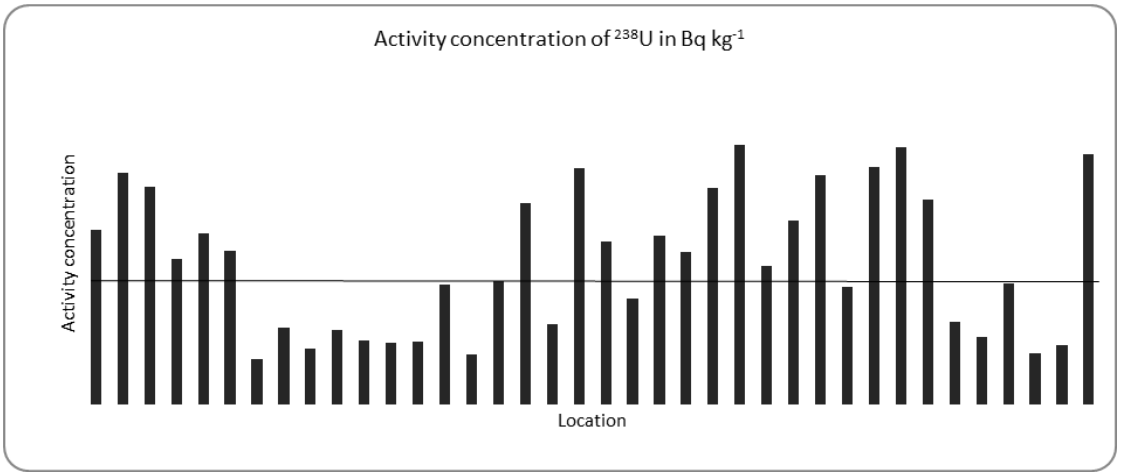


Figure 2. Typical gamma ray spectrum

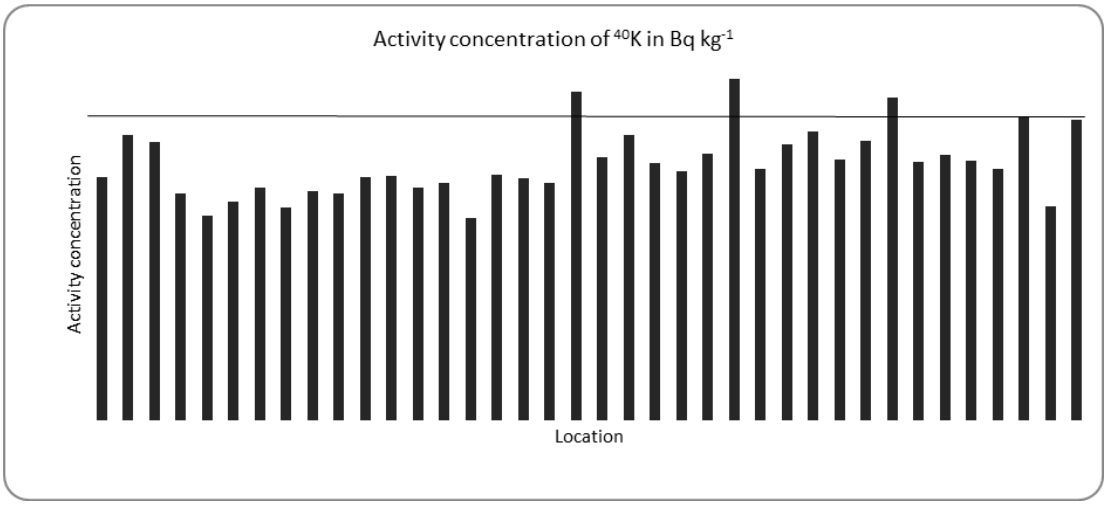
height 2.5 cm. Finally,



(a)



(b)



(c)

Figure 3.: (a) Activity concentration of ^{232}Th, (b) Activity concentration of ^{238}U and (c) Activity concentration of ^{40}K in Bq kg^{-}

The approximate distance between two sampling locations was 2 km. A square area of 1 m^2 was selected from each location and divided into 16 sub squares. Sand was collected from upper few centimeters (5 cm depth) of the surface layer of each sub square amounting to a total mass of 1 kg. Sand sample collected was packed in polyethylene bags, labeled and brought to the laboratory. Then they were washed three times using tap water to remove sea water and other contaminants.Then they were air dried for a day and further dried at 110 ˚C for 6 hours using an electric oven. To separate large grains of sand from the sample, dried sand samples were sieved through a 0.8 mm wire mesh. The sand sample was reduced in size using cone and quartering method to ensure proper mixing. Thereafter the samples were packed in pre weighed labeled plastic cylindrical containers of diameter 8 cm and the containers were weighed, sealed and kept for 3 weeks for ^{226}Ra and its daughters to come to secular equilibrium.

B. Gamma spectroscopy measurement

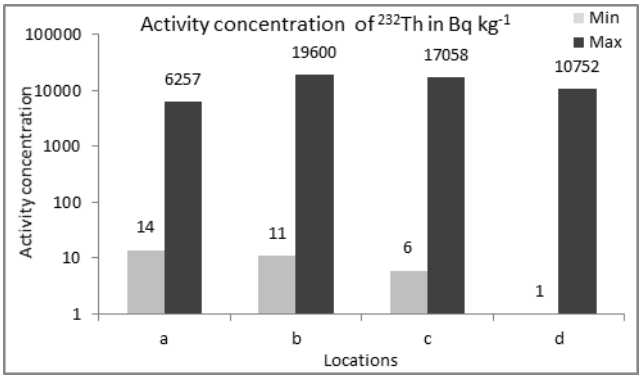
Each sample was counted using HPGe detector (EG & G Ortec model 13200). The resolution and relative efficiency of HPGe detector at 1.33 MeV photo peak of ^{60}Co were 1.85 keV and 20.6%. The system was calibrated using similar containers packed with standard reference bulk sources RGTh-1 (Thorium ore), RGU-1 (Uranium ore), and RGK-1 (Potassium Sulphate) produced by the International Atomic Energy Agency (IAEA). Background was measured using an empty container similar to the sample container. Signature energy peaks used for ^{232}Th, ^{238}U and ^{40}K are shown in Table 1. Samples were counted for time periods ranging from 11000 to 248500 seconds depending on the activity of the sample. GENIE 2000 software was used to analyze the data. Typical gamma ray spectrum obtained from a sand sample is shown in Figure 2.

Table 1. Signature energy peaks used for ^{232}Th, ^{238}U and ^{40}K

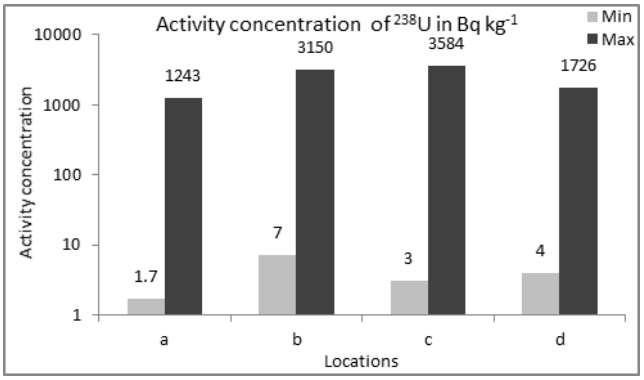
Element	Signature peaks (keV)
^{232}Th	583 (^{208}Tl) 911 (^{228}Ac) 2614 (^{208}Tl)
^{238}U	609 (^{214}Bi) 1120 (^{214}Bi) 1760 (^{214}Bi)
^{40}K	1460

III. RESULTS AND DESCUSSION

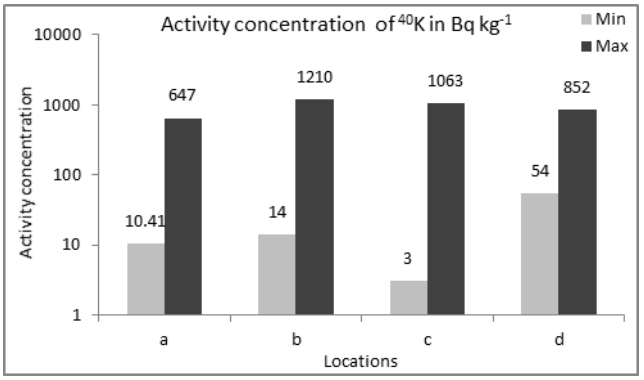
Activity concentration of ^{232}Th, ^{238}U and ^{40}K in the sand collected were between 1.4±0.7 – 10752±203, 4±0.6 – 1726±41, and 54±5 – 852±57 Bq kg^{-1} and the minimum detection limit of the system for the three radionuclides are 0.9, 0.3 and 5.4 Bq kg^{-1} respectively. Activity concentrations of ^{232}Th, ^{238}U and ^{40}K measured at each location are shown in Figure 3. According to the results sample-25, which was collected from Nilwella (5°57'54.8"N 80°43'03.3"E) has the highest activity concentration for all three radionuclides. Polgahamulla (5°57'28.3"N 80°39'54.1"E), Unukuruwella (6°00'17.7"N 80°46'02.7"E) and Wellamadama (5°55'53.6"N 80°34'56.0"E) also had high radionuclide content. The percentages of the samples having the activity concentration below the worldwide average for ^{232}Th (45 Bq kg^{-1}), ^{238}U (33 Bq kg^{-1}) and ^{40}K (420 Bq kg^{-1}) in soil were 34%, 47% and 92% respectively. ^{232}Th and ^{238}U average activities obtained in this study were 40 and 6 times that of the worldwide average. However for ^{40}K it is less than the worldwide average. Results obtained in three similar studies done in Sri Lanka are shown in Figure 4. From the results it can be seen that the maximum activity concentration of ^{232}Th, ^{238}U and ^{40}K measured in the present study is somewhat less than that obtained in Crow Island to Beruwala and Beruwala to Dondra studies but higher than that of Uswetakeyyawa to Chillaw study (Withanage and Mahawatte, 2012), (Bandara and Mahawatte, 2013) and (Mahawatte and Fernando, 2013). The ^{232}Th, ^{238}U and ^{40}K levels measured in some other coastal areas in the world are tabulated in Table 2. It can be seen that the some values measured in this study are higher than those measured in Algeria, Ghana and Spain.



(x)



(y)



(z)

Figure 4. Activity concentrations of ^{232}Th, ^{238}U and ^{40}K in the previous studies and present study

*a – Uswetakeyyawa to Chillaw, b – Crow Island to Beruwala, c – Beruwala to Dondra and d – Present study

Table 2**.** The ^{238}U, ^{232}Th and ^{40}K levels measured in some other coastal areas in the world (*Average value)

Location	^{232}Th	^{238}U	^{40}K	Reference
Hambantota to Dondra (Current project)	1-10752 1286*	4-1726 283*	54-852 204*	-
Kerala, India	150-15420	40-3420	-	(Shukla *et al*.,2001)
Kalpakkam, India	352-3872	36-258	324-405	(Kannan *et al*., 2002)
Brazilian beach sands	55537*	4443* (^{226}Ra)	888*	(Veiga *et al*., 2005)
Heavy sand concentration, Bangladesh	4684*	2582*	-	(Alam *et al*., 1999)
Northern Region of Tlemcen-Algeria	0.80-3.00	4.70-7.85 (^{226}Ra)	22-55	(Abdulrahman *et al.,* 2013)
Coast of Greater Accra, Ghana	0.17-732.60 108.60*	0.62-148.80 22.04* (^{226}Ra)	8.60-61.01 29.7*	(Amekudzie et al., 2011)
Northeast coast, Spain	5-44	5-19	136-1087	(Rosell *et al.*, 1991)
Worldwide averages in soil	45*	33*	420*	(UNSCEAR, 2000)

Figure 5 shows the specific activity of ^{232}Th as a function of specific activity of ^{238}U. A good correlation (R^2=0.92) between the two activity concentrations can be seen. In the present study the ratio between ^{232}Th and ^{238}U activity concentration is in the range 0.17 to 7.88. This ratio can vary with the sedimentary process and the depositional environment. (Adams and Weaver, 1958). According to Withanage and Mahawatta (2012) the ratio of ^{232}Th to ^{238}U in sand sample collected from Crow Island to Beruwala was between 0.8 and 7.5.

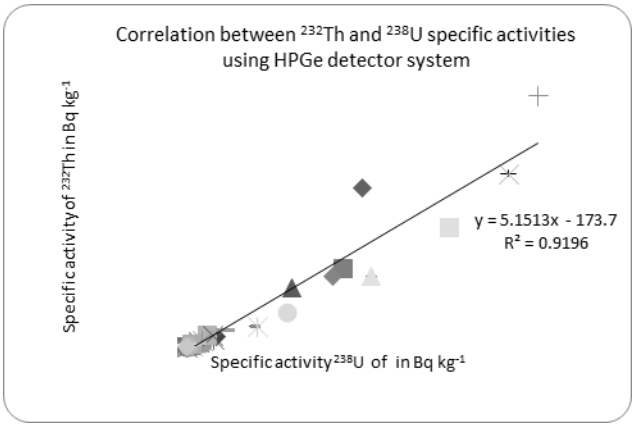


Figure 5. specific activity of ^{232}Th as a function of specific activity of ^{238}U

III. CONCLUSION

The activity level measured in this study is comparable with the activity levels measured in the previous studies done in the other areas of the coastline of Sri Lanka. Four new locations (Nilwella, Polgahamulla, Unukuruwella and Wellamadama) with sand having high radionuclide content were identified.

REFERENCES

Abdulrahman K, Abdelhakim HB and Benamar D, (2013) Radioactivity Investigation of Sand from the Northern Region of Tlemcen-Algeria, Using Well-Shape NaI(Tl) Detector. *Civil and Environmental Research,* 2224-5790, Vol.3, No.12.

Adams JAS and Weaver CE, (1958) Thorium to uranium ratio as indicator of sedimentary processes: Example of concept of geochemical facies. *Am. Assoc. Petrol. Geol.*

Alam MN, Chowdhury MI, Kamal M, Ghose S, Islam MN, Mustafa MN, Miah MMH and Ansary MM, (1999) The 226 Ra, 232 Th and 40K activities in beach sand minerals and beach soils of Cox's Bazar, Bangladesh.. *J. Environ. Radioact.,* Volume 46, p. 243–250.

Amekudzie A, Emi-Reynolds G, Faanu A, Darko EO, Awudu AR, Adukpo O, Quaye LAN, Kpordzro R, Agyemang B and Ibrahim A (2011) Natural Radioactivity Concentrations and Dose Assessment in Shore Sediments along the Coast of Greater Accra, Ghana. *World Applied Sciences Journal, 13 Journal.pp.* (11): 2338-2343.

Bandara RMUKGMS and Mahawatte P, (2013) Radioactivity of sand in the coastal strip from Beruwala to Dondra. *Proceeding of the 69th Annual Sessions, Sri Lanka Association for the Advancement of Science (SLAAS).*

El-Kameesy SU, El-Ghany, AS, El-Minyawi SM, Miligy Z and El-Mabrouk EM, (2008) Natural Radioactivity of Beach Sand Samples in the Tripoli Region, Libya. *Tubitak,* Volume 32, p. 245–251.

Herath MM, (2008) *Beach mineral sand in Sri Lanka. Geological survey and mines bureau, Colombo, Sri Lanka.*

Kannan V, Rajan MP, Iyengar MAR and Ramesh R, (2002) Distribution of natural and anthropogenic radionuclides in soil and sand samples of Kalpakkam (India) using hyper pure germanium (HPGe) gamma ray spectrometry. *Appl. Radiat. Isot.,* Volume 57, pp. 109-119.

Mahawatte P and Fernando KNR, (2013) Radioactivity levels in beach sand from the West Coast of Sri Lanka. *J. Natural Science Foundation Sri Lanka ,* 279-285.

Mirjana BR, Saeed MA, Velibor BA and Ščepan SM, (2009) Radioactivity of sand from several renowned public beaches and assessment of the corresponding environmental risks. *Journal of Serbian Chemical Society,* pp. (4) 461-470.

Peiris B, (2009) Occurrence of Thorium Bearing Minerals in Sri Lanka & Progress of Survey of Nuclear Raw Material with Emphasis on Locating Thorium and Uranium Mineralization and Demarcating Radiogenically Hazardous Areas, Sri Lanka*: s.n.*

Ramli AT, (1997) Environmental terrestrial gamma radiation dose and its relationship with soil type and underlying geological formations in Pontian District, Malaysia. *ELSEVIER, 3 March,* Volume 48, pp. 407-412.

Rosell JR, Ortega X and Dies X, (1991) Natural and artificial radionuclides on the northeast coast of Spain. *Health Phys,* Volume 60, p. 709–712.

Shukla VK, Sartandel SJ, Ramachandran TV, (2001) Radiation Protection and Environment; *v. 24(1-2); ISSN 0972-0464; Jan-Jun 2001;* p.25.

United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) (2000). *Sources and effects of Ionizing radiation. United Nations, New York, USA.*

Veiga RG, Sanches N, Anjos RM, Macario K, Bastos J, Iguatemy M, Aguitar JG, Santos MA, Mosquera B, Carvaiho C, Baptista M, Umisedo NK, (2006) Measurement of natural radioactivity in Brazilizn beach sands. *Radiation Measurements.* 41: 189-196.

Withanage AP and Mahawatte P, (2013) Radioactivity of beach sand in the south western coast of Sri Lanka. *Radiat. Prot. Dosimetry.* 153(3): 384-389.

BIOGROPHY OF AUTHOS

RandimaBnadara is a Graduate of the Faculty of Science, University of Colombo. Currently he is working as a Teaching Assistant at the Department of Nuclear Science, University of Colombo. Soon he will be starting his post graduate studies

Professor Palee Mahawatte is an Associate Professorattachedto the Department of Nuclear Science of University of Colombo and she is also the current Head of the Department. Her research interests are in the field of Environmental Radioactivity and Nuclear Analytical Techniques. She obtained her MSc in Nuclear Science from University of Colombo and MSc in Applied Radiation Physics from University of Birmingham, UK.She has nearly 30 years of experience in teaching Nuclear Science at undergraduate and post graduate level