Available online at www.elixirpublishers.com (Elixir International Journal)

Nuclear and Radiation Physics

Elixir Nuclear & Radiation Phys. 138 (2020) 54018-54030

ISSN: 2229-712X

Studies on the Nuclear Activities Effects and it's Impact on the Marine Life of the Arabian Gulf Region

Yehia M. Abbas[1], Abd El-Fattah I. Helal[2], Safwat Salama[3], Nassief A. Mansour[4], and Mohamed Saad Seoud[1, 5,*]

[1]Department of Physics, Faculty of Science, Suez Canal University, Ismailia, 41522, Egypt.

[2]Former Vice Chairman for Egyptian Atomic Energy Authority (EAEA), Nuclear Research Center, EAEA, Egypt.

[3]Department of Radiation Protection & Civil Defence, Nuclear Research Centre, EAEA, Egypt.

[4]Department of Physics, Faculty of Science, Zagazig University, Zagazig 44519, Egypt.

[5]Calibration and Radiation Dosimetry Division, Radiation Protection Department, Ministry of Health, Kuwait.

ARTICLE INFO

Article history:
Received: 4 December 2019;
Received in revised form:
22 December 2019;
Accepted: 2 January 2020;

Keywords
Radioactive Contamination,
Natural Radioactivity,
Kuwaiti Environmental Marine Samples,
Fissionable Isotopes,
Gamma-ray Spectroscopy,
Radioactivity Concentration,
Hazard Parameters,
Kuwait,
Arabian Gulf,
Radiation.

ABSTRACT

Paper in the work presents the first comprehensive and complete report on the concentration of on natural radioactivity measurements, other fissionable isotopes and the hazard parameters in the NORM samples from different marine environment Samples of the Arabian Gulf region (Beach Muddy/Sands, Arabian Gulf Water, Shells and Different types of Marine Fish) collected along the eastern coastline of the State of Kuwait. All samples were measured using gamma spectrometry technique, with high purity germanium detector. The results show that the average activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K, ^{137}Cs and ^{60}Co for Kuwaiti Environmental Marine Samples are lower than the worldwide average value. The worldwide average values (32, 45 and 420) for ^{226}Ra, ^{232}Th and ^{40}K, respectively. The activity concentration of ^{226}Ra, ^{232}Th and ^{40}K, ^{137}Cs and ^{60}Co for Kuwaiti Environmental Marine Samples ranged between [(0.18 - 10.43) Bq/kg with average of 3.26 ± 0.80 Bq/kg, (-0.23–3.63) Bq/kg with average of 1.15 ± 0.67 Bq/kg, (1.27-110.92) Bq/kg with average of 43.62 ± 1.7 Bq/kg, (0.50 - 10.61) Bq/kg with average of 3.11 ± 0.34 Bq/kg and (ND – 0.35) Bq/kg with average of 0.01 ± 0.01 Bq/kg] respectively. Marine Environment Samples of the Arabian Gulf region in Kuwait have been investigated. Samples were collected along the eastern coastline of the State of Kuwait. All samples were collected from different beach sites in Kuwait. These samples were collected randomly from different locations in these sites (from north to south along the eastern coastline of Arabian Gulf). According to the Kuwaiti samples, the estimated range for (Radium Equivalent Rate, External Hazard Index, Internal Hazard Index, Absorbed Dose, annual effective dose, Gamma Index, Alpha Index) is [(0.79 – 21.80) Bq/kg with average of 8.26 ± 1.90 Bq/kg, (0.00 – 0.06) Bq/kg with average of 0.02 ± 0.01 Bq/kg, (0.00–0.09) Bq/kg with average of 0.03 ± 0.01 Bq/kg,(0.36 - 10.68) Bq/kg with average of 4.04 ± 0.86 Bq/kg, (0.44 – 13.10) Bq/kg with average of 4.96 ± 1.06 Bq/kg, (0.00–0.08) Bq/kg with average of 0.03 ± 0.01 Bq/kg and (0.00 – 0.05) Bq/kg with average of 0.02 ± 0.00 Bq/kg], respectively. The estimated hazard parameters in all Kuwaiti samples are lower than the recommended limits for occupationally worker. From this study, it was noticed that the average activity concentrations of ^{226}Ra series, ^{232}Th series, ^{40}K, ^{137}Cs and ^{60}Co for Kuwaiti Environmental Marine Samples are lower than the worldwide average value. Results obtained are discussed and compared with the international recommended data.

1. Introduction

Due to the fact that Arabian Gulf is a semi-enclosed sea where the experts estimate that Gulf water needs 7 to 9 years to change passing by the Strait of Hormuz. Therefore the concentration of the radioactive materials in its water will not fade and disappear easily. This complicates the matter and contaminates all types of marine life in the Gulf; thus affect and stop fishing completely for many years. Of course, this will have a negative economic impact that can't be underestimated (high costs).

Sailing and transporting goods to ports of the gulf and the insurance; this may lead to that some shipping companies refrain from entering the gulf. This is why may be exposed to the sea, as for in the ratio. The lands of State of Kuwait and the east of Saudi Arabia and the Kingdom of Bahrain and State of Qatar in addition to United Arab Emirates will reach the radioactive dust in different and varying degrees. This, in turn, will leave a bad effects on the region and will tighten the budgets of these countries for several years with financial all locations to coping and handling the effects of the disaster. Most of them will be health costs to treat their citizens from various types of diseases; the most important of which are: cancer and mental illness; followed by cleaning and disinfecting the establishment and cities from radioactive materials. The dilemma will be how to clear the open land and deserts surrounding the cities. There are other logistical

Tele: +96596000498 / +201019496986
E-mail address: prof.mohamedsaad@gmail.com

costs; for example, providing alternative water instead of desalination plants. No doubt the costs will not be low as it will exceed hundreds of billion dollars.

This Research aims to measure the concentrations of radioactive materials in the marine life in the Arabian Gulf Region and in the state of Kuwait in particular. Fish is considered as the most widely used commodities in the world. Fish and marine life in general which are consumed by a human is the food that maintains human health. It was found that the cooling water of nuclear reactors which are thrown into the rivers and which are polluted with radiation was behind the destruction of many creatures in the rivers and those decrease of fish stocks especially in Europe and developed countries. Today, water pollution with radiation is considered as one of the main problems especially those that are stored in the deep ocean. Science 1946 until now, the major industrialized countries (120 countries in particular) have deposited hundreds of thousands of tons of radioactive materials in seawater and oceans. The specialized previous studies signalizes that the techniques of burying atomic waste in the depths of the oceans are not completely safe as some radioactive materials leak out. Also, a mass mortality of the fish in the area where these wastes are stored has been found. The crustaceans pterosaurs also store these high levels of waste; especially cesium and plutonium [Kuwait National Assembly, 2015].

From the previous representation, the research work carried out in this work aims to measurement the concentration of radionuclides (^{238}U, ^{232}Th, ^{40}K, ^{137}Cs and ^{60}Co), other radionuclides concentration levels and the radiation dose from different Environmental Marine Samples such as the Beach Muddy/Sands, Arabian Gulf Water, Shells and Different types of Marine Fish in the State of Kuwait Under the existing nuclear activities in the Gulf region, Calculation of radiological hazard indices and dose parameters for the mentioned samples in Kuwait, and finally Comparing the research results with the local and worldwide ranges in different coastal areas around the world.

2. Material and Methods

Sample Preparation and experimental procedure:

There are a number of steps that should be carried out during a survey of the sampling area. They can be summarized as follows:

1- Samples collection.
2- Samples number.
3- Site geographical coordinates.
4- Sample mass and volume.
5- Removal of extraneous material.
6- Sample homogenization.
7- Sample splitting.

A total of 37 of marine environment Samples of the Arabian Gulf region (Beach Muddy/Sands, Arabian Gulf Water, Shells and Different types of Marine Fish) collected along the eastern coastline of the State of Kuwait. All samples were collected from different beach sites in Kuwait. These samples were collected randomly from different locations in these sites (from north to south along the eastern coastline of Arabian Gulf) with geographical location of the samples by coordinates, and the distance of Bushehr reactor from the Kuwaiti Capital and the movement and direction of waves in the Arabian Gulf as show in figure (1), (2), (3) and table (1).

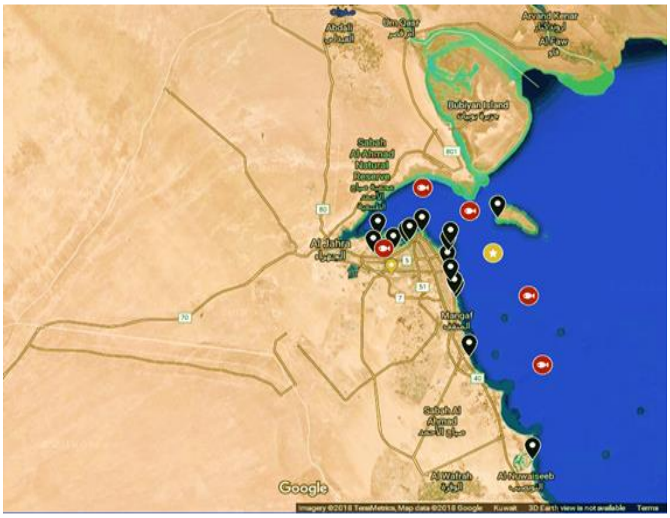

Figure (1). Map of geographical location of the collected samples in Kuwait

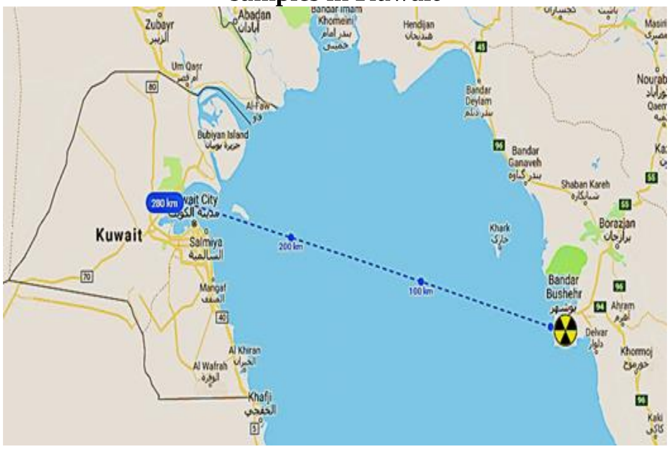

Figure (2). Map of closest nuclear activity areas in the Arabian Gulf region from the Kuwaiti Capital

Figure (3). Map of the movement and direction of waves in the Arabian Gulf

The preparation for Marine samples (Beach Muddy/Sands, Arabian Gulf Water, Shells and Different types of Marine Fish) as follows: A total of 37 samples were collected from selected locations along the eastern coastline of the State of Kuwait. The type of samples and their locations are shown in table (1). Each sample was collected in plastic cylindrical bottles of 500 ml. All samples were weighted and sealed for 61 days before one day of the measurements began, to ensure secular equilibrium between radium and radioactive progenies. After the attainment of secular equilibrium between ^{232}Th, ^{238}U and their progenies, the samples were subjected to gamma ray spectrometric analysis. Each sample was measured during an accumulating time between (12504) and (365663) second.

Table 1. Summary of the type samples collected.

Sample Type	Location	Latitude N (Deg. Min.)	Latitude E (Deg. Min.)	Sample Code	Mass (kg)
Sand of Muddy Shore	Al-Sulaibikhat bay Coast	29.33303	47.89676	KwS1	0.432
Sand of Muddy Shore	Ras Ushayrij Coast	29.37991	47.84395	KwS2	0.433
Beach Sand	Al-Salam Beach	29.39131	47.99855	KwS3	0.366
Beach Sand	Anjafa Beach	29.27856	48.08967	KwS4	0.395
Beach Sand	Khiran Beach	28.66117	48.39197	KwS5	0.403
Beach Sand	Al-Missila Beach	29.23483	48.10099	KwS6	0.342
Beach Sand	Al-Egaila Beach	29.18127	48.12114	KwS7	0.501
Beach Sand	Wanasa Beach	29.43531	48.26949	KwS8	0.522
Beach Sand	Shuwaikh Beach	29.35694	47.94522	KwS9	0.537
Beach Sand	Al-Watya Beach	29.36273	47.95613	KwS10	0.525
Beach Sand	Al-Fintas Beach	29.19279	48.11552	KwS11	0.483
Beach Sand	Al-Doha Beach	29.32451	47.82708	KwS12	0.489
Beach Sand	Al-Blajat Beach	29.32854	48.09342	KwS13	0.494
Beach Sand	Ras Al-Ard Beach	29.35197	48.09952	KwS14	0.480
Beach Sand	Abdulla Port Beach	28.9925	48.16795	KwS15	0.525
Sea Water	Al-Salam Beach	29.39131	47.99855	KwSW3	0.270
Sea Water	Anjafa Beach	29.27856	48.08967	KwSW4	0.257
Sea Water	Khiran Beach	28.66117	48.39197	KwSW5	0.335
Sea Water	Al-Missila Beach	29.23483	48.10099	KwSW6	0.323
Sea Water	Al-Egaila Beach	29.18127	48.12114	KwSW7	0.325
Sea Water	Wanasa Beach	29.43531	48.26949	KwSW8	0.271
Sea Water	Shuwaikh Beach	29.35694	47.94522	KwSW9	0.275
Sea Water	Al-Watya Beach	29.36273	47.95613	KwSW10	0.266
Sea Water	Al-Fintas Beach	29.19279	48.11552	KwSW11	0.257
Sea Water	Al-Doha Beach	29.32451	47.82708	KwSW12	0.264
Sea Water	Al-Blajat Beach	29.32854	48.09342	KwSW13	0.270
Sea Water	Abdulla Port Beach	28.9925	48.16795	KwSW14	0.259
Sea Shell	Khiran Beach	28.66117	48.39197	KwSS5	0.275
Sea Shell	Al-Egaila Beach	29.18127	48.12114	KwSS7	0.266
Sea Shell	Al-Sulaibikhat bay Coast	29.33303	47.89676	KwSS9	0.265
Sea Shell	Al-Doha Beach	29.32451	47.82708	KwSS12	0.261
Starfish	Arabian Gulf	29.32521	48.25234	KwSf1	0.078
Marine Fish	Arabian Gulf	29.33958	47.86324	KwF1	0.285
Marine Fish	Arabian Gulf	29.53405	48.00229	KwF2	0.289
Marine Fish	Arabian Gulf	29.18865	48.37733	KwF3	0.256
Marine Fish	Arabian Gulf	29.45776	48.1685	KwF4	0.225
Marine Fish	Arabian Gulf	28.96752	48.42674	KwF5	0.235

2.1 Experimental Technique

The instrument used to measure γ-rays from radioactive samples consists of a HPGe semiconductor detector, associated electronics, and a computer-based multichannel analyzer [Verma H. R., 2007] as shown in Figure (4).

The energy and intensity of various gamma-ray lines have been measured using a system consist of Canberra coaxial High-Purity Germanium detector (HPGe) which has a photo peak efficiency of 70%. The energy resolution of 2 keV Full-Width at Half Maximum (FWHM) for the 1332 keV gamma-ray line of 60Co. A cylindrical lead shield of 5 cm thickness, which contains inner concentric cylinder of Cu with thickness of 10 mm, was used to shield the detector and to reduce the effect of background. The detector coupled to a PC-based 8K multichannel analyzer and an ADC with Genie 2000 for data acquisition and analysis. The system was calibrated in the mode of keV/ch. As shown in figure (5), (6), the gamma-ray energies emitted due to the following radioactive sources: ^{60}Co, ^{137}Cs, and ^{152}Eu were used for the calibration. A list of these energies is illustrated in the table [Lederer et al., 1978].

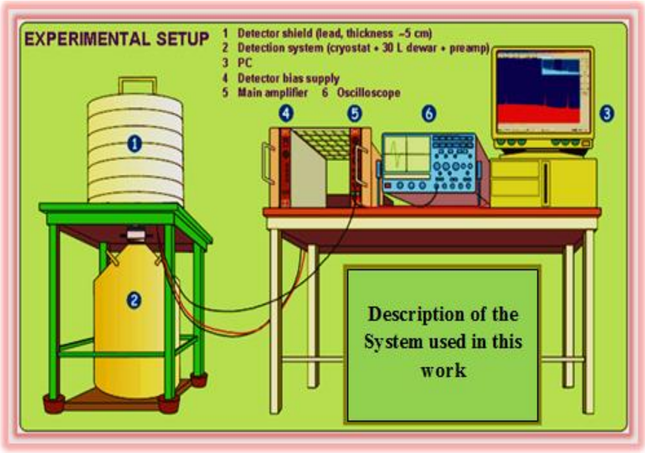

Figure (4). Experimental setup for high resolution gamma-ray spectroscopy

Radioactive samples to be measured have considerable volume and mass, and the gamma rays can be attenuated by self-absorption within the sample material as well as the sample container material. So correction for this attenuation is needed. For that a container called Marinelli beaker which closely fits over the end cap of the detector crystal, is specified for the measurements of environmental samples [Knoll, G.F., 2000]. The Energy and Efficiency calibration of the detector were performed using a set of point-sealed sources; ^{133}Ba, ^{137}Cs, ^{60}Co, ^{152}Eu and ^{226}Ra [Cant and R. Jacquemin, 1990].

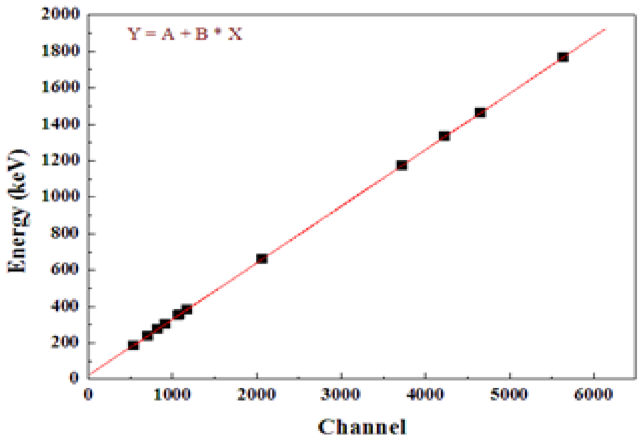

Figure (5). Energy Calibration

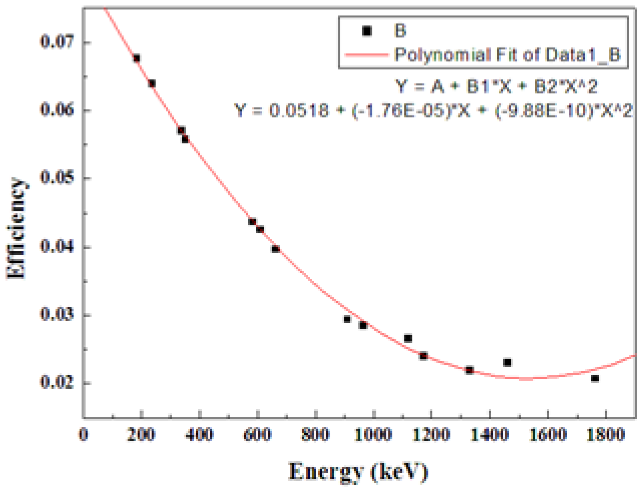

Figure (6). Efficiency Calibration

Specific Activity Measurements: Contents of the different radionuclides in the ^{232}Th, ^{226}Ra series, ^{40}K, ^{137}Cs and ^{60}Co were determined in Bqkg^{-1} by measuring the characteristic gamma peaks of their daughters in their radioactive decay series and ^{40}K. The specific activity (Bqkg^{-1}) of radionuclide content for the measured samples was determined from the relation:

$$A(BqKg^{-1}) = \frac{(C/s)_{net}}{\zeta \times I \times W \times G}$$

Where A is the specific activity of the radionuclide in the measured sample (Bqkg^{-1}), (C/s) is the net count rate of daughter nuclide, ζ is the absolute efficiency of the used γ-ray spectrometer, I is the intensity (%), G is the geometry factor which is equal to unity when all measured samples were counted under the same conditions and W is the weight constant sample. The Characteristics of selected gamma-emitting radionuclides were shown in table (2).

Table 2. Characteristics of selected gamma-emitting radionuclides

Nuclide	Energy (keV)	I (%)	Source
^{226}Ra	185	3. 3	^{238}U decay series
^{214}Pb	351	35.8	
^{214}Bi	609 1120 1764	45 14.9 16.07	
^{228}Ac	338 911	12.3 29	^{232}Th decay series
^{212}Pb	238	45	
^{208}Tl	583	30	
^{40}K	1460	10.6	^{40}K
^{137}Cs	661.6	85	Fission product by the nuclear fission of uranium-235 and other fissionable isotopes in nuclear reactors and nuclear weapons
^{60}Co	1332.5 1173.2	100 100	Product from nuclear reactor operations

3. Results and Discussion

3.1 –Natural specific activity measurement

The activity levels for radionuclides in the measured samples are computed using the following equation [Amrani, 2001]:

$$A(BqKg^{-1}) = \frac{(C/s)_{net}}{\zeta \times I \times W \times G}$$

Where:

A = The activity level of a certain radionuclide (Bq/kg)

C_R = The net count rate of the sample (counts /seconds)

Ɛ (E) = The detector efficiency for the specific gamma ray energy

Iγ = The intensity of gamma-line in a radionuclide

W = The dried sample weight in kg.

In the present study tables (3), (4), (5), (6), (7), and (8) gives the activity concentration for different radionuclides in Bq/kg for all samples Collected in Kuwait and comparison of their values with different countries all over the world. The Peaks of radioactive elements and their energies and results of the samples are clearly detailed in Fig. (7) to (26).

Beach Sand Samples

The γ-ray measurements for Beach Sand samples are from along the eastern coastline from different beach locations in Kuwait. The average activity for the Beach Sand collected for 40K is 32.047 Bq/kg. For ^{232}Th, it is 0.841 Bq/kg, for ^{226}Ra it is 2.048 Bq/kg, for 1^{37}Cs it is 2.389 Bq/kg, and for ^{60}Co it is 0.121 Bq/kg. This low activity can be attributed to the geological settings of these fields.

Starfish Samples

The γ-ray measurements for StarFish samples are from deep inside water. The average activity for the StarFish collected for ^{40}K is 110.917 Bq/kg. For ^{232}Th, it is 1.978 Bq/kg, for ^{226}Ra it is 10.434 Bq/kg, for ^{137}Cs it is 10.614 Bq/kg, and for ^{60}Co it is Non-detected.

Seawater Samples

The γ-ray measurements for Seawater samples are from along the eastern coastline from different beach sites in Kuwait. The average activity for the Seawater collected for ^{40}K is 45.61 Bq/kg. For ^{232}Th, it is 1.31 Bq/kg, for ^{226}Ra it is 4.01 Bq/kg, for ^{137}Cs it is 3.01 Bq/kg, and for ^{60}Co it is 0.21 Bq/kg.

Sea Shell Samples

The γ-ray measurements for Sea Shell samples are from along the eastern coastline from different beach sites in Kuwait. The average activity for the Sea Shell collected for ^{40}K is 56.76 Bq/kg. For ^{232}Th, it is 1.69 Bq/kg, for ^{226}Ra it is 3.58 Bq/kg, for ^{137}Cs it is 3.64 Bq/kg, and for ^{60}Co it is Non-detected.

Marine Fish Samples

The γ-ray measurements for Marine Fish samples are from along the eastern coastline from different Sea locations in Kuwait. The average activity for the Marine Fish collected for ^{40}K is 56.786 Bq/kg. For ^{232}Th, it is 1.086 Bq/kg, for ^{226}Ra it is 3.388 Bq/kg, for ^{137}Cs it is 3.614 Bq/kg, and for ^{60}Co it is Non-detected.

The results show that the mean activity concentration of Ra-226 and Th-232 is lower than the world average activity concentration in Beach Sand, 25 Bq/kg. Whereas the mean value for K-40 is high compared to the whole samples, but much lower than the global average of 370 Bq/kg. The activity concentration of Cs-137 in the analyzed samples was relatively low in all samples, which indicates low level of contamination due to atmospheric nuclear weapons testing and/or nuclear accidents such as Chernobyl or nuclear activities from nuclear bushehr reactor. The variation in activity concentration of Ra-226 was narrow for all locations, except for samples KWSf1, KWS2 and KWSW9. The wide variations of the activity concentration values are due to their physiochemical and geo-chemical properties and the pertinent environment. The results show that the mean activity concentration of Co-60 is non-detected or lower than the world average activity concentration.

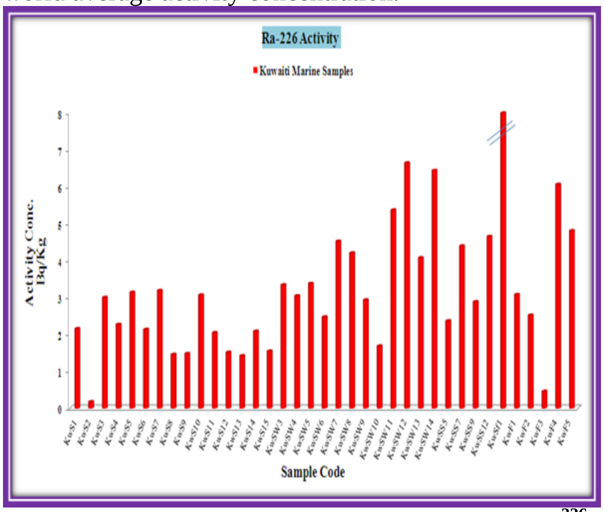

Figure (7). Specific activities concentrations of ^{226}Ra in the Kuwaiti Marine samples

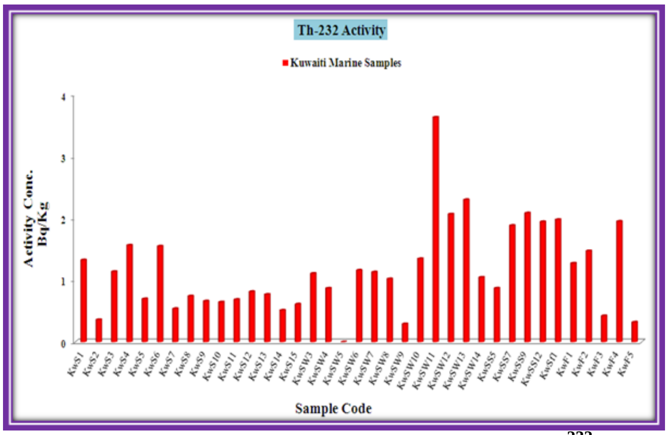

Figure (8). Specific activities concentrations of ^{232}Th in the Kuwaiti Marine samples

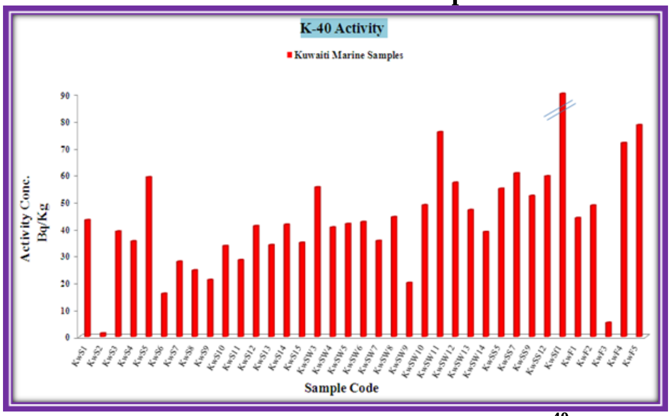

Figure (9). Specific activities concentrations of ^{40}K in the Kuwaiti Marine samples

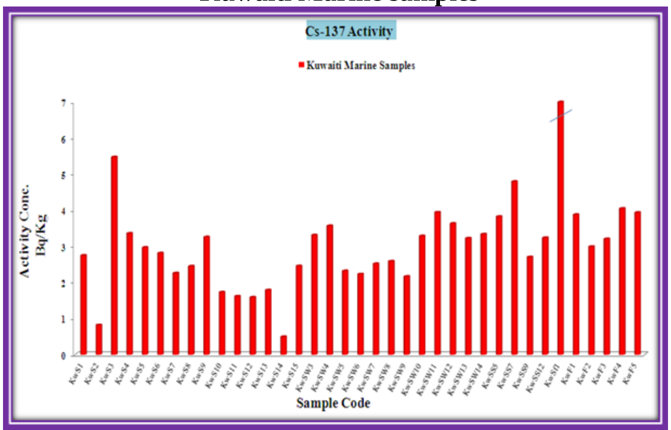

Figure (10). Specific activities concentrations of ^{137}Cs in the Kuwaiti Marine samples

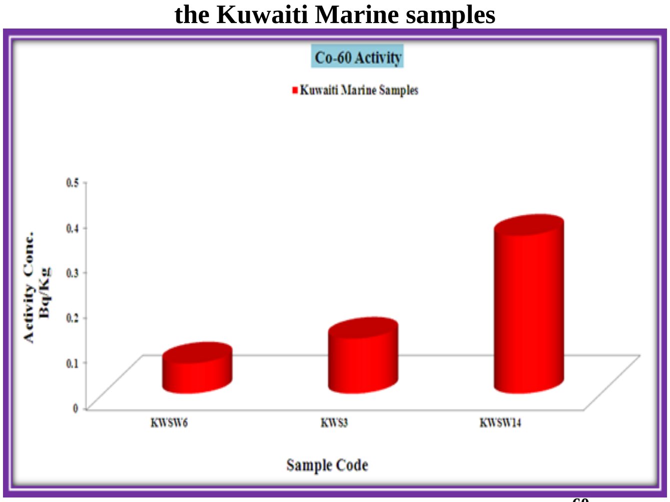

Figure (11). Specific activities concentrations of ^{60}Co in the Kuwaiti Marine samples

Table 3. Specific Activities Concentrations Ra-226, Th-232, K-40 , Cs-137 and Co-60 in the Samples.

Activities Concentrations of Marine Samples In Kuwait (Bq/ kg)								
No.	**Sample Type**	**Location**	**Code**	**^{226}Ra**	**^{232}Th**	**^{40}K**	**^{137}Cs**	**^{60}Co**
1	Sand of Muddy Shore	Al-Sulaibikhat Bay Coast	KwS1	2.16 ± 0.76	1.32 ± 0.57	43.21 ± 1.86	2.75 ± 0.22	0.12 ± 0.17
2	Sand of Muddy Shore	Ras Ushayrij Coast	KwS2	0.18 ± 0.31	0.36 ± 0.11	1.27 ± 1.17	0.82 ± 0.06	ND
3	Beach Sand	Al-Salam Beach	KwS3	3.00 ± 0.31	1.14 ± 0.46	38.98 ± 1.12	5.47 ± 1.33	ND
4	Beach Sand	Anjafa Beach	KwS4	2.27 ± 0.20	1.56 ± 0.42	35.36 ± 1.25	3.36 ± 0.10	ND
5	Beach Sand	Khiran Beach	KwS5	3.14 ± 0.75	0.70 ± 0.72	59.09 ± 3.21	2.97 ± 0.33	ND
6	Beach Sand	Al-Missila Beach	KwS6	2.14 ± 0.78	1.55 ± 0.72	15.94 ± 1.68	2.81 ± 0.31	ND
7	Beach Sand	Al-Egaila Beach	KwS7	3.19 ± 0.49	0.54 ± 0.29	27.83 ± 0.58	2.26 ± 0.12	ND
8	Beach Sand	Wanasa Beach	KwS8	1.46 ± 0.48	0.74 ± 0.12	24.60 ± 0.43	2.45 ± 0.44	ND
9	Beach Sand	Shuwaikh Beach	KwS9	1.48 ± 0.95	0.66 ± 0.22	21.05 ± 0.50	3.26 ± 0.12	ND
10	Beach Sand	Al-Watya Beach	KwS10	3.07 ± 0.50	0.64 ± 0.30	33.62 ± 1.39	1.73 ± 0.17	ND
11	Beach Sand	Al-Fintas Beach	KwS11	2.05 ± 0.40	0.69 ± 0.43	28.41 ± 1.15	1.62 ± 0.70	ND
12	Beach Sand	Al-Doha Beach	KwS12	1.52 ± 0.83	0.81 ± 0.25	41.01 ± 1.38	1.59 ± 0.17	ND
13	Beach Sand	Al-Blajat Beach	KwS13	1.42 ± 0.23	0.77 ± 0.33	33.96 ± 0.68	1.79 ± 0.10	ND
14	Beach Sand	Ras Al-Ard Beach	KwS14	2.09 ± 0.29	0.51 ± 0.52	41.56 ± 1.68	0.50 ± 0.92	ND
15	Beach Sand	Abdulla Port Beach	KwS15	1.55 ± 0.37	0.61 ± 0.29	34.81 ± 1.17	2.46 ± 0.72	ND
16	Sea Water	Al-Salam Beach	KwSW3	3.34 ± 0.62	1.11 ± 0.92	55.35 ± 2.37	3.31 ± 0.30	ND
17	Sea Water	Anjafa Beach	KwSW4	3.05 ± 0.43	0.87 ± 0.63	40.50 ± 0.65	3.57 ± 0.13	ND
18	Sea Water	Khiran Beach	KwSW5	3.38 ± 0.71	-0.23 ± 0.84	41.77 ± 2.24	2.32 ± 0.29	ND
19	Sea Water	Al-Missila Beach	KwSW6	2.48 ± 0.22	1.16 ± 0.12	42.52 ± 0.53	2.23 ± 0.11	0.07 ± 0.02
20	Sea Water	Al-Egaila Beach	KwSW7	4.53 ± 1.25	1.13 ± 0.90	35.51 ± 3.40	2.52 ± 0.34	ND
21	Sea Water	Wanasa Beach	KwSW8	4.21 ± 0.64	1.02 ± 0.38	44.32 ± 5.19	2.59 ± 0.21	ND
22	Sea Water	Shuwaikh Beach	KwSW9	2.93 ± 1.11	0.29 ± 0.58	19.97 ± 2.03	2.17 ± 0.22	ND
23	Sea Water	Al-Watya Beach	KwSW10	1.69 ± 1.51	1.35 ± 0.48	48.75 ± 1.15	3.29 ± 0.23	ND
24	Sea Water	Al-Fintas Beach	KwSW11	5.37 ± 2.53	3.63 ± 1.02	75.79 ± 3.14	3.94 ± 0.38	ND
25	Sea Water	Al-Doha Beach	KwSW12	6.65 ± 0.95	2.07 ± 0.86	57.06 ± 2.46	3.63 ± 0.31	ND
26	Sea Water	Al-Blajat Beach	KwSW13	4.08 ± 0.55	2.30 ± 0.90	46.94 ± 1.40	3.23 ± 0.30	ND
27	Sea Water	Abdulla Port Beach	KwSW14	6.44 ± 0.49	1.05 ± 0.20	38.82 ± 0.80	3.34 ± 0.12	0.35 ± 0.05
28	Sea Shell	Khiran Beach	KwSS5	2.37 ± 0.45	0.87 ± 0.62	54.84 ± 2.36	3.83 ± 0.27	ND
29	Sea Shell	Al-Egaila Beach	KwSS7	4.40 ± 1.32	1.88 ± 1.13	60.56 ± 2.95	4.80 ± 0.54	ND
30	Sea Shell	Al-Sulaibikhat Bay Coast	KwSS9	2.89 ± 1.23	2.08 ± 0.82	52.18 ± 1.26	2.70 ± 0.30	ND
31	Sea Shell	Al-Doha Beach	KwSS12	4.65 ± 0.99	1.94 ± 0.81	59.46 ± 2.56	3.24 ± 0.31	ND
32	Starfish	Arabian Gulf	KwSf1	10.43 ± 1.07	1.98 ± 2.10	110.92 ± 2.05	10.61 ± 0.39	ND
33	Marine Fish	Arabian Gulf	KwF1	3.08 ± 0.74	1.27 ± 0.49	43.99 ± 1.24	3.88 ± 0.34	ND
34	Marine Fish	Arabian Gulf	KwF2	2.52 ± 0.59	1.47 ± 0.39	84.6 ± 0.89	2.99 ± 0.20	ND
35	Marine Fish	Arabian Gulf	KwF3	0.46 ± 0.17	0.42 ± 0.25	5.18 ± 0.92	3.21 ± 0.44	ND
36	Marine Fish	Arabian Gulf	KwF4	6.07 ± 2.19	1.95 ± 3.23	71.76 ± 2.23	4.05 ± 0.51	ND
37	Marine Fish	Arabian Gulf	KwF5	4.81 ± 2.23	0.32 ± 1.54	78.40 ± 4.68	3.94 ± 0.61	ND

ND: Non Detected Value

Table 4. The Maximum, Minimum and Average values for the activity concentration of ^{226}R, ^{232}Th series and ^{40}K in Kuwaiti samples

Activity Concentration	^{226}Ra	^{232}Th	^{40}K	^{137}Cs	^{60}Co
Mean	3.26 ± 0.80	1.15 ± 0.67	43.62 ± 1.78	3.11 ± 0.34	0.01 ± 0.01
Min	0.18 ± 0.17	-0.23 ± 0.11	1.27 ± 0.43	0.50 ± 0.06	ND
Max	10.43 ± 2.53	3.63 ± 3.23	110.92 ± 5.19	10.61 ± 1.33	0.35 ± 0.17
ST. Deviation	1.96 ± 0.57	0.73 ± 0.59	20.65 ± 1.12	1.62 ± 0.26	0.06 ± 0.03

ND: Non Detected

Table 5 .The Maximum, Minimum and Average values for the hazard parameters in Kuwaiti samples.

Hazard Parameters	Absorbed Dose (DR) (nGy/h)	Annual Effective Dose (Effe) (µSv/y)	Gamma Index (Iγ)	Alpha Index (Iα)
Mean	4.04 ± 0.86	4.96 ± 1.06	0.03 ± 0.01	0.02 ± 0.00
Min.	0.36 ± 0.20	0.44 ± 0.24	0.00 ± 0.00	0.00 ± 0.00
Max.	10.68 ± 3.10	13.10 ± 3.81	0.08 ± 0.02	0.05 ± 0.01
ST. Deviation	1.96 ± 0.60	2.40 ± 0.74	0.02 ± 0.00	0.01 ± 0.00

Hazard Parameters	Radium Equivalent (Raeq) (Bq/Kg)	External Hazard Index (Hex)	Internal Hazard Index (Hin)
Mean	8.26 ± 1.90	0.02 ± 0.01	0.03 ± 0.01
Min	0.79 ± 0.43	0.00 ± 0.00	0.00 ± 0.00
Max	21.80 ± 6.98	0.06 ± 0.02	0.09 ± 0.02
ST. Deviation	4.03 ± 1.35	0.01 ± 0.00	0.02 ± 0.01

The average activity concentration of ^{226}Ra, ^{232}Th series, ^{40}K, ^{137}Cs and ^{60}Co for Marine samples is 3.26 ± 0.80 Bq/kg, 1.15 ± 0.67 Bq/kg, 43.62 ± 1.78 Bq/kg, 3.11 ± 0.34 Bq/kg and 0.01 ± 0.01Bq/kg respectively. The results show that the mean activity concentration is lower than the world average activity concentration.

According to the Kuwaiti Marine samples, The estimated average for (Radium Equivalent Rate, External Hazard Index, Internal Hazard Index, Absorbed Dose, Annual effective dose, Gamma Index, Alpha Index) is (8.26 ± 1.90 Bq/kg, 0.02 ± 0.01 Bq/kg, 0.03 ± 0.01 Bq/kg, 4.04 ± 0.86 Bq/kg, 4.96 ± 1.06 Bq/kg, 0.03 ± 0.01 Bq/kg and 0.02 ± 0.00 Bq/kg), respectively. The estimated hazard parameters in all samples are Lower than the recommended limits for occupationally worker.

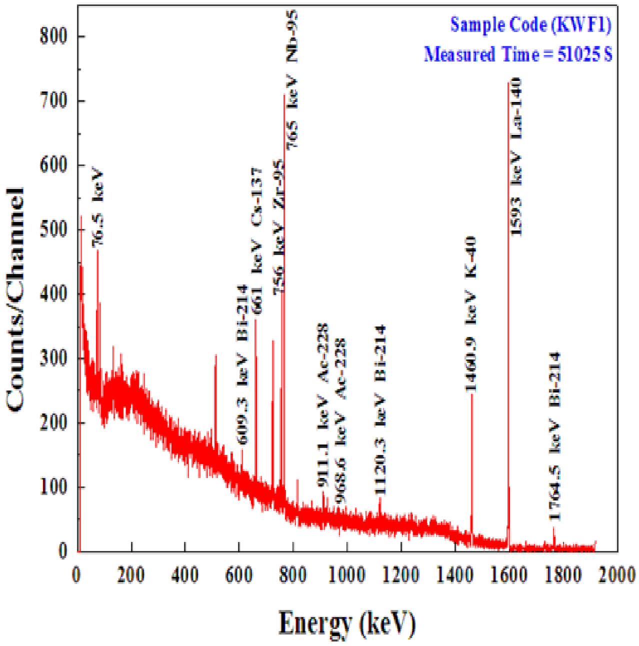

Figure (12). Gamma ray spectrum of sample code (KWF1)

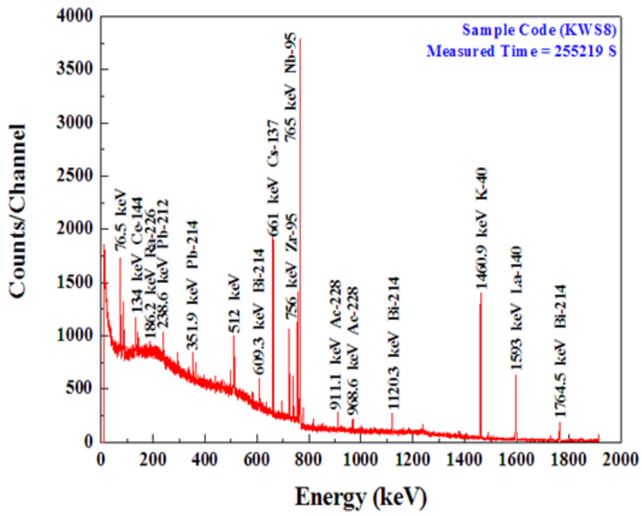

Figure (13). Gamma ray spectrum of sample code (KWS8)

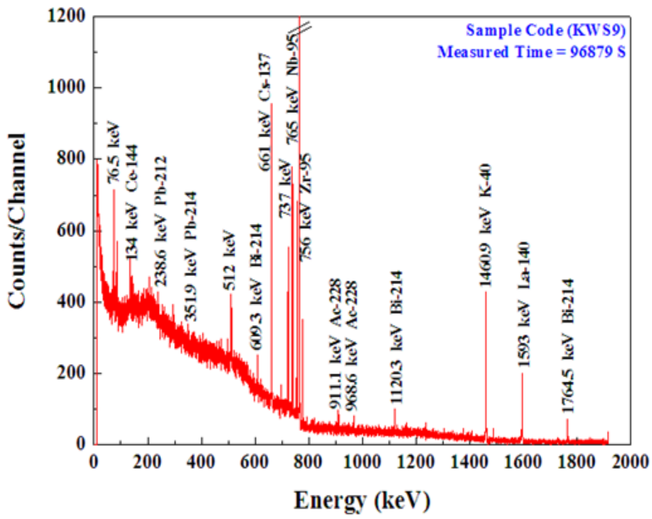

Figure (14). Gamma ray spectrum of sample code (KWS9)

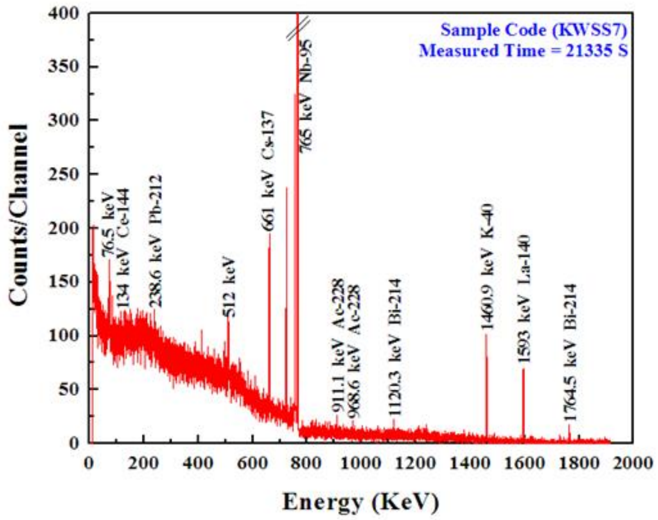

Figure (15). Gamma ray spectrum of sample code (KWSS7)

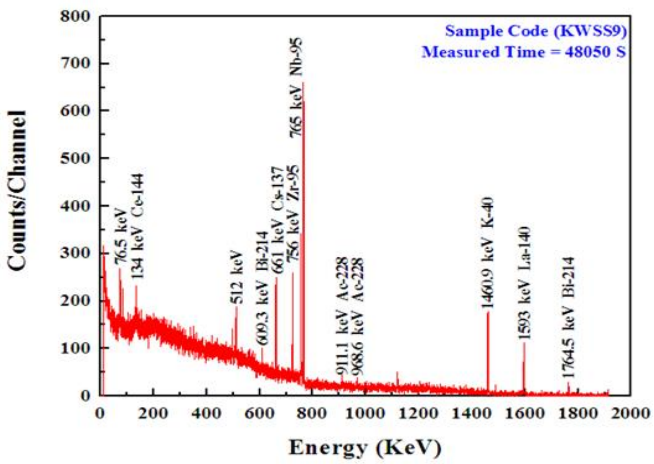

Figure (16). Gamma ray spectrum of sample code (KWSS9)

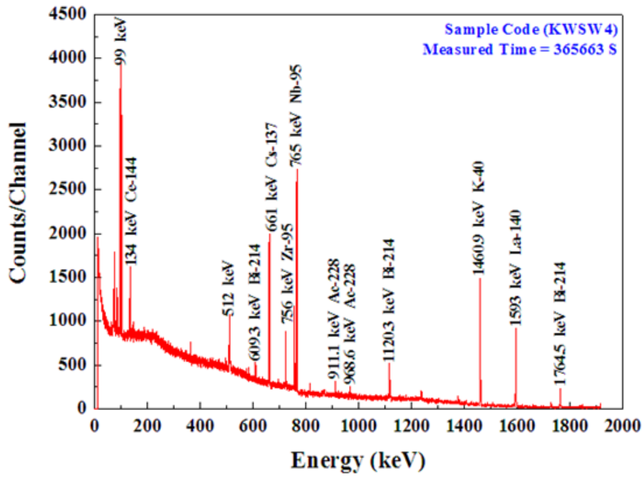

Figure (17). Gamma ray spectrum of sample code (KWSW4)

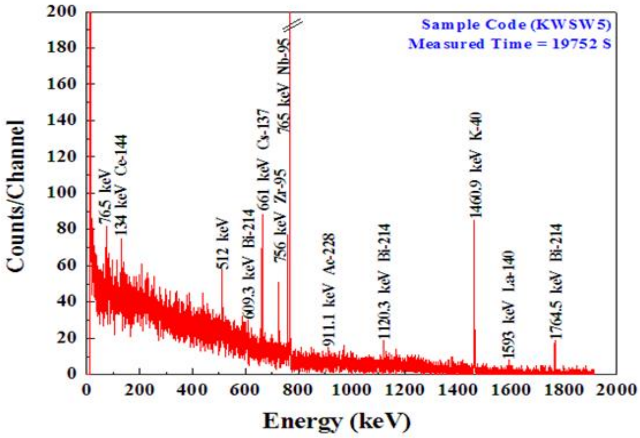

Figure (18). Gamma ray spectrum of sample code (KWSW5)

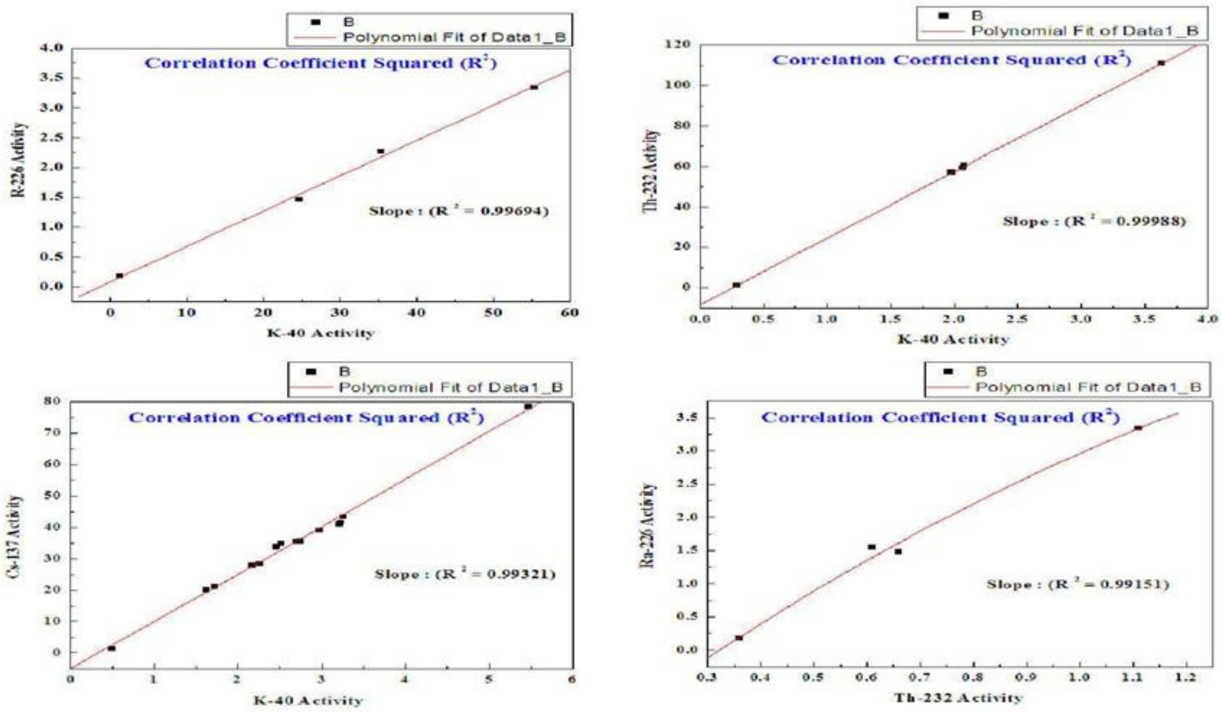

Figure (19). Linear correlation between naturally occurring radionuclides for present study

3.2 Hazard Parameters

Calculation of the Absorbed Dose Rate (D_R)

If naturally occurring radioactive nuclides are uniformly distributed in the ground, dose rates at 1 m above the ground surface are calculated by the following formula [Beck, 1972].

Dose rate (nGy/h) = Concentration of nuclide (Bq/kg) x Conversion Factor (nGy/h per Bq/kg).

There is concern that some of sands will cause excessive radiation doses to the total body due to gamma rays emitted by ^{232}Th decay chain, ^{214}Pb and ^{214}Bi progeny of ^{226}Ra and ^{40}K also contribute to the total body radiation dose. The absorbed dose rates one meter above the ground due to the radioactivity in the sands were calculated using the flowing equation [UNSCEAR, 2000]:

$D_R = C_{Ra}\, A_{Ra} + C_{Th}\, A_{Th} + C_k\, A_k$

D_R (nGy/h) $= (0.46 * A_{Ra}) + (0.62 * A_{Th}) + (0.042 * A_K)$

Where D_R is the absorbed dose rate (nGy/h). The C_{Ra}, C_{Th} and C_K are the conversion factors, expressed in (nGyhr^{-1} per Bq kg^{-1}) for potassium (0.042), thorium (0.62), and radium (0.46) respectively.

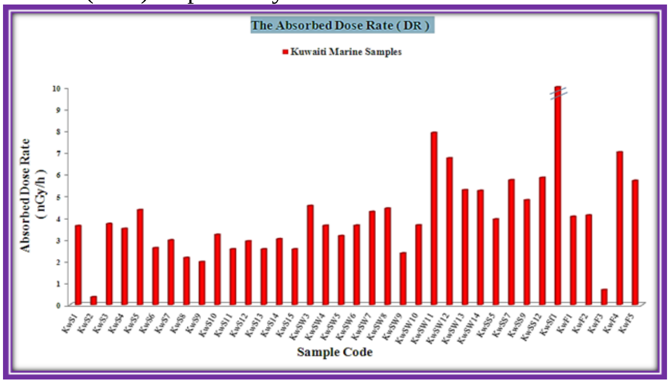

Figure (20). The Absorbed Dose Rate (D_R) In Kuwaiti and Egyptian Samples

3.2.1 Calculation of the Annual Effective Dose (Eeff)

Also annual effective dose is a useful concept that enables the radiation doses from different radionuclides and from different types and sources of radioactivity to be added. It is based on the risks of radiation induced health affects which the annual effective dose rate Eeff (mSv/ y) can be calculated using the following relations [UNSECEAR, 2000 and Huy et al., 2006].

Eeff = DR (nGy h-1) × 8760(h y-1) × O × C (mSv/nGy)

$$E_{eff} = D_R \times 8760 \times 0.7 \times \frac{10^{3}\, mSv}{10^{9}\, nGy} \times 0.2$$

Where D is the absorbed dose rate in (nGy/h). O is the occupancy factor and C is the absorbed to effective dose conversion factor (0.7 × 10-6 Sv per Gy).

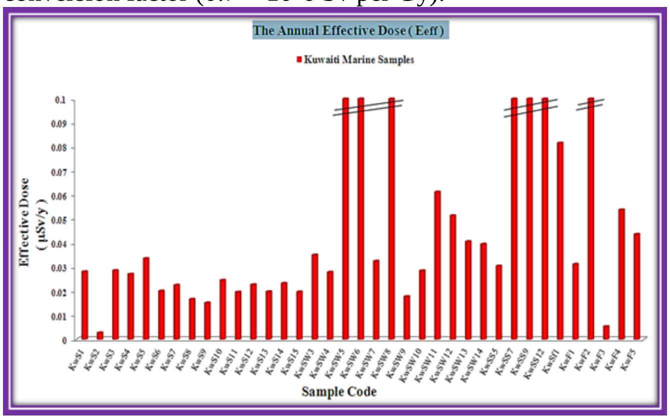

Figure (21). The Annual Effective Dose (E_{eff}) In Kuwaiti Samples

3.2.2 The Radioactivity Level Index (Gamma Index (Iγ))

The γ-ray radiation hazards associated with the natural radionuclides of building materials can be assessed by means of radioactivity level index, Iγ. Radioactivity level index should be less than unity for radiation dose of 1 mSv/ y. Radioactivity level index (Iγ) can be calculated from equation:

Iγ = (ARa/300) + (ATh/200) + (Ak/3000)

Where (Iγ) is the Gamma Index. The ARa, ATh and AK are the activity concentrations, expressed in (Bq/kg) for radium, thorium and potassium respectively.

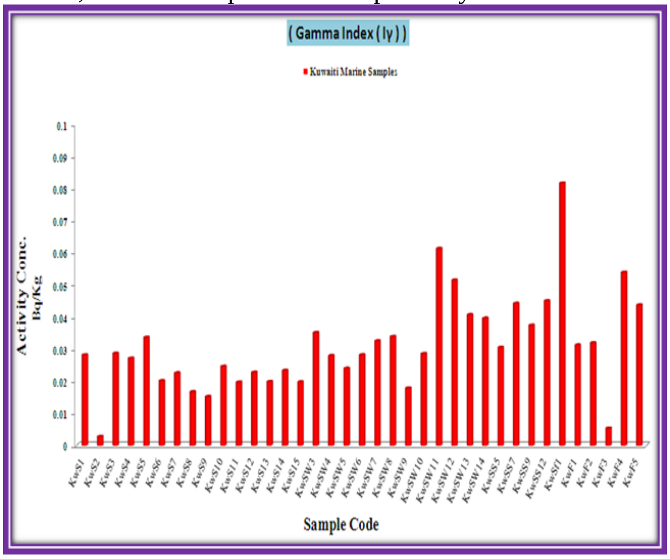

Figure (22). Radioactivity Level Index (Gamma Index (Iγ)) In Kuwaiti Samples

3.2.3. The Radioactivity Level Index (Alpha Index (Iα))

Alpha radiation due to radon inhalation released from of west petroleum was calculated from equation, and it is called alpha index (Iα). Alpha index should be less than unity in order to reflect a value of radium concentration less than 200 Bq kg-1 (the upper recommended value) and consequently the release radon concentration will be more than 200 Bq m^{-3}.

Iα = ARa/200

Where (Iα) is the Alpha Index. The ARa is the activity concentration of radium in (Bq/kg).

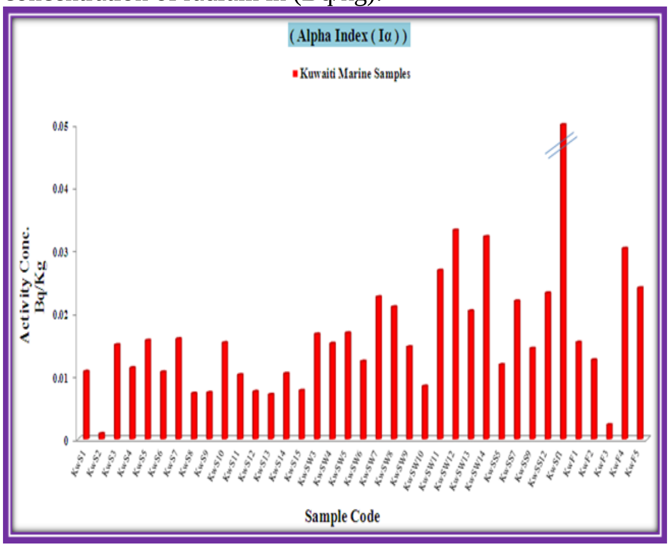

Figure (23). Radioactivity Level Index (Alpha Index (Iα)) In Kuwaiti Samples

Table 6. Absorbed Dose Rate (D_R), Annual Effective Dose (Effe), Gamma Index (Iγ) and Alpha Index (Iα) of The Kuwaiti Marine Samples

Marine Sample Code	Absorbed Dose (DR) (nGy/h)	Annual Effective Dose (Effe) (µSv/y)	Gamma Index (Iγ)	Alpha Index (Iα)
KwS1	3.628 ± 0.781	4.449 ± 0.781	0.028 ± 0.781	0.011 ± 0.004
KwS2	0.358 ± 0.263	0.439 ± 0.263	0.003 ± 0.263	0.001 ± 0.002
KwS3	3.724 ± 0.471	4.567 ± 0.471	0.029 ± 0.471	0.015 ± 0.002
KwS4	3.500 ± 0.409	4.292 ± 0.409	0.027 ± 0.409	0.011 ± 0.001
KwS5	4.359 ± 0.928	5.346 ± 0.928	0.034 ± 0.928	0.016 ± 0.004
KwS6	2.613 ± 0.874	3.205 ± 0.874	0.020 ± 0.874	0.011 ± 0.004
KwS7	2.971 ± 0.428	3.644 ± 0.428	0.023 ± 0.428	0.016 ± 0.002
KwS8	2.164 ± 0.314	2.654 ± 0.314	0.017 ± 0.314	0.007 ± 0.002
KwS9	1.976 ± 0.591	2.423 ± 0.591	0.015 ± 0.591	0.007 ± 0.005
KwS10	3.223 ± 0.472	3.953 ± 0.472	0.025 ± 0.472	0.015 ± 0.002
KwS11	2.561 ± 0.501	3.141 ± 0.501	0.020 ± 0.501	0.010 ± 0.002
KwS12	2.925 ± 0.592	3.587 ± 0.592	0.023 ± 0.592	0.008 ± 0.004
KwS13	2.557 ± 0.341	3.136 ± 0.341	0.020 ± 0.341	0.007 ± 0.001
KwS14	3.024 ± 0.527	3.709 ± 0.527	0.023 ± 0.527	0.010 ± 0.001
KwS15	2.554 ± 0.403	3.132 ± 0.403	0.020 ± 0.403	0.008 ± 0.002
KwSW3	4.550 ± 0.954	5.580 ± 0.954	0.035 ± 0.954	0.017 ± 0.003
KwSW4	3.640 ± 0.616	4.464 ± 0.616	0.028 ± 0.616	0.015 ± 0.002
KwSW5	3.17 ± 0.94	3.38 ± 1.15	0.024 ± 0.007	0.017 ± 0.004
KwSW6	3.64 ± 0.20	4.47 ± 0.24	0.028 ± 0.002	0.012 ± 0.001
KwSW7	4.273 ± 1.273	5.241 ± 1.273	0.033 ± 1.273	0.023 ± 0.006
KwSW8	4.43 ± 0.75	5.43 ± 0.91	0.037 ± 0.006	0.021 ± 0.003
KwSW9	2.370 ± 0.957	2.906 ± 0.957	0.018 ± 0.957	0.015 ± 0.006
KwSW10	3.657 ± 1.044	4.485 ± 1.044	0.029 ± 1.044	0.008 ± 0.008
KwSW11	7.905 ± 1.931	9.695 ± 1.931	0.061 ± 1.931	0.027 ± 0.013
KwSW12	6.735 ± 1.075	8.260 ± 1.075	0.052 ± 1.075	0.033 ± 0.005
KwSW13	5.274 ± 0.869	6.468 ± 0.869	0.041 ± 0.869	0.020 ± 0.003
KwSW14	5.242 ± 0.382	6.429 ± 0.382	0.040 ± 0.382	0.032 ± 0.002
KwSS5	3.932 ± 0.686	4.823 ± 0.686	0.031 ± 0.686	0.012 ± 0.002
KwSS7	5.73 ± 1.43	7.03 ± 1.75	0.044 ± 0.011	0.022 ± 0.007
KwSS9	4.81 ± 1.13	5.90 ± 1.38	0.037 ± 0.009	0.014 ± 0.006
KwSS12	5.84 ± 1.07	7.17 ± 1.31	0.045 ± 0.008	0.023 ± 0.005
KwSf1	10.685 ± 1.880	13.104 ± 1.880	0.082 ± 1.880	0.052 ± 0.005
KwF1	4.054 ± 0.695	4.972 ± 0.695	0.031 ± 0.695	0.015 ± 0.004
KwF2	4.125 ± 0.551	5.047 ± 0.676	0.032 ± 0.004	0.013 ± 0.003
KwF3	0.691 ± 0.272	0.847 ± 0.272	0.005 ± 0.272	0.002 ± 0.001
KwF4	7.013 ± 3.104	8.600 ± 3.104	0.054 ± 3.104	0.030 ± 0.011
KwF5	5.704 ± 2.173	6.995 ± 2.173	0.044 ± 2.173	0.024 ± 0.011

3.2.4 The Radium Equivalent Activity:

Radium equivalent activity is a widely used hazard index. It is calculated as follows [Huy et al., 2006].

$Ra_{eq} = A_{Ra} + 1.43\ A_{Th} + 0.077A_k$

Where A_{Ra}, A_{Th} and A_K are activities of ^{226}Ra, ^{232}Th and ^{40}K, respectively, in Bq/kg. It is assumed that 370 Bq/kg of ^{226}Ra, 259 Bq/kg of ^{232}Th, and 4810 Bq/kg of ^{40}K produced the same gamma-ray dose rate.

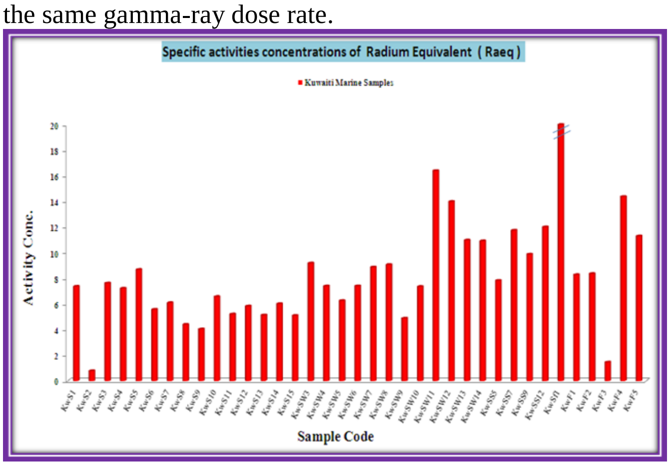

Figure (24). Specific activities concentrations of Radium Equivalent (Ra_{eq}) in Kuwaiti Samples

The maximum value of Ra-eq must be <370 Bqkg^{-1} in order to keep the external dose <1.5 mGy/y [OECD, 1979 and Huy et al., 2006].

3.2.5. The External Hazard Index (Hex):

The external hazard index is obtained from Raeq expression through the supposition that its allowed maximum value (equal to unity) corresponds to the upper limit of Raeq (370 Bq/kg). The external hazard index (Hex) considers only the external exposure risk due to gamma-rays. The external hazard index (Hex) is given by the following equation [Krieger, 1981]:

$H_{ex} = A_{Ra}/370 + A_{Th}/259 + A_K/4810$

Where (H_{ex}) is external hazard index. The A_{Ra}, A_{Th} and A_K are the activity concentrations, expressed in (Bq/kg) for radium, thorium and potassium respectively. The values of external hazard index (H_{ex}) must not exceed the limit of unity for the radiation hazard to be negligible

3.2.6 The Internal Hazard Index (H_{in})

The internal hazard index (H_{in}) gives the internal exposure to carcinogenic radon and its short-lived progeny and is giving by the following formula [Beretka, 1985; Cottens, 1990]:

$H_{in} = A_{Ra}/185 + A_{Th}/259 + A_K/4810$

Where (H_{in}) is internal hazard index. The A_{Ra}, A_{Th} and A_K are the activity concentrations, expressed in (Bq/kg) for radium, thorium and potassium respectively.

The values of internal hazard index (H_{in}) must be less than unity to have negligible hazardous effects of radon and its short lived progeny to the respiratory organs [UNSCARE, 2000].

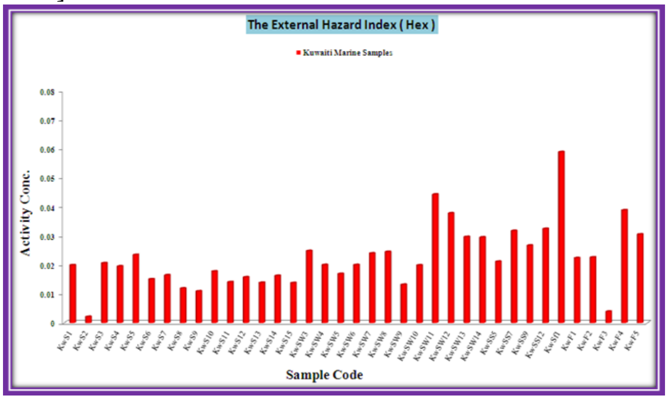

Figure (25). Specific activities concentrations of the External Hazard Index (H_{ex}) in Kuwaiti Samples.

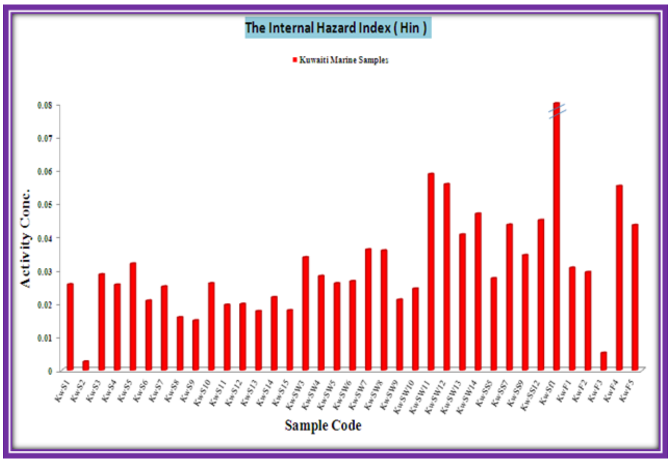

Figure (26). Specific activities concentrations of The Internal Hazard Index (Hin) In Kuwaiti Samples.

Table 7. Radium Equivalent, External and Internal Hazard Index of The Kuwaiti Marine Samples

Marine Sample Code	Radium Equivalent (Raeq) (Bq/Kg)	External Hazard Index (Hex)	Internal Hazard Index (Hin)
KwS1	7.38 ± 1.72	0.020 ±0.005	0.026 ±0.007
KwS2	0.79 ± 0.56	0.002 ±0.002	0.003 ±0.002
KwS3	7.63 ± 1.05	0.021 ±0.003	0.029 ±0.004
KwS4	7.23 ± 0.91	0.020 ±0.002	0.026 ±0.003
KwS5	8.69 ± 2.03	0.023 ±0.005	0.032 ±0.008
KwS6	5.58 ± 1.93	0.015 ±0.005	0.021 ±0.007
KwS7	6.10 ± 0.95	0.016 ±0.003	0.025 ±0.004
KwS8	4.41 ± 0.69	0.012 ±0.002	0.016 ±0.003
KwS9	4.05 ± 1.29	0.011 ±0.003	0.015 ±0.006
KwS10	6.58 ± 1.03	0.018 ±0.003	0.026 ±0.004
KwS11	5.22 ± 1.11	0.014 ±0.003	0.020 ±0.004
KwS12	5.84 ± 1.29	0.016 ±0.003	0.020 ±0.006
KwS13	5.14 ± 0.76	0.014 ±0.002	0.018 ±0.003
KwS14	6.02 ± 1.16	0.016 ±0.003	0.022 ±0.004
KwS15	5.10 ± 0.88	0.014 ±0.002	0.018 ±0.003
KwSW3	9.19 ± 2.11	0.025 ±0.006	0.034 ±0.007
KwSW4	7.40 ± 1.38	0.020 ±0.004	0.028 ±0.005
KwSW5	6.26 ± 2.08	0.017 ± 0.006	0.026 ± 0.008
KwSW6	7.41 ± 0.43	0.020 ± 0.001	0.027 ± 0.002
KwSW7	8.88 ± 2.79	0.024 ±0.008	0.036 ±0.011
KwSW8	9.08 ± 1.58	0.025 ± 0.004	0.036 ± 0.006
KwSW9	4.89 ± 2.10	0.013 ±0.006	0.021 ±0.009
KwSW10	7.36 ± 2.29	0.020 ±0.006	0.024 ±0.010
KwSW11	16.40 ± 4.24	0.044 ±0.011	0.059 ±0.018
KwSW12	13.99 ± 2.37	0.038 ±0.006	0.056 ±0.009
KwSW13	10.98 ± 1.94	0.030 ±0.005	0.041 ±0.007
KwSW14	10.93 ± 0.84	0.030 ±0.002	0.047 ±0.004
KwSS5	7.84 ± 1.51	0.021 ±0.004	0.028 ±0.005
KwSS7	11.75 ± 3.16	0.032 ± 0.009	0.044 ± 0.012
KwSS9	9.89 ± 2.50	0.027 ± 0.007	0.035 ± 0.010
KwSS12	12.01 ± 2.35	0.032 ± 0.006	0.045 ± 0.009
KwSf1	21.80 ± 4.23	0.059 ±0.011	0.087 ±0.014
KwF1	8.29 ± 1.53	0.022 ±0.004	0.031 ±0.006
KwF2	8.37 ± 1.22	0.023 ± 0.003	0.029 ± 0.005
KwF3	1.46 ± 0.60	0.004 ±0.002	0.005 ±0.002
KwF4	14.38 ± 6.98	0.039 ±0.019	0.055 ±0.025
KwF5	11.30 ± 4.78	0.031 ±0.013	0.044 ±0.019

Table 8. Comparison of Ranges of activity levels of Ra226, Th232, K40 and the other fissionable isotopes products in nuclear reactors and nuclear weapons (if any) in the studied Marine Samples and their values for different countries all over the world

Country	Activities Concentrations of Radionuclides in Marine Samples all over the world. (Bq/ kg)					Reference
	Ra^{226} Range (Uranium Chain)	Th^{232} Range (Thorium Chain)	K^{40} Range	Cs^{137} Range	Co^{60} Range	
Red Sea, Egyptian coast	21.1	12.4	930	ND-1.2	ND	Harb, 2008
Red Sea, Sudanese coast	-	6.02	158.4	4.09	ND	Sam, et al., 1998
Mediterranean, Egyptian coast	56	83.4	88.1	-	ND	Seddeek et al., 2005
Mediterranean, Algerian coast	28.6	Ac^{228}: 13.4 Pb^{212}: 15.3	205	0.7	ND	Noureddine et al., 1997
Mediterranean, French coast	-	Ac^{228}: 4.8-690	140-690	-	ND	Vassas et al., 2006
Ionian sea, Albanian coast	23	Ac^{228}: 26 Bi^{212} : 31 Pb^{212}: 28.4	532	10	ND	Tsabaris, et al. 2007
Aegean sea, Turkish coast	-	523	1161	2.31	ND	Örgün et al, 2007
Arabian gulf, Kuwait coast	8.72	1.6-17	40.5-492	<0.1	ND	Saad and Al-Azmi, 2002
Atlantic ocean, Brazilian coast	34-637	36-6675	42.666	-	ND	Veiga, et al. 2006
Atlantic ocean, Spanish southwestern coast	7.3	6.8	160	0.5	ND	Ligero et al., 2001
Indian ocean, Kenyan coast	-	11-26	206-520	<2.9-3.2	ND	Hashim et al, 2004
Indian ocean, Indian southwestern coast	31	38	152	-	ND	Karunakara et al, 2005
Bengal bay, Indian southeastern coast	-	120	2500	-	ND	Mohanty et al, 2004
Bengal bay, Bangladesh coast	19	37	458	-	ND	Alam et al, 1999
Andaman sea, Thailand coast	2.7-24	3-35	11-654	-	ND	Malain et al., 2009)
Black Sea, Bulgarian coast	4.2-5.8	4.2-4.8	-	-	ND	Strezov et al., 1998
Arabian Gulf (Kuwaiti Coast)	**0.18 - 10.43**	**-0.23 - 3.63**	**1.27 - 110.92**	**0.50 - 10.61**	**ND - 0.35**	**Present Study**

4. Conclusions

According to the present results, it appears clearly the following:

A total of 37 of marine environment Samples of the Arabian Gulf region (Beach Muddy/Sands, Arabian Gulf Water, Shells and Different types of Marine Fish) collected along the eastern coastline of the State of Kuwait. All samples were collected from different beach sites in Kuwait. These samples were collected randomly from different locations in these sites (from north to south along the eastern coastline of Arabian Gulf). All samples were measured using gamma spectrometry technique, with high purity germanium detector (HPGe). The results show that the average activity concentrations of ^{226}Ra series, ^{232}Th series and ^{40}K, ^{137}Cs and ^{60}Co for Kuwaiti Environmental Marine Samples are lower than the worldwide average value. The worldwide average values (32, 45 and 420) for ^{226}Ra, ^{232}Th series and ^{40}K, respectively. The activity concentration of ^{226}Ra series, ^{232}Th series and ^{40}K, ^{137}Cs and ^{60}Co for Kuwaiti Environmental Marine Samples ranged between [(0.18-10.43) Bq/kg with average of 3.26±0.80 Bq/kg, (-0.23–3.63) Bq/kg with average of 1.15±0.67 Bq/kg, (1.27-110.92) Bq/kg with average of 43.62±1.7 Bq/kg, (0.50-10.61) Bq/kg with average of 3.11 ± 0.34 Bq/kg and (ND–0.35) Bq/kg with average of 0.01±0.01 Bq/kg] respectively. Marine Environment Samples of the Arabian Gulf region in Kuwait have been investigated. Samples were collected along the eastern coastline of the State of Kuwait. All samples were collected from different beach sites in Kuwait. These samples were collected randomly from different locations in these sites (from north to south along the eastern coastline of Arabian Gulf). According to the Kuwaiti samples, the estimated range for (Radium Equivalent Rate, External Hazard Index, Internal Hazard Index, Absorbed Dose, annual effective dose, Gamma Index, Alpha Index) is [(0.79 – 21.80) Bq/kg with average of 8.26 ± 1.90 Bq/kg, (0.00 – 0.06) Bq/kg with average of 0.02 ± 0.01 Bq/kg, (0.00 – 0.09) Bq/kg with average of 0.03 ± 0.01 Bq/kg, (0.36 - 10.68) Bq/kg with average of 4.04 ± 0.86 Bq/kg, (0.44 – 13.10) Bq/kg with average of 4.96 ± 1.06 Bq/kg, (0.00 – 0.08) Bq/kg with average of 0.03 ± 0.01 Bq/kg and (0.00 – 0.05) Bq/kg with average of 0.02 ± 0.00 Bq/kg], respectively. The estimated hazard parameters in all Kuwaiti samples are lower than the recommended limits for occupationally worker. From this study, it was noticed that the average activity concentrations of ^{226}Ra series, ^{232}Th series, ^{40}K, ^{137}Cs and ^{60}Co for Kuwaiti Environmental Marine Samples are lower than the worldwide average value. The worldwide average values (32, 45 and 420) for ^{226}Ra, ^{232}Th series and ^{40}K, respectively. It is noticed that the results of activities of ^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs are higher in the Sea Water sample with code KWSW12 and KWSW14 and higher in Starfish sample with code KWSF1. This high activity can be attributed to other sources from the surrounding areas carried the elements by wind, dust or ground water, or From the remnants of the giant oil tankers and reactors that are located on the Arabian Gulf and the previous wars of the Gulf region and its outcome from which leads to health, environmental and economic ramifications. Its effects are reflected on the region or in the earth shakes that are exposed to Countries that are located on the Arabian Gulf. All citizens, fishers, divers and beach-goers must follow the precautionary regulations and any changes to the beaches, Gulf waters or traded fish. The scarcity of concentration of industrial radionuclides in all the samples under study proves that the

Gulf water is not currently radioactive and is completely safe as well as Kuwaiti beaches. Such workers should follow approved radiation protection regulations and receive regular medical surveillance. The Marine sites of NORM activities require qualified radiation protection experts to safeguard workers and environment from exposure and contaminations during all stages. Restricted regulations should be applied for the workers that performing cleaning of the contaminated marine equipment.

Acknowledgement

The authors would like to express their thanks and appreciation to [Suez Canal University (Ismailia), Zagazig University, Egypt] and Egyptian Atomic Energy Agency, for giving them the opportunity to carry out this work in their laboratories, for their helping during the measurement, useful comments and assistance. Nothing can be compared with this honorable work and effort to show it in this honorable way.

References

1- [Kuwait National Assembly, 2015 – State of Kuwait, https://www.kna.kw/research/boshhr/01.pdf (Official Information Bulletin – chapter 1].

2- [Verma H. R., (2007) : "Atomic and Nuclear Analytical Methods" VerlagBerlin Heidelberg, New York].

3- [Knoll, G.F., (2000): "Radiation Detection and Measurement "; Univ. of Michigan, John Wiley and Sons, Inc, Third Edition New York].

4- [Lederer, C.M., and Shirley, V.S., (1978): Eds.,"Table of Isotopes", 7th Edition, John Wiley & Sons, Inc., New York,U.S.A.].

5- [Cant and R. Jacquemin, (1990):"the Environmental Behavior of Radium" Volume I, IAEA, Vienna].

6- [Amrani D. Tahta M (2001): "An on-belt elemental analyser for the cement industry", Appl. Radiat.and Iso.; 54: 687].

7- [Beck, H.L, Decampo, J., and Gogolak, C., (1972): "In situ Ge(Li) and NaI(Tl) Gamma-ray Spectrometry", New York: US Dos. Environmental Measurement Laboratory, Hasl-258].

8- [UNSCEAR, (2000): "Sources and Effects of Ionizing Radiation", Report to General Assembly, with Scientific Annexes, United Nation, New York].

9- [Huy, N.Q., and Luyen, T.V., (2006): "Study on external exposure doses from terrestrial radioactivity in southern Vietnam". Radiat.Prot.dosimetry.V.118, pp.331-336].

10- [OECD, Organization for Economic Cooperation and Development, (1979): "Exposure to Radiation from Natural Radioactivity in Building Materials". Report by a Group of Experts of the OECD Nuclear Energy Agency, OECD, Paris].

11-[Krieger, R., (1981): "Radioactivity of construction materials", Betonwerk. Fertigteil-Technol. 47, 468]

12- [Beretka, J., Mathew, P.J., (1985): "Natural Radioactivity of Australian Building Materials Industrial Waste and Byproducts". Health Physics 48, 87-95].

13-[Cottens, E., (1990): "Actions against radon at the international level". In: Proceedings of the Symposium on SRBII, Journee Radon, Royal Society of Engineers and Industrials of Belgium, 17 January 1990, Brussels].

14-[Harb, S., 2008: "Natural radioactivity and external gamma radiation exposure at the coastal Red Sea in Egypt". Radiation Protection Dosimetry Vol.130, No.3, p 376-384].

15-[Sam, K. A., Ahmed, M. M.O., El-Khangi, F.A., Nigumi, Y.O., Holm, E., 1998: "Radioactivity levels in the Red Sea coastal environment of Sudan". Marine Pollution Bulletin 36, p 19–26].

16-[Seddeek, M.K., Badran, H.M., SharShar, T. and Elnimr, T., 2005: "Characteristics, spatial distribution and vertical profile of gamma-ray emitting radionuclides in the coastal environment of North Sinai". Journal of Environ Radioactivity 84, p 21-50].

17-[Noureddine, A., Baggoura, B., Hocini, N., Boulahdid M., 1997: "Uptake of radioactivity by marine surface sediments collected in Ghazaouet, west coast of Algeria". Applied Radiation and Isotopes Vol. 49 No. 12, p 1745-1748].

18- [Vassas, C., Pourcelot, L. Vella, C., Carpe´na, J., Pupin, J.-P., Bouisset, P. and Guillot, L. 2006: "Mechanisms of enrichment of natural radioactivity along the beaches of the Camargue, France". Journal of Environmental Radioactivity 9, p 1146-159].

19- [Tsabarisa, C., Eleftherioub, G., Kapsimalisa, V., Anagnostoua, C., Vlastoub, R., Durmishic, D., Kedhid, M., and Kalfase, C.A., 2007: "Radioactivity levels of recent sediments in the Butrint Lagoon and the adjacent coast of Albania". Applied Radiation and Isotopes 65, p 445–453].

20- [Örgün, Y., Altınsoy, N., Şahin, S.Y. Güngőr, Y., Gűltekin, A.H., Karahan, G. and Karacık, Z., 2007: "Natural and anthropogenic radionuclides in rocks and beach sands from Ezine region (Çanakkale), Western Anatolia, Turkey". Applied Radiation and Isotopes 65, p 739–747].

21- [Saad, H.R., Al-Azmi, D., 2002: "Radio activity concentrations in sediments and their correlation to the coastal structure of Kuwait". Applied Radiation and Isotopes 56, p 991-997].

22- [Veiga, R., Sanches, N., Anjos, R.M., Macario, K., Bastos, J., Iguatemy, M., Aguiar, J.G., Santos, A.M.A., Mosquera, B., Carvalho, C., Baptista Filho, M., Umisedo, N.K., 2006: "Measurements of natural radioactivity in Brazilian beach sands". Radiation measurements 41, p 189-196].

23- [Ligero, R.A., Ramos-Lerate, I., Barrera, M. and Casas-Ruiz, M., 2001: "Relationships between sea-bed radionuclide activities and some sedimentological variables". Journal of Environmental Radioactivity 57, p 7–19].

24- [Hashim, N.O., Rathore, I.V.S., Kinyua, A.O., Mustapha, A.O., 2004: "Natural and artificial radioactivity levels in sediments along the Kenyan coast". Radiation Physics and Chemistry 71, p 805-806].

25- [Karunakara, N., Somashekarappa, H.M. and Siddappa, K. , 2005: "Natural radioactivity in South West Coast of India". International Congress Series 1276, p 346–347].

26- [Mohanty, A.K., Sengupta, D., Das, S.K., Saha, S.K., Van, K.V., 2004: "Natural radioactivity and radiation exposure in the high background area at Chhatrapur beach placer deposit of Orissa, India". Journal of Environmental Radioactivity 75, p 15-33].

27-[Alam, M.N., Chowdhury, M.I., Kamal, M., Ghose, S., Ismal, M.N., 1999: "The 226Ra 232Th and 40K activities in beach sand minerals and beach soils of Cox's Bazar, Bangladesh". Journal of Environmental radioactivity 46 (2), p. 243-250]. 28- [Malain, D., Regan, P.H., Bradley, D.A., Matthews, M., Santawamaitre, T. and Al-Sulaiti, H.A., 2009: "Measurements of NORM in beach sand samples along the Andaman coast of Thailand after the 2004 tsunami". Nuclear Instruments and Methods A,[oi:10.1016/j.nima.2009.11.047]

29-[Strezov, A., Milanov, M., Mishev, P. and Stoilova, T., 1998: "Radionuclide Accumulation in Near-shore Sediments along the Bulgarian Black Sea Coast". Applied Radiation and Isotopes 49, 12, p 1721-1728].