International Journal of Engineering Innovation & Research
Volume 8, Issue 5, ISSN: 2277 – 5668

# Detection and Analysis of Radionuclides Accumulated in Soil of Cox's Bazar Sea Beach Area using Gamma Spectroscopy System

**Laila Zaman**
Ph.D Student, Physics Department, Jahangirnagar University Savar, Dhaka Bangladesh.
Corresponding author email id: laila_zaman13@yahoo.com

*Date of publication (dd/mm/yyyy): 27/09/2019*

***Abstract* – Shore areas of Bangladesh are a landform along the shoreline of the Bay of Bengal. Cox's Bazar is one of the most important tourist places. Every year a large number of visitors both local and foreigners come to visit sea-beach of Cox's Bazar for its attractive natural beauties. The particles comprising soil of the beach areas are full of pollutants which are transferred from sea to land and land to sea due to high tide or low tide. These pollutants may be the source of radio-nuclides having different half-lives. On the other hand, natural radio-nuclides accumulate in soil of beaches due to cosmic radiation, naturally occurring radioactive materials, man-made fallout from nuclear weapons testing and nuclear accidents. Whatever may be the sources of the radio-nuclides, they should be found out so that necessary actions can be taken to keep both visitors and local peoples of beach areas safe. The objectives of the research work was to investigate the radio-nuclides present in soil of sea- beach areas. This research work was carried out on some soil samples of sea-beach areas in the Accelerator Facilities Division of Atomic Energy Centre Dhaka. The gamma-ray spectroscopy system was used for the measurement of radioactivity. In this procedure HPGe detector was used with other experimental setup. The radio-nuclides $^{133}$Ba, $^{234}$Th, $^{212}$Bi, $^{124}$Sb, etc. were detected.**

***Keywords* – HPGe, MCA, Gamma-ray spectroscopy, Radionuclides, Pollution, Spectrum, Net Area.**

## I. INTRODUCTION

The ecosystem is a complex set of relationship between living (animals including human beings) and nonliving things (air, water, soil, plants, etc.). The deterioration of ecosystem of the shore areas has an adverse effect on human health resulting a major health problem [1,2]. Detectable amounts of radioactive elements occur naturally in soil, rocks, water, air and vegetation from which it is inhaled and ingested into the body. If the concentration of any radio-nuclide in the soil and water exceeds the permissible limit, it becomes harmful for environment and as well as living being [3]. It is therefore, essential to have detailed information of the presence of radionuclides of soil of the sea shore and adjoining land mass so that proper precaution can be taken. Gamma-ray spectroscopy is well established technique for determination of radionuclides.

Any type of contamination that occurs in the environment has one or more critical pathways between the point of release of pollutants and animals or plants. Soil is one of the most important elements of ecosystem, it plays an important role to animals and plants. It can be treated as one of the major pathways of any type of pollution.

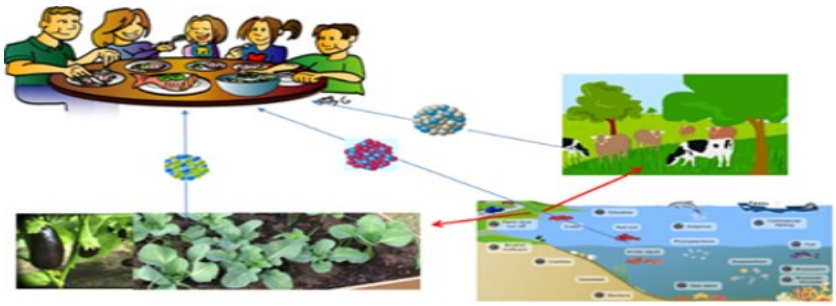

Fig. 1.1. Cyclic Effect of Pollution.

There are about 90 elements that occur naturally, among these 26 are essential for animal life. And 11 of them are major elements like carbon, hydrogen, oxygen, nitrogen, sulfur, calcium, phosphorus, potassium, sodium, chlorine, and magnesium and other 15 elements are known as trace elements. Most of the elements have one or more radio- nuclides with different half-lives. For example, the nuclides of iron are $^{54}Fe$, $^{55}Fe$, $^{56}Fe$, $^{57}Fe$, $^{58}Fe$, $^{59}Fe$, $^{60}Fe$, among them $^{55}Fe$ (half-life: 2.73 y), $^{59}Fe$ (half-life:44.6d), $^{60}Fe$ (half-life: 2.6x106 y) are radio-nuclides. All the radio-nuclides are harmful to animals and human health.

The objective of this research work was to find out the sources of radio-activity i.e., the presence of radio-nuclides in soils of sea adjacent areas. As soil of sea-beach area is adjacent to sea, the source of pollution may be sea water or others. Possible reasons of pollution of sea water as well as soil may be oil spills, mining and activities by other heavy industries, acid rain, agrochemicals, waste disposal, direct discharge of industrial wastes to the soil, etc. Any type of reason can be the source of radioactive nuclides which are harmful. A radioactive nuclide is unstable and emits continuously dangerous three kinds of ionizing radiation. The emission of ionizing radiation or particles caused by the spontaneous disintegration of atomic nuclei is called radioactivity which is responsible for cancer.

## II. Materials and Methods

### 2.1. *Sample Collection:*

For this research, soil samples were collected from some shore areas of Cox' Bazar. Sites for soil samples were selected as near sea water, populated areas (about 500 m away from beach), cultivated areas (about 1km away from beach). Samples were collected from different depths.


Fig. 2.1. Map of Cox' Bazar sea-beach.

For collecting samples, some steps were followed, such as separate small plastic containers were cleaned well and numbered 1, 2, 3 ... etc. Going to the selected areas, soil was collected using a spatula one by one. Each time the spatula was washed properly.

Fig. 2.2. Sea-beach area.

## 2.2. *Gamma-ray Spectroscopy System*

In this study, the radio-nuclides were detected using gamma-ray spectroscopy system. For this, HPGe detector was used with data acquisition setup. Gamma spectroscopy is the most important tool to study properties of excited nuclei and to determine decay schemes and explore nuclei with respect to nuclear models. In nuclear technology it is one of the basic methods for identification of radionuclides. At present, about 270 stable and more than 2000 unstable i.e. radioactive nuclides are available. In any nuclear research, it is necessary to identify radionuclides which are present alone or in a mixture. Gamma spectroscopy is a suitable technique for this purpose. It is used to detect and analyze gamma-rays to produce a gamma-ray spectrum which is the characteristic of the gamma-emitting nuclides available in the sample. The spectrum of gamma is discrete and it's analysis is used to determine the identity of gamma emitters present in a gamma source.

### 2.2.1. *Basic Parameters of Gamma Spectroscopy System*

The basic parameters involving Gamma-ray spectrometry system are:

- High purity germanium detector (HPGe) [Model GC12175].
- High voltage power supply (3.5 keV) [Model 3106D, CANBERRA].
- Liquid nitrogen ($N_2$).
- Pre-amplifier [Model 2002 CSL].
- Spectroscopy Amplifier [Model 672, ORTEC].
- A Multi-Channel Analyzer (MCA) [Model 919 E, ORTEC].

The block diagram of the gamma–ray spectroscopy detection system is shown in Figure: 2.3.

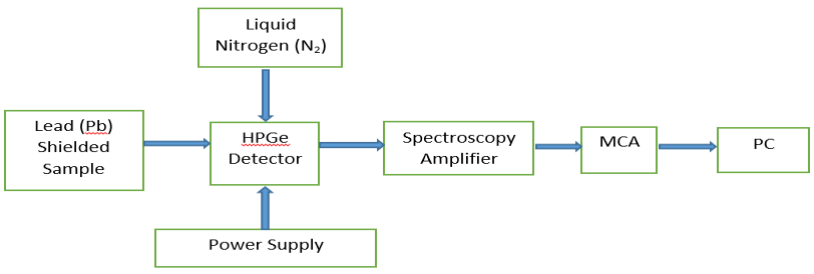


Fig. 2.3. Block diagram of the gamma–ray spectroscopy detection system.

The detector is connected to a charge-sensitive preamplifier in which the primary charge pulses are converted into voltage pulses. The output-voltage is proportional to the input charge. The pulses are amplified up to a range of 1-10 V in the spectroscopic amplifier. The incoming pulses are recognized by the multichannel analyzer which evaluates the pulses with respect to their height (voltage). These voltages contain the information about the energy and sorts them into consecutive pulse-height channels. As a result a pulse-height spectrum is found which contains the energy information of all recognized gamma quants. Each measured gamma quant is a count in the corresponding energy channel of the multichannel analyzer. The mean pulse heights correspond to the energy of the gamma quants. The required high voltage is fed to the gamma detector via the preamplifier. Gamma-ray spectroscopy system is shown in Figure: 2.4.

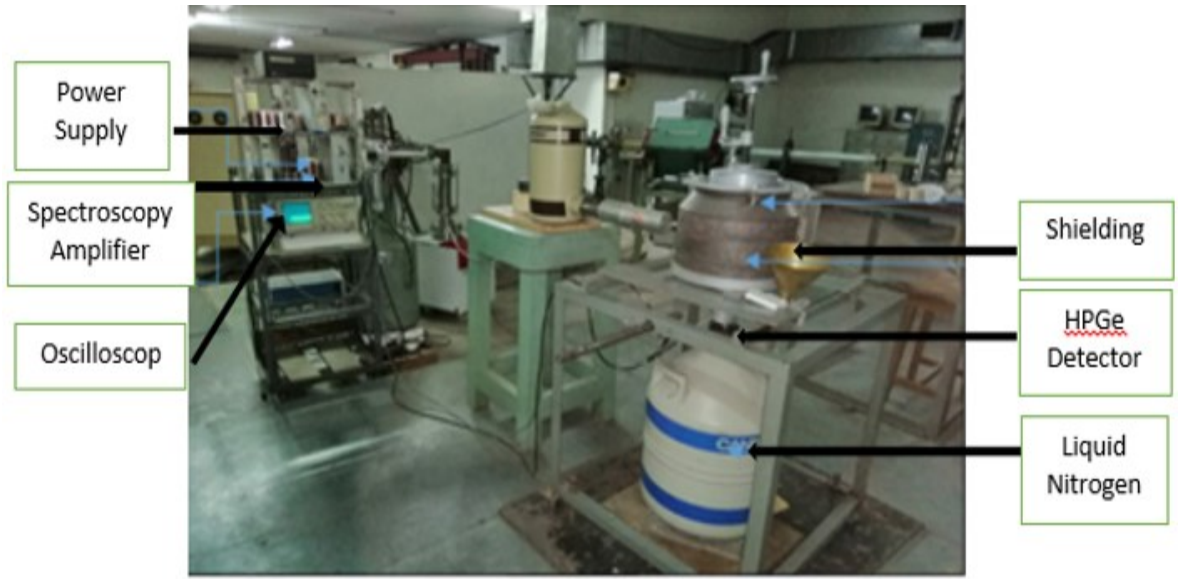


Fig. 2.4. Gamma-ray spectroscopy system.

### 2.2.2. *High Purity Germanium (HPGe) Detector*

For this work, HPGe detector was used. In detectors, ionizing radiation produces charge carriers (free electrons and holes) in the detector material. The number of electron-hole pairs is proportional to the energy of the radiation emitted to the semiconductor. In this case, a number of electrons are transferred from the valence band to the conduction band, and an equal number of holes are created in the valence band. Under the influence of an electric field, electrons and holes travel to the electrodes, where they result in a pulse that can be measured in an outer circuit. The energy required to produce electron-hole-pairs for HPGe detector is about 3 eV, which is dependent on the energy of the incident radiation. So it is possible to determine the intensity of the incident radiation by measuring the number of electron-hole pairs [4]. The electrons that are excited to the conduction band by photon interactions are excited thermally. This type of excitation produces a statistical noise background. To minimize this noise, the detector is to be operated at reduced temperature, normally at 77 K.

### 2.2.3. *Set-up Calibration*

Energy calibration of detecting system is performed to get a relationship between peak position in the spectrum and the corresponding γ-ray energy. It is performed by measuring spectrum of γ-ray with known energy of a source and comparing the measured peak position energy. In this study $^{137}$Cs source was used for energy calibration. Energy level of this source was known accurately.

### 2.2.4. *Background Radiation*

Background radiation is a measure of the ionizing radiation present in the environment at a particular location which is not due to radiation sources. All radiation detectors record some background signal due to cosmic radiation that bombard the earth's atmosphere and existence of natural radioactivity in the environment. For the present work with HPGe detector, the background effect was an important problem. To minimize the influence of background radiation, the gamma detector was surrounded by a radiation shielding made of lead. In this case, background counts were taken for the best results.

### 2.2.5. *Data Acquisition and Radionuclide Detection*

By using MAESTRO-32 Software, the gamma energy spectrum of the radio-nuclides can be observed on the screen of the pc, directly evaluated or saved. The detection of any unknown radionuclide was done from the list of Commonly Observed Gamma energies. As all radionuclides have a unique decay scheme, a definite detection was possible.

## III. RESULTS

In this research work, different radio-nuclides were detected for different soil samples. For this paper, table and spectrum for calibration, background and six samples in beach areas (for different depths and locations) are given.

Table. 1. For calibration.

| **Measured gamma energy Eγ [keV]** | **Possible Nuclides** | | **Half-life** |
|---|---|---|---|
| | **Eγ [keV]** | **Nuclides** | |
| 660.13 | 661.66 | $^{137}$Cs | 30.17 years |

Spectrum: - 1 - For calibration

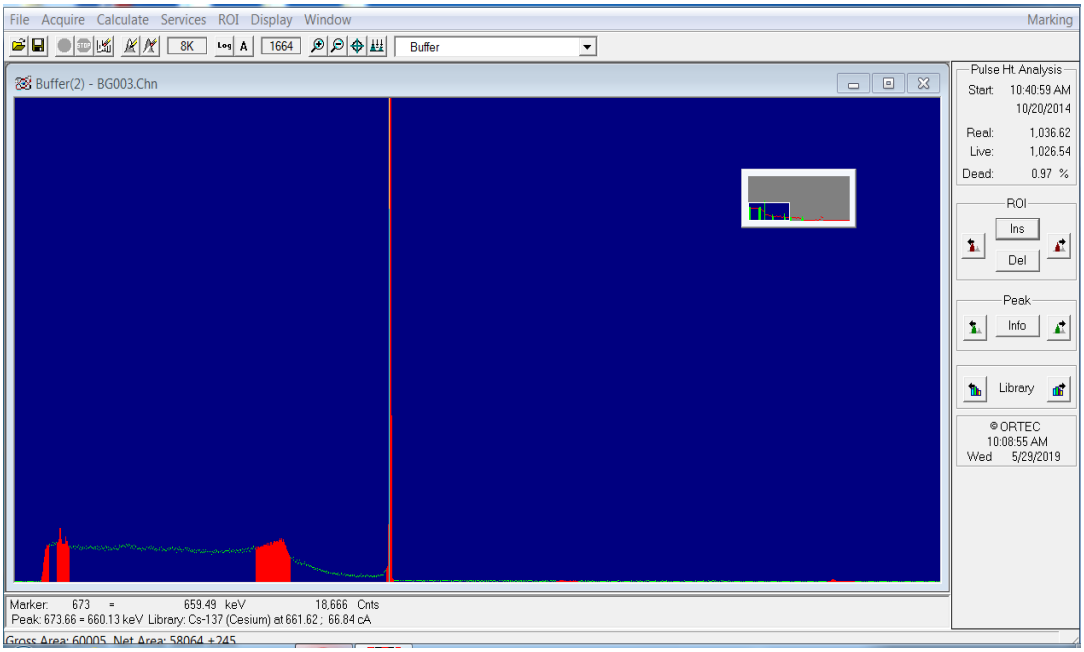

Table 2. For Background radiation.

| Measured gamma energy Eγ [keV] | Possible Nuclides | | Net Area of the Spectrum | Half-life |
|---|---|---|---|---|
| | Eγ [keV] | Nuclides | | |
| 79.90 | 80.1 | $^{144}$Ce | 1223 ± 178 | 284.6 years |
| 512.07 | 511.0 | $^{108}$Ag | 541 ± 60 | 2.39 months |
| 583.49 | 583.1 | $^{208}$Tl | 281 ± 53 | 183 seconds |
| 609.56 | 609.3 | $^{214}$Bi | 413 ± 53 | 19.9 months |
| 821.03 | 818.7 | $^{116}$In | 45 ± 37 | 54.2minutes |
| 907.78 | 911.1 | $^{228}$Ac | 267 ± 40 | 6.15 hours |
| 965.07 | 964.0 | $^{152}$Eu | 177 ± 38 | 13.48years |
| 1425.54 | 1434.1 | $^{52}$V | 48 ± 25 | 3.76months |
| 1464.37 | 1460.8 | $^{40}$K | 83 ± 23 | 1.28x10$^{9}$ years |

Spectrum: 2 - For background radiation

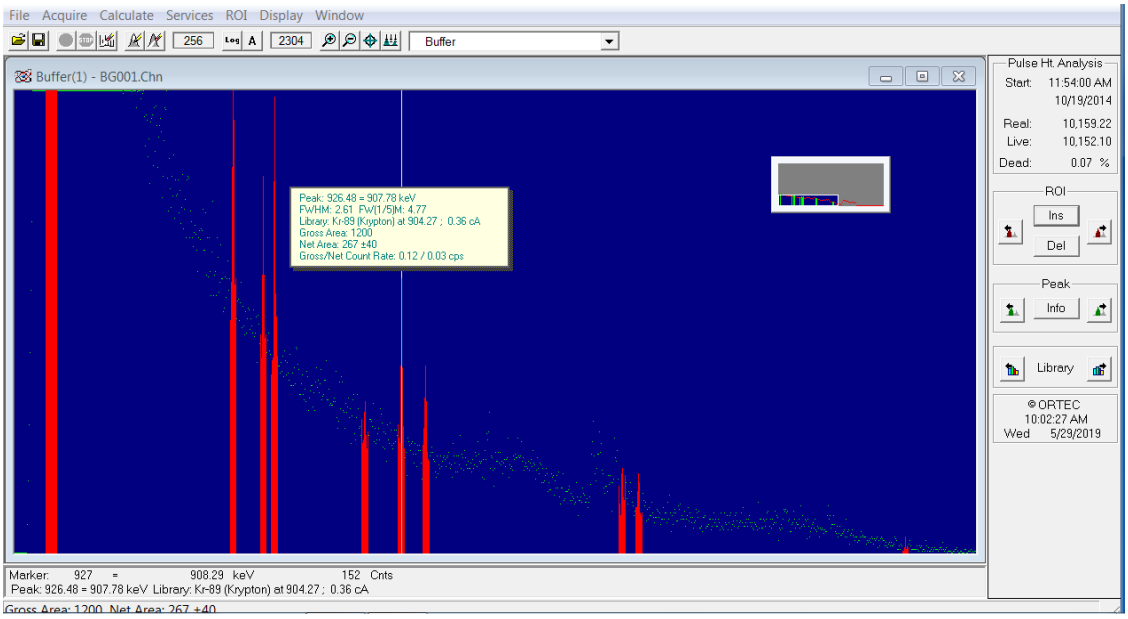


Table 3. For soil sample-1 (Location-Beach area, high-tide, depth: 30 cm).

| Measured gamma energy Eγ (keV) | Possible nuclides | | Net Area of the Spectrum | Half-life |
|---|---|---|---|---|
| | Eγ (keV) | Nuclides | | |
| 79.33 | 79.1 | $^{108m}$Ag | 488 ± 118 | 130 y |
| 242.99 | 244.7 | $^{152}$Eu | 68 ± 53 | 13.48 y |
| 354.21 | 356 | $^{133}$Ba | 53 ± 45 | 10.53 y |
| 512.44 | 511 | $^{108}$Ag | 358 ± 40 | 2.39 m |
| 582.99 | 583.1 | $^{208}$Tl | 139 ± 36 | 183 s |
| 609.44 | 609.3 | $^{214}$Bi | 151 ± 35 | 19.9 m |
| 907.31 | 911.1 | $^{228}$Ac | 375 ± 35 | 6.15 h |
| 1341 | 1368 | $^{124}$Sb | 110 ± 14 | 60.2 days |

Spectrum: 3- For soil sample-1 (Location-Beach area, high-tide, depth: 30 cm)

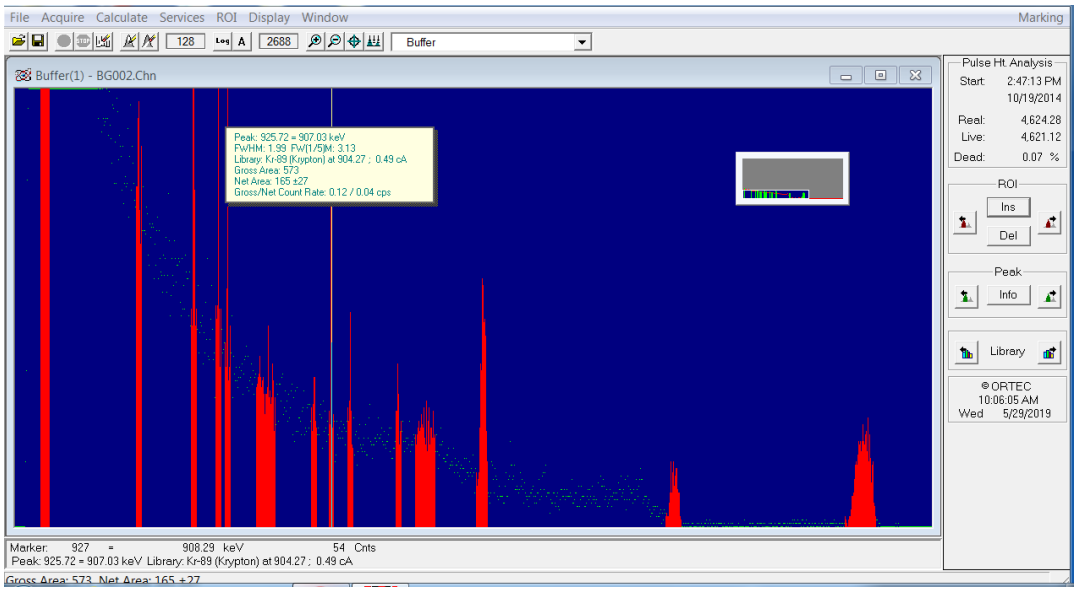


Table 4. For soil sample-2 (Location-Beach area, low-tide, depth: 30 cm).

| Measured gamma energy Eγ (keV) | Possible nuclides | | Net Area of the Spectrum | Half-life |
|---|---|---|---|---|
| | Eγ (keV) | Nuclides | | |
| 81.22 | 81 | $^{133}$Ba | 1508 ± 153 | 10.53 y |
| 512.77 | 511 | $^{108}$Ag | 692 ± 49 | 2.39 m |
| 583.23 | 583.1 | $^{208}$Tl | 299 ± 42 | 1.83 s |
| 610.62 | 609.3 | $^{214}$Bi | 485 ± 43 | 19.9 m |
| 726.1 | 727.2 | $^{212}$Bi | 112 ± 33 | 60.6 m |
| 908.11 | 911.1 | $^{228}$Ac | 375 ± 34 | 6.15 h |
| 965.84 | 964 | $^{152}$Eu | 182 ± 32 | 13.48 y |

Spectrum: 4- For soil sample-2 (Location-Beach area, low-tide, depth: 30 cm)

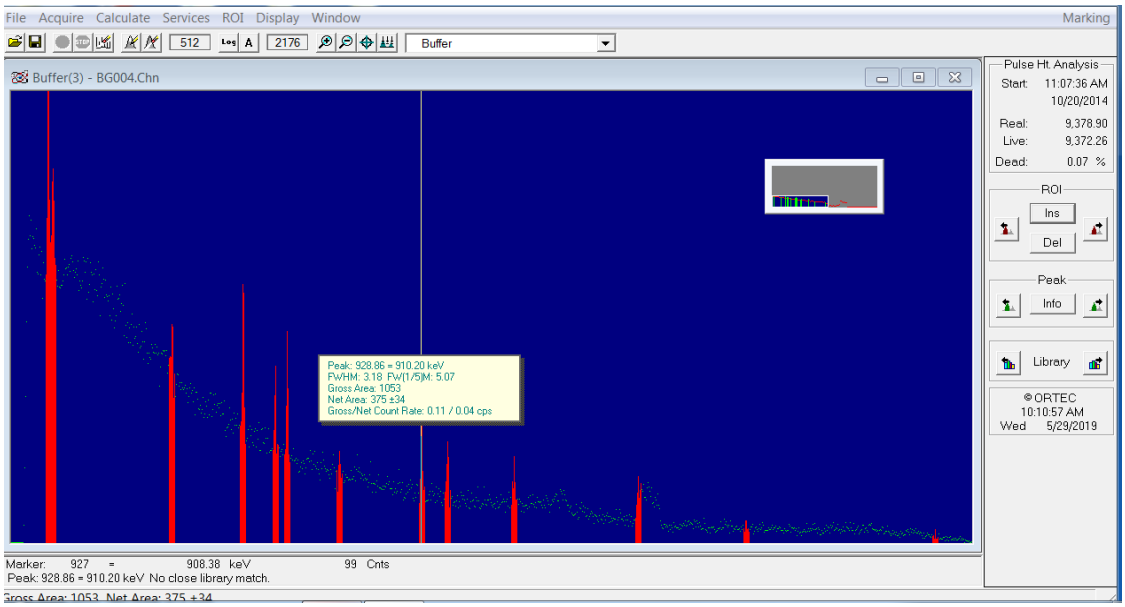

Table 5. For soil sample-3 (Location-Beach area, low-tide, depth: 30 cm).

| Measured gamma energy Eγ (keV) | Possible nuclides | | Net Area of the Spectrum | Half-life |
|---|---|---|---|---|
| | Eγ (keV) | Nuclides | | |
| 79.88 | 80 | $^{144}$Ce | 742 ± 121 | 284.6 days |
| 30.46 | 35.5 | $^{125}$Sb | 345 ± 46 | 2.758 y |
| 241.83 | 241 | $^{226}$Ra | 196 ± 51 | 3.66 days |
| 355.21 | 356 | $^{133}$Ba | 13 ± 30 | 10.53 y |
| 512.03 | 511 | $^{108}$Ag | 419 ± 40 | 2.39 m |
| 583.62 | 583.1 | $^{208}$Ti | 168 ± 35 | 183 s |
| 609.39 | 609.3 | $^{214}$Bi | 375 ± 35 | 19.9 m |

Table 6. For soil sample-4 (Location-1 km away from beach area, depth: 30 cm).

| Measured gamma energy Eγ (keV) | Possible nuclides | | Net Area of the Spectrum | Half-life |
|---|---|---|---|---|
| | Eγ (keV) | Nuclides | | |
| 241.63 | 241 | $^{226}$Ra | 229 ± 71 | 3.66 days |
| 353.6 | 352 | $^{214}$Pb | 258 ± 62 | 26.8 m |
| 510.6 | 510.8 | $^{208}$Tl | 818 ± 57 | 183 s |
| 581.91 | 583.1 | $^{208}$Tl | 495 ± 48 | 183 s |
| 607.68 | 606.6 | $^{125}$Sb | 580 ± 49 | 2.758 y |
| 724.85 | 725.2 | $^{114}$In | 116 ± 39 | 49.51 days |
| 855.52 | 860.4 | $^{208}$Tl | 106 ± 34 | 183 s |
| 906.13 | 911.1 | $^{228}$Ac | 514 ± 38 | 6.17 h |
| 963.43 | 964 | $^{152}$Eu | 242 ± 35 | 13.48 y |
| 1228.42 | 1221.4 | $^{182}$Ta | 83 ± 29 | 114.43 days |
| 1441.98 | 1435.8 | $^{138}$La | 598 ± 49 | 1.05 X 10 y |
| 1553.68 | 1507.4 | $^{116}$In | 206 ± 84 | 54.2 m |

Table 7. For soil sample-5 (Location-25 km away from beach area, depth: 30 cm).

| Measured gamma energy Eγ (keV) | Possible nuclides | | Net Area of the Spectrum | Half-life |
|---|---|---|---|---|
| | Eγ (keV) | Nuclides | | |
| 68.28 | 69.7 | $^{153}$Gd | 228 ± 88 | 241.6 days |
| 135.33 | 136 | $^{75}$Se | 126 ± 81 | 119.78 days |
| 149.02 | 148.6 | $^{241}$Pu | 57 ± 161 | 14.4 y |
| 171.28 | 176.3 | $^{125}$Sb | 104 ± 80 | 2.758 y |
| 209.19 | 209 | $^{67}$Ga | 214 ± 187 | 3.260 d |
| 220.24 | 222.1 | $^{182}$Ta | 30 ± 77 | 114.43 d |
| 244.83 | 244.7 | $^{152}$Eu | 229 ± 751 | 13.48 y |

| Measured gamma energy Eγ (keV) | Possible nuclides | | Net Area of the Spectrum | Half-life |
|---|---|---|---|---|
| | Eγ (keV) | Nuclides | | |
| 513.65 | 511 | $^{108}$Ag | 952 ± 153 | 2.39 m |
| 585.58 | 583.1 | $^{208}$Tl | 319 ± 52 | 183 s |
| 611.16 | 609.3 | $^{214}$Bi | 643 ± 52 | 19.9 m |
| 728.28 | 725.2 | $^{114m}$In | 71 ± 40 | 49.51 d |
| 794.94 | 795.8 | $^{134}$Cs | 168 ± 38 | 2.065 y |
| 909.35 | 911.1 | $^{228}$Ac | 449 ± 41 | 6.15 h |
| 1426.11 | 1434.1 | $^{52}$V | 13 ± 30 | 3.76 m |
| 1445.98 | 1435.8 | $^{138}$La | 299 ± 30 | 1.05 X 10 y |
| 1851.81 | 1836.1 | $^{88}$Y | 16 ± 18 | 106.6 days |
| 2655.37 | 2677.9 | $^{88}$Rb | 269 ± 62 | 183 s |

Table 8. For soil sample-6 (Location-beach area, low-tide, depth: 30 cm).

| Measured gamma energy Eγ (keV) | Possible nuclides | | Net Area of the Spectrum | Half-life |
|---|---|---|---|---|
| | Eγ (keV) | Nuclides | | |
| 32.37 | 35.5 | $^{125}$Sb | 218 ± 44 | 2.758 y |
| 512.84 | 511 | $^{108}$Ag | 394 ± 37 | 2.39 m |
| 583.98 | 581.1 | $^{208}$Ti | 134 ± 31 | 183 s |
| 610.37 | 609.3 | $^{214}$Bi | 159 ± 31 | 19.9 m |
| 725.82 | 725.2 | $^{114m}$In | 56 ± 25 | 49.51 days |
| 908.16 | 911.1 | $^{228}$Ac | 212 ± 24 | 6.15 h |
| 965.27 | 964 | $^{152}$Eu | 133 ± 24 | 13.48 |

## IV. Discussion

Table-1 and Table-2 show the data for calibration and background counts respectively. Their spectrum have been shown also. Table-3 toTable-8 show the data for different soil samples collected randomly from different locations of sea-beach area. Spectra have been shown for sample-1 and sample-2. Different radio-nuclides have been detected. Each data represent the half-life and respective net area of the spectrum.

## V. Conclusion

The source of the above radio-nuclides may be the sea water or any other natural disasters. Radiations are emitting continuously from these type of radio-nuclides which are harmful for local peoples and visitors. These type of research should be continued.

## Acknowledgement

I would like to extend my profound sense of gratitude to my thesis supervisor, co-supervisor, all officers and staffs of AECD (Accelerator Facilities Division of Atomic Energy Centre, Dhaka, Bangladesh).

## REFERENCES

[1] "Pollution - Definition from the Merriam-Webster Online Dictionary". Merriam-webster.com. 2010-08-13. Retrieved 2010-08-26.
[2] Beil, Laura (15 November 2017). "Pollution killed 9 million people in 2015". Sciencenews.org. Retrieved 1 December 2017.
[3] Carrington, Damian (October 20, 2017). "Global pollution kills 9m a year and threatens 'survival of human societies'". The Guardian. Retrieved October 20, 2017.
[4] Knoll, G.F. (1999). Radiation Detection and Measurement (3rd ed.). Wiley. ISBN 978-0-471-07338-3. p 365.

## AUTHOR'S PROFILE

**Laila Zaman,** Lecturer of Physics department at Mohammadpur Preparatory School and College, Dhaka has completed M.Sc from thesis group with Nuclear Physics from Rajshahi University, Rajshahi achieving first class. She has also obtained first division in both SSC and HSC examination. Later she has done M.Phil in Medical Physics from Bangladesh University of Engineering and Technology, Dhaka and currently doing PhD in Physics under Jahangirnagar University. As a part of PhD course, a paper has already been published titled "Elemental Analysis of Soil Samples of Coxs' Bazar Sea beech area using PIXE techniques" in April 2016 through International Journal of Innovative Research in Advanced Engineering, Volume 3, Issue 4.

**Dr. S.M. Azharul Islam,** Professor, Physics department of Jahangirnagar University has completed M. Sc. in Physics from Jahangirnagar University. He has done PhD in Reactor Physics from Jahangirnagar University. His field of specialization includes Experimental Nuclear Physics and Reactor Physics (Health Physics, Radiation Shielding and Protection, Medical Physics). He has been awarded Commonwealth Staff Scholarship for higher Studies in Physics and Technology of Nuclear Reactors for a M.Sc. degree at the University of Birmingham, England, U.K. in 1983-85. He has also been awarded Bangladesh University Grants Commission Research Fellowship for higher studies leading to Ph.D. degree in 1990-92.

**Dr. Md. Joynal Abedin,** Chief Scientific Officer of Bangladesh Atomic Energy Commission has completed B. Sc. in Engineering from Islamic University of Technology (IUT). He has done PhD in Physics from Jahangirnagar University. Dr. Abedin is involved in research using IBA Methodology.