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A case study of environmental gamma radiation measurements: West Kirby Beach, River Dee Estuary

Adekunle Job *

Department of Physics Oliver Lodge Laboratory, University of Liverpool, Oxford Street Liverpool L69 7ZE United Kingdom.

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Abstract

The current on-site evaluation of environmental contamination is examined. This is achieved by using soil samples taken from three points at West Kirby beach in the River Dee Estuary. This site is chosen because it is a tidal area in close proximity to the nuclear facilities at Sellafield, Windscale, and Calder Hall (which are all near Seascale, Cumbria). Sellafield is a former nuclear power station that closed in 2004 and now a nuclear reprocessing site, whilst Windscale and Calder Hall are both nuclear power plants undergoing decommissioning. This case study examines whether there is evidence to show that possible wash off of radioactive substances via the neighbouring rivers Calder and Ehen enter the sea and may then be washed along the nearby coastline. The samples collected were analysed with the aid of gamma spectrometry using high purity germanium (HPGe) detectors, this included both BEGe, and N-type detectors. Two natural occurring decay chains were observed, Th-232 and the U-238 series. Observed radionuclides included Ac-228, Pb-212, Bi-212 and Tl-208 and Pb-214, Th-234 and Bi214 for Th-232 and U-238 respectively, although with a very low activity level in both cases which might not be unconnected to their short half-lives that are either in days or in minutes. Two artificial radionuclides (Am-241 and Cs-137) were detected in some of the collected samples. Am-241 was present in only a few of the samples and with very low activities of ≤ 0.023Bq/kg. Cs-137 was present in almost all of the samples irrespective of the depth or point of collection, also with a low level of activity of ≤0.029Bq/kg. The most obvious activity detected was that of the naturally occurring radionuclide K- 40, with a recorded activity level of about 0.4Bq/kg. The discovery of K-40 may be due to its presence in rocks and from the use of fertilizers by farmers, which could have subsequently washed off into the river system. However, there are also other radionuclides detected which include, Eu-152 with half-life 13.537 years, Y-88 with half-life of 106.65 days, etc., Eu-152 is a member of the lanthanide series which are rare earth metals that can be found in exploitable ore deposit whilst the Y-88 is the most stable radioisotope of natural Yttrium with Y-89 being the only isotope, though in their lowest activity levels.

Keywords: BEGe Detector; N-Type Detector; P-Type Detector; Fitz peaks; Prospect; Soil Samples

1. Introduction

Radiation is present in the environment as a result of both human activities and also by natural occurring phenomenon. The release of radioactive material from nuclear facilities or installations is one of the major causes of man-made radioactive contamination of the environment. Once discharged into the atmosphere, long ranged atmospheric mechanical transport processes can lead to widespread contamination. However, it can originate from a point, as in the case of an accident, or from waste that is washed by flood from a nuclear site, particularly in coastal regions. (Taira et al., 2013). Furthermore, Radionuclides are mainly conveyed by attachment to soil particles or aerosol particles and the weather conditions, for instance snow, rain and wind are more likely to play a major role in conveying radionuclides. This is mainly along the coastal areas where nuclear facilities are built. In this sense, it is assumed that certain parts of radionuclide deposit on the surface soil whilst others are conveyed beneath the ground. Therefore, Radionuclide analysis of environmental samples is very relevant for the judgment of recent environmental radioactivity levels

* Corresponding author: Adekunle Job

(Shimura et al., 2012). Two notable examples are the cases of Chernobyl and Fukushima. Amidst manmade radionuclides, mainly 90Sr and 137Cs are tagged as a main danger to organisms, as a result from the uncommon combination of relative half-lives of 29.12yrs for Sr-90 and 30.14yrs for Cs-137 and their metabolic and chemical properties which closely resemble calcium and potassium respectively (Franic et al., 2007).

This report will equally show how the sample analysis is carried out; from the sampling stage, which has to do with sample collection procedure, the preparation (purification) stage to the analysis stage, using detection means such as high pure germanium (HPGe) detector. It also demonstrates how samples were analyzed, that is the ones with non-background subtraction and those with background subtraction using manual procedures.

This experimental work was carried out to determine the level of activity of radionuclides, especially the long-lived nuclides, for safety purposes in the Northwest of England taking West Kirby beach as a case study because of its coastal link with rivers around a former Nuclear site (Sellafield ltd).

2. Study Area and Sample Description

The samples were collected from a particular point, West Kirby beach on the river Dee estuary, which is a tidal coastal area in the Northwest of England. From the beginning of the beach toward the main river, I counted 295 to 300 paces whilst walking; this was tagged as the high-water mark area and the site sample labeled SAMPLE. sample was collected with a 50 cm long and 10cm diameter cylindrical plastic pipe with the help of a sledgehammer to drive in the pipe into the soil and digging out with a shovel. The pipe for the SAMPLE was damaged by bedrock in the soil, as a result of this only samples from 0cm to 30cm were collected.

2.1. Samples Preparation

Therefore, in order to remove any possible variation that might be due to evaporating moisture, the samples were dried thoroughly in an electric oven for one week, after first putting them in paper films. Their sample label and depth were inscribed on each. Thereafter, the sample was grinned in a mug mortar with pestle before putting them in a Marinelli beaker, these beakers provide a more reasonable symmetrical sample detector geometry. In addition, all Marinelli beakers were weighed before and after adding content.

3. Sample Result

The average activities (Bq/kg) for each nuclide found in each spot were calculated manually as shown in table 1 (a and b) and figure 1 (a and b), for sample.

Table 1 (a and b) and figure 1 (a and b), below gives the variations in specific activity with depth for the detected and measured radionuclides for the sample . The most conspicuous level measured in this area was from a naturally occurring singly nuclide, K-40. Others measured are naturally occurring chains of Th-232 and U-238.

Table 1(a) Average activity (Bq/kg) for SAMPLE (Non-Background Subtraction) BEGe Detector

Nuclide	**Depth in cm**	**Activity Concentration (Bq/kg)**	
	SampleA1(0-10cm)	**SampleA2(10-20cm)**	**SampleA3(20- 30cm)**
Ac-228	1.31E-02	1.79E-02	2.29E-02
Am-241	5.34E-04	1.86E-03	*
Bi-212	1.39E-02	1.90E-02	3.44E-02
Bi-214	6.18E-02	6.48E-02	6.93E-02
Cs-137	8.34E-03	2.40E-02	1.44E-02
Eu-152	5.08E-03	5.60E-03	7.19E-03
K-40	3.71E-01	3.72E-01	3.71E-01
Pb-212	5.40E-03	1.11E-02	1.33E-02
Pb-214	1.19E-02	1.48E-02	1.54E-02

Th-234	*	*	3.45E-02
Tl-208	5.11E-03	1.64E-02	6.34E-03
U-235	*	*	*
*not detected			

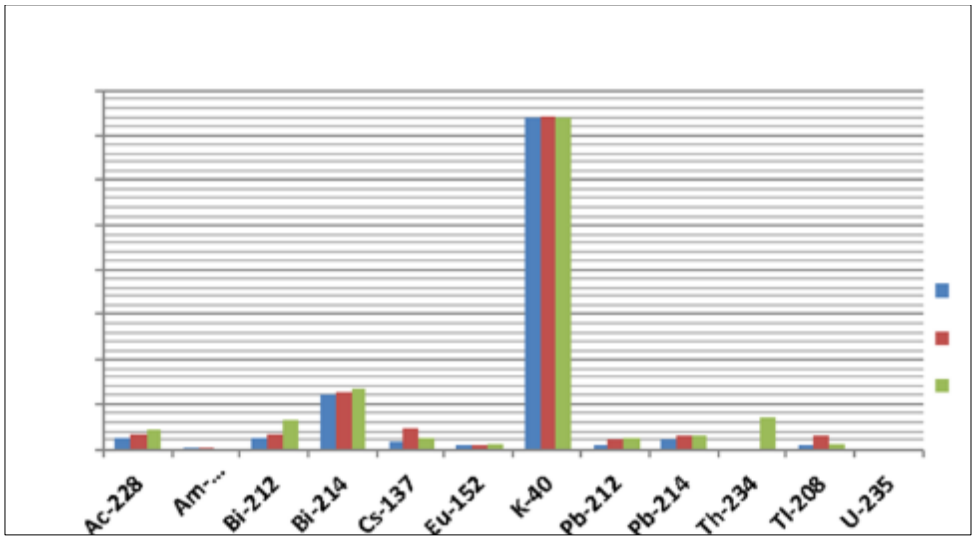

Figure 1 (a) Non-Bkg Subtarction

Table 1 (b) Average activity (Bq/kg) for SAMPLE (With Background Subtraction) BEGe Detector

Nuclide	**Depth in cm**	**Actvity Concentration (Bq/kg)**	
	SampleA1(0-10cm)	**SampleA2(10-20cm)**	**SampleA3(20- 30cm)**
Ac-228	1.04E-02	1.47E-02	2.13E-02
Am-241	5.34E-04	1.86E-03	*
Bi-212	1.39E-02	1.90E-02	3.44E-02
Bi-214	1.18E-02	2.17E-02	2.34E-02
Cs-137	7.69E-03	2.34E-02	1.38E-02
Eu-152	5.08E-03	5.60E-03	7.19E-03
K-40	1.92E-01	2.04E-01	1.97E-01
Pb-212	5.40E-03	1.11E-02	1.33E-02
Pb-214	1.01E-02	1.32E-02	1.28E-02
Th-234	*	*	3.45E-02
Tl-208	1.41E-03	2.82E-03	2.75E-03
U-235	*	*	*
* not dtected			

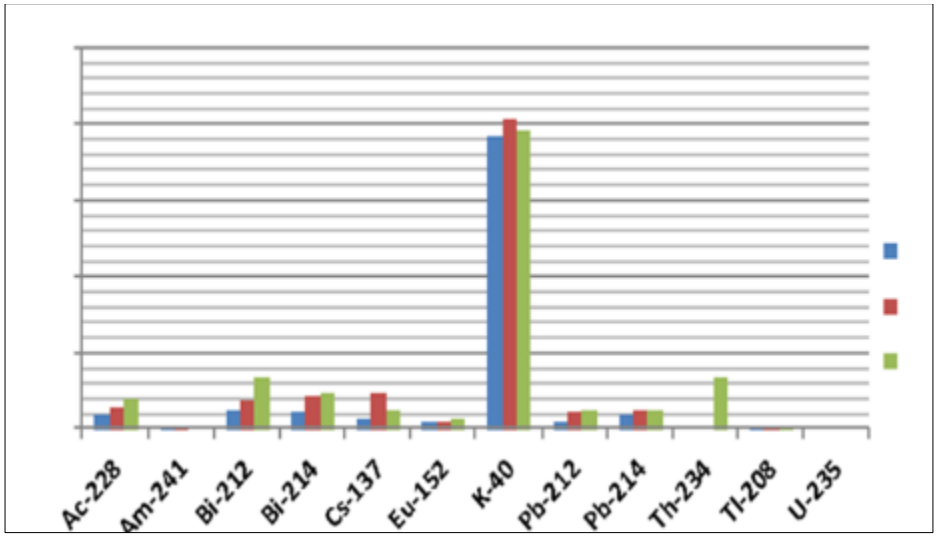

Figure 1 (b) With Bkg Subtraction

4. Discussion

The sample spot in West Kirby beach, River Dee estuary spot A is about 295 to 300 paces from the beginning of the beach, and taken during the summer. The sample was collected with a 50cm long pipe, and each pipe was divided into 5 depth section making 10cm depth for every sample, however we loss about 20cm of the pipe due to the broken part as a result of striking bedrock, in which only 3 sub samples were collected that is 0-10cm, 10-20cm and 20-30cm All samples were detected and measured using high purity germanium detector ((HPGe), lynx box and the computer software called Prospect.

The sample was processed in the detectors for about 24hours and data collected after calibration with a Europium-152-point source and efficiency carried out with a standard Marinelli source (NPRL 597) using best fit parameters obtained for the shaping and rise time using Cobalt-60. The spectra obtained from the detector for each sample were analyzed manually.

The majority of the nuclides found were naturally occurring nuclides of terrestrial origin that occur singly, the nuclides that occur in chains and the man-made radionuclides. The nuclide that occurs singly is the K-40 and the ones that occur in chains are Th-232 and U-238 series, which includes Ac-228, Pb-212, Bi-1212, Tl-208 for Th-232 and Pb-214, Th-234 Bi-214 for U-238 respectively. K-40 with average activity of around 0.3Bq/kg to 0.4Bq/kg has the most significant activity which is much higher than others that have average activities far less than 0.2Bq/kg. Others with not too significant activities seen were from both the U-238 and Th-232 series. The man-made nuclides, Cs-137 shows not too vital activity. While Am-241 could be tagged almost not present because of its low presence in certain depths

5. Conclusion

This research of environmental gamma using soil sample shows that the level of activity of Cs-137 and Am-241 are very low, given that for public protection, there is nothing to be afraid of going by the above discovered activities. In respect to the U-238 and Th-232 series they also show low activities. It should be noted that Uranium in the soil through phosphate fertilizer does not significantly affect the dose received by the general population. I hope this study will lead to further investigation of this area in West Kirby to further prove the low level of activities or possibly taken soil samples more deeper into the river or even at the island beyond the beach where people usually go for sightseeing.

Compliance with ethical standards

Disclosure of conflict of interest

This research was conducted in accordance with ethical standards for environmental sampling and radiological monitoring. All procedures involving the collection and handling of environmental samples adhered to applicable national and institutional guidelines. No human or animal subjects were involved in this study.

Disclosure of Conflict of Interest

The author declares that there is no conflict of interest regarding the publication of this manuscript.

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