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Determine Activity Concentration for the Soil Contaminated with Eu-152 Experimentally

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ABSTRACT

The aim of this work is to develop an equation that links the concentration of radiation activity measured practically with the radioactivity of radioactive waste which is measured theoretically.

The purpose is to develop a working methodology for the characterization of radioactive materials for drums containing waste which used for storage, transport and treatment of waste and the determine radiation dose rate which is necessary to protect workers. Characterization of drums containing radioactive waste by measuring them (without opening) provides general ease to determine the method of work and the necessities of radiation protection. A drum characterization system (gamma spectrometry) was used to characterize drums containing radioactive waste. The concentration of radiation activity was calculated by taking several models of radioactive waste (samples and drums) and describing them in the gamma analysis system.

Keywords: Gamma spectrometry, Activity concentration, Dose rate

INTRODUCTION

Characterization of the waste in drums to ensure safeguard purposes and to classify/transport/store [1]. The characterization of radioactive waste is an essential commitment in waste administration and shields [2].

Radioactive waste is often resulting from nuclear production processes, medical, research, Agriculture, Industrial or through the fusion of radioactive sources that are not subject to radiation control. All remaining waste is considered as a dangerous source of radiation contamination on the human body. Contaminated Soil is resulted by the existence of man-made processes or other changes in the natural soil.

Some reasons which cause soil contamination are:

•Strain of industrial waste into the soil

•Percolation of contaminated water into the soil

•Split of underground storage tanks

This study is to estimate and calculate the activity concentration of radioactive waste which generated from decontamination processes and put at special drums, through using gamma analysis spectrum system (Drums characterization system DCS) and Ludlum detector to measure dose rate on drums surface. Samples from drums were collected to be analyzed in order to measure the activity concentrations.

EXPERIMENTAL WORK

Safety assessment

Occupational exposures are incurred at work and principally as a result of working directly with radiation. Exposure to radiation from natural sources is generally excluded from occupational exposure, except when the exposure is a

direct consequence of a planned exposure situation. The application of the requirements for the system of protection and safety shall be commensurate with the radiation risks associated with the exposure situation [3].

Safety principles were taken in considered for this work by applying the principle of ALARA (radiation dose, measurement time and distance). At the research work, the measurement time was determined (in the drum characterization system DCS) and thus the calculation of the radiation dose received for the workers was estimated according to the following equation:

$$D_{Total} = D_I(\mathrm{N}^* t) \quad (1)$$

Where: D_{Total} is the total dose during the single activity, D is the average dose per drums, N is the number of drums, t is the measurement time for drum. The radiation dose received for the workers was found to be within the limits allowed by the International Atomic Energy Agency (IAEA) and International Commission on Radiological Protection [4].

Work methodology

The soil contaminated with ^{152}Eu radionuclides which set in drums is resulted from the decontamination site works. Drums characterization system (DCS) which provided with (Portable HPGE Hand-Held Radioisotope Identifier type MICRO-DET-PKG-1 (HX)) [5] used for characterization and identification of the radionuclides in the drums. The equipment (HPGE) provided with a neutron and GM detectors, GPS system and gamma vision version (6.8) software for gamma spectrum analysis. Energy Calibration of HPGe Detector, lessening coefficient for steel drums [6].

The dimensions of the drums are: height (90 cm), diameter (56 cm). The drums are made of iron with wall thickness 2 mm. The dose rate measured using Ludlum detector Model at the surface of the drums ranged between 103 and 5560 μR/h [7].

The strategy of this work:

1. 14 sample of soil from waste drum were taken, soil samples were dried for a sufficient period of time at a fixed temperature 80°C using electric oven. All samples are homogenized, then 0.5 kg of each sample in completely sealed Marinilli beaker was measured by Gamma spectrometry system (Table 1).
2. 12 drums contains contaminated soil were taken, these drums were characterized using Gamma spectrometry analysis method by determining activity for nuclide in contaminated soil (Table 2).
3. Dose rate on surface of drum (touch) were measured equation connected between calculated activity concentration and activity measure by DCS for waste drums (eq. 3) were found.

RESULTS AND DISCUSSION

For calculating activity concentration of contaminated soil equation 2 was used [8].

$$A_C = \frac{CPS}{I\gamma * \varepsilon * M} \quad (2)$$

Where: A_c is the concentration of the radionuclide in the sample (Bq. kg^{-1}), *cps* is the counts of the sample, I_γ is the

Table 1: Characterization of waste samples

Sample	Dose Rate (μRlh)	Activity Bq	cps	Calculated Activity Concentration (Bq/kg)
1	109	3033.34	9.04	7523.92
2	133	158320.6	426.28	354789.84
3	133	336.21	0.99	823.97
4	39	1833.33	5.12	4261.33
5	927	658.58	1.96	1631.296
6	685	1237.33	3.26	2713.27
7	695	311.59	0.92	765.70
8	785	6049	12.9	10736.57
9	1278	5110.8	14.00	11659.05
10	1845	7152	19.51	16246.02
11	2456	9351.6	25.45	21188.94
12	3200	12030	32.69	27207.82
13	870	3642	10.04	8358.38
14	1485	5856	16.02	13333.66

emission probability of a specific energy photo peak. M is the weight of the sample (kg); ε is the absolute efficiency of the detector. One can note the result of calculated concentration Table 1.

The dose rate by Ludlum radiation detector was measured through taking several points on the surface of all drums and then calculated the average for these measurements to determine safety assessment for worker.

Through the spectral analysis for contaminated soil at drums which characterized using germanium system, one can notice radionuclide Eu-152 (344) keV represented in Figure 1.

Relation between Activity Concentration (Bq/kg) and measured activity (Bq) of sample illustrated in Figure 2.

$$A_c = 2.4705 * A - 28.2 \quad (3)$$

Where: A_c is the activity concentration for the waste (Bq/kg). A is the activity of the waste at drum. Equation 3, which illustrates the relationship between activity for the waste in the drum and activity concentration for radioactive nuclides measured theoretically. Figure 3 shows the relationship between calculated activity concentrations (Bq/kg) (radioactive waste) placed inside the drums and activity (Bq) was measured in the drum characterization system.

Table 2: Database of radiological measurements of radioactive waste drums contaminated by Eu-152 nuclides

Sample	Dose Rate (µRlh)	Activity Bq	Activity concentration (Bq/kg)
1	103	2979.81	6649.57
2	920	3382.19	7551.30
3	228	1384.62	3074.75
4	325	2696.49	6014.65
5	135	470.50	1026.21
6	5560	11597.36	25961.50
7	650	3141.87	7012.73
8	730	3459.36	7724.24
9	458	2379.88	5305.123
10	320	1832.20	4077.77
11	830	3856.23	8613.62
12	924	4229.29	9449.64

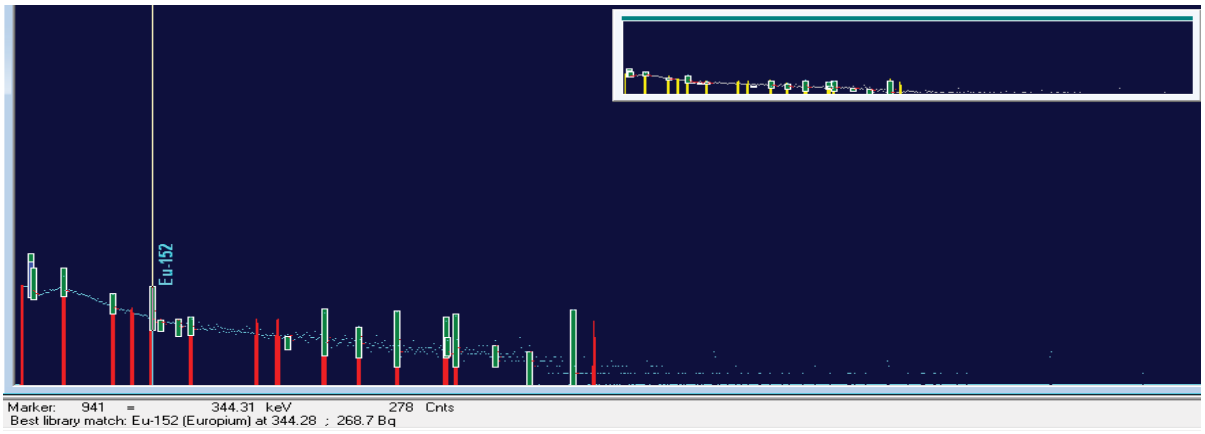

Figure 1: Represented the spectral analysis for soil contaminated with radionuclide Eu-152 (344) keV putted at drums (standard sample)

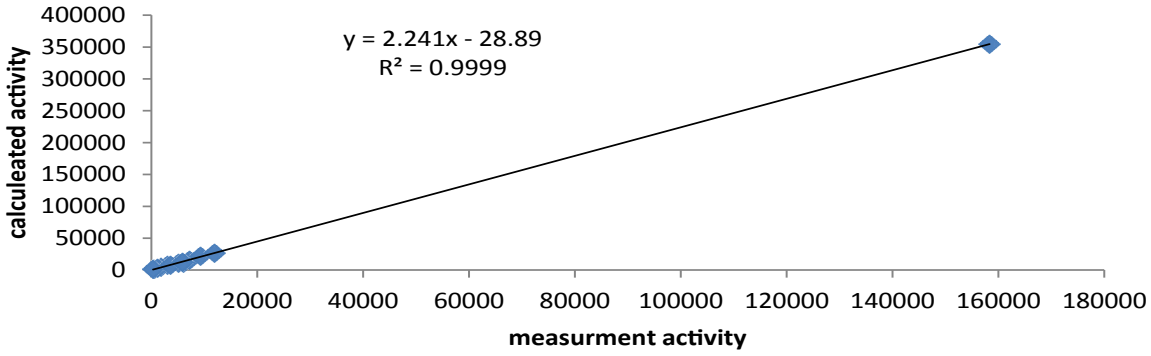

Figure 2: Relation between activity concentration (Bq/kg) and measured activity (Bq) of sample

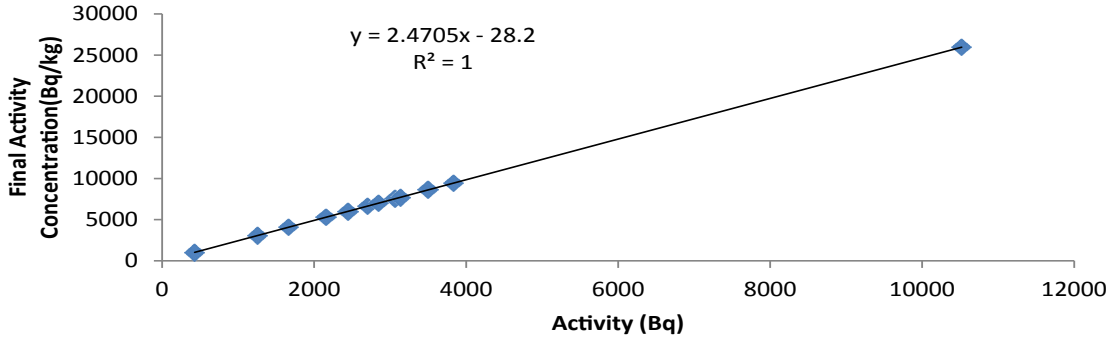

Figure 3: Relation between activity concentration (Bq/kg) and measured activity (Bq) in the DCS of waste at drums

CONCLUSION

Good correlation was found between the results of the two techniques for activity concentration and activity of the waste and one can show the result of measured activity by DCS without open the drum and then using equation (3) to calculate real activity concentration.

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