Preparation of Standard Source as a Petri Dish for Plant by Using ^{152}Eu Element

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Abstract

Observed in the recent period, there is an urgent need to a prepare standard sources can be adopted in the research Iraqi universities and scientific Institutions, whether if these measurements for large sizes samples such as Marinelli beaker , or small sizes such as a petri dish and the latter was not available as standard sources, which was the purpose of this work to prepare standard source with size of a petri dish for plants using ^{152}Eu Isotope , that can be adopted in the experimental measurements.The prepared sample was measured in the first lab (Department of physics/ college of education for pure science/Ibn Al-Haitham/University of Baghdad) and the second lab (Central Laboratories Directorate / nuclear research center at Tuwaitha) by using Gamma spectroscopy system with a high-purity germanium detector (HPGe). The specific activity of the prepared standard sample was calculated using an efficiency curve , which drawn by using the Monte Carlo Program . The results of the specific activity are equal to (1167.610Bq/kg) in first lab and (1081.94 Bq/kg) in second lab. It was noted there is good agreement between the results in the first and second lab, so the overall average of the specific activity adopted was equal to (1124.7 Bq / kg)From this work, we can use this source to calculate the radioactivity for other radionuclide in small samples (plants), which is difficult to obtained in large quantities, through a calibration spectrum for efficiency and energy of this prepared source.

Keywords: petri dish, prepare standard source, Gamma spectroscopy, activity, HPGe, Plant.

1. Introduction

Gamma-ray reference sources are an essential accessory in any radiation measurements laboratory in which gamma-ray measurements are carried out. They normally consist of samples of radioisotopes of a few micro-curies (around lo^5 Bq) encased in plastic disks or rods. Although the radiation hazard of such sources is minimal, the gamma-ray emission rate is sufficiently high to permit ready energy calibration of most types of gamma-ray detectors. If the sources are to be used to carry out accurate efficiency calibration, their absolute activity must also be known. [**1**]

In gamma-ray spectroscopy with germanium detectors, the pulse height scale must be calibrated in terms of absolute gamma-ray energy if various peaks in the spectrum are to be properly identified. In many routine applications, the gamma rays expected to appear in the spectrum are well known in advance and the corresponding peaks can readily be identified by inspection. Accurate calibration should involve a standard source with gamma-ray energies that are not widely different from those to be measured in the unknown spectrum.[**1**]

Criteria that enter into the selection of standards to be used for germanium spectrometer calibration have been reviewed by Kern.[**2**] When the ultimate precision is required, use of one of two primary standards is recommended: the tungsten K-α_1 X-ray (near 59 keV) or the ^{198}Au gamma-ray (near 411 keV).[**3**]

Some authors have also treated annihilation radiation (near 511 keV) as a primary standard, but its use in high-precision calibrations should be avoided. The observed line is always several keV wide due to finite momentum effects at the annihilation point and will also be shifted below the electron rest-mass energy (511.003 keV) by up to 10 eV. [**4, 5**]

Secondary gamma-ray standards more widely separated over the energy range. Other energy standards between 26 and 100 keV are discussed in Ref. [**6**], between 50 and 420 keV in Ref. 69, and between 400 and 1300 keV in Ref. [**7**].

Another method of extrapolation to higher energies (often called the cascade-crossover method) can be carried out if gamma rays from a cascade such as that illustrated in the sketch below are involved.[**1**]

For the example of the ^{60}Co spectrum shown in Fig. (1), the simultaneous detection of the 1.173 MeV and 1.332 MeV coincident gamma ray photons leads to a sum peak at 2.506 MeV that can also be used in the energy calibration of the detector.[**1**]

Many of the national standards laboratories will provide isotopes whose gamma-ray emission rates have been calibrated to a precision ranging from 0.5 to 2.0%. Single isotope sources provide a few well-separated gamma-ray peaks whose area can be determined by simple methods to calibrate the detector efficiency. If the energy scale must extend over a relatively wide range, multiple sources must be used, either sequentially or in combination. To aid in the calibration of large-volume samples, typically of water solutions or soil, a standard sample container called a Marinelli beaker has been specified that closely fits over the end cap of the detector crystal.[**8**]

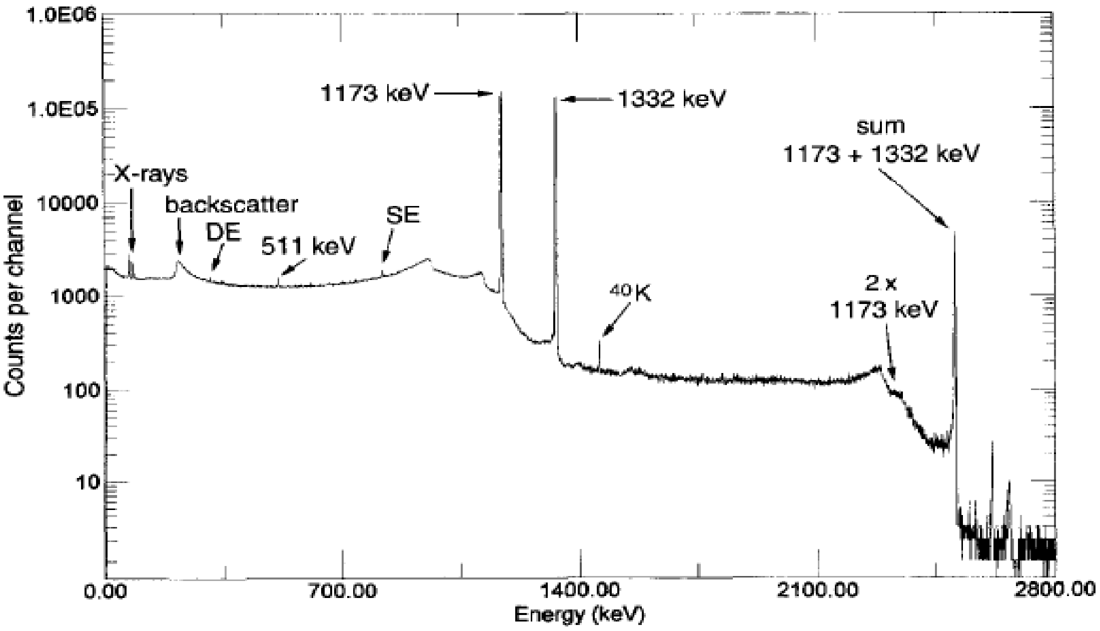


Figure 1. Pulse height spectrum from 1173 keV and 1332 keV gamma rays emitted by ^{60}Co measured using a p-type HPGe detector with 110% relative efficiency[**1**] .

Several standard sizes of Marinelli beakers are specified to accommodate samples of various volumes. Several authors suggest the use of ^{226}Ra in equilibrium with its decay products and provide tables of gamma-ray intensities per disintegration.These cover the energy range from 186 to 2448 keV and are particularly useful because a source of ^{226}Ra is often available in radioisotope laboratories.[**9-11**]

References 12 and 13 provide similar lists of gamma-ray intensities per disintegration for a number of other isotopes proposed for detector efficiency calibration. Of these, ^{152}Eu has gained popularity because of its convenient half-life (13.5 y) and the wide range of gamma-ray energies produced in its decay (as shown in the Table 1) [**12, 13**].

2. Material and Method

2.1. Preparation Standard Sample Method

1. 10ml of Hydrochloric acid (HCl) has been added with 0.1M to the container of the powder component of irradiated ^{152}Eu in order to convert it into a solution that could be dealt with it. This volume of HCl, which represents the largest possible size of the vial glass (container), has been chosen to reduce the radioactivity that can be withdrawn from this amount.
2. Shake up the container for the purpose of dissolving and homogeneity. It will leave for one hour and then reshaking to get a complete homogeneous solution.
3. The size of 5µl has been withdrawn by using the micropipette.
4. 1kg of powdered plant used in the present work has been sieved to get a complete homogeneity.
5. We add the withdrawn volume 5µl of the ^{152}Eu solution to 1kg of plant powders by distributing it on the surface of plant for the diffusion and the preparation of the initial ^{152}Eu powder.
6. The ^{152}Eu powder has been heating at a temperature of 100°C for two hours to evaporate any calcified liquid and for the deposition of Europium element to intervene into a plant powder.
7. The powder has been mixed for two hours, by using the mixer in order to get good homogeneity.
8. Petri dish containers have been filled and closed completely. The rest has been placed in plastic sealed containers.
9. After calculations and check the results; A label has been fixed to each container stating the name of the used radioactive element, its radioactivity and the date of manufacture.

2.2. Measurement Standard Sample

A. The gamma spectroscopy system in the lab.1 (College of Education for Pure Science / Ibn Al-Haitham / University of Baghdad) was calibrated for the energy by using ^{60}Co and ^{137}Cs isotope, then the spectrum of prepared standard sample (Petri Dish) was recorded . The system consist from multichannel analyzer computer card from (CANBERA) with integrated computer spectrometer version-2 software (ICS-PCI 4K)

Copyright 2003-2005, which analyses the spectrum in 4096 channels with a maximum count 16M , with primary and main amplifier, and (HPGe) detector (CANBERA-model 7229N, USA) with an efficiency of 40% is a high purity N-type semiconductor detector with physical characteristics of (geometry closed-end coaxial, 3×3 inch and operation voltage is (-3500V)). And Resolution 2.8 keV for the energy1.33MeV of ^{60}Co isotope , the (HPGe) detector is kept cold by immersing it in a liquid-nitrogen vessel at (-196°C) to reduce the leakage current to acceptable levels. The detector is surrounded by lead shield of about 10cm thickness to reduce the background radiation. The figure (2) showing the spectrum of the prepared standard sample , through which it was identified energies of Europium-152 and extract the net count for peak each energy .

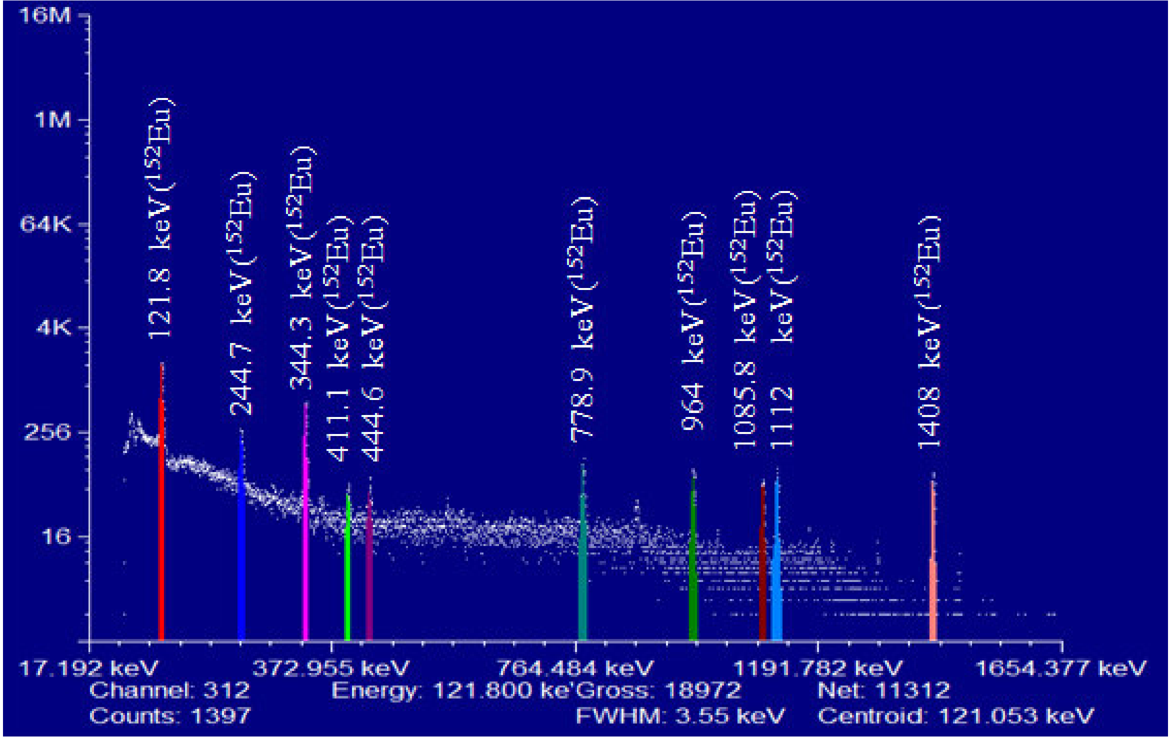


Figure 2. Spectrum of the prepared standard sample (petri dish) in the lab.1

B. The gamma spectroscopy system in the lab.2 (central laboratories / Nuclear Research Center at Tuwaitha / Ministry of Science and Technology), was calibrated for the energy by using multi-sources , then the spectrum of prepared standard sample (Petri Dish) was recorded. The system consists of a high purity germanium detector (HPGe), one of a detectors semiconducting material type (P-type) made by Canberra company, a model (GC4018) contains a crystal be of (Model 7500 SL) and be of a diameter (62mm) and length (60 mm) and the distance from the window (4.67mm). This detector works with operating voltage 4500 V and (efficiency) (≥40%) and Resolution (≤1.8 keV) for the energy 1.33 MeV (60Co) element. The (HPGe) detector is kept cold by immersing it in a liquid-nitrogen vessel at (-196°C) to reduce the leakage current to acceptable levels. The detector is surrounded by lead shield of about 10cm thickness to reduce the background radiation, The spectra of a personal computer analyst (PCA) made by Lenovo company, a personal computer equipped with electronic units is working on the receipt and the rating of the pulse coming from the amplifier according to capacity and then stored in the sites depends on capacity, and therefore showing in the form of a visual image on the personal computer screen . The used Program(Genie 2000 software / version 3.1), which is an integrated program for qualitative analysis and quantitative for gamma spectra to find the radioactivity of radionuclides emitting of the gamma rays of the sample .The figure (3) showing the Europium standard Source spectrum for the petri dish sample which registered by gamma spectroscopy system in central laboratories .

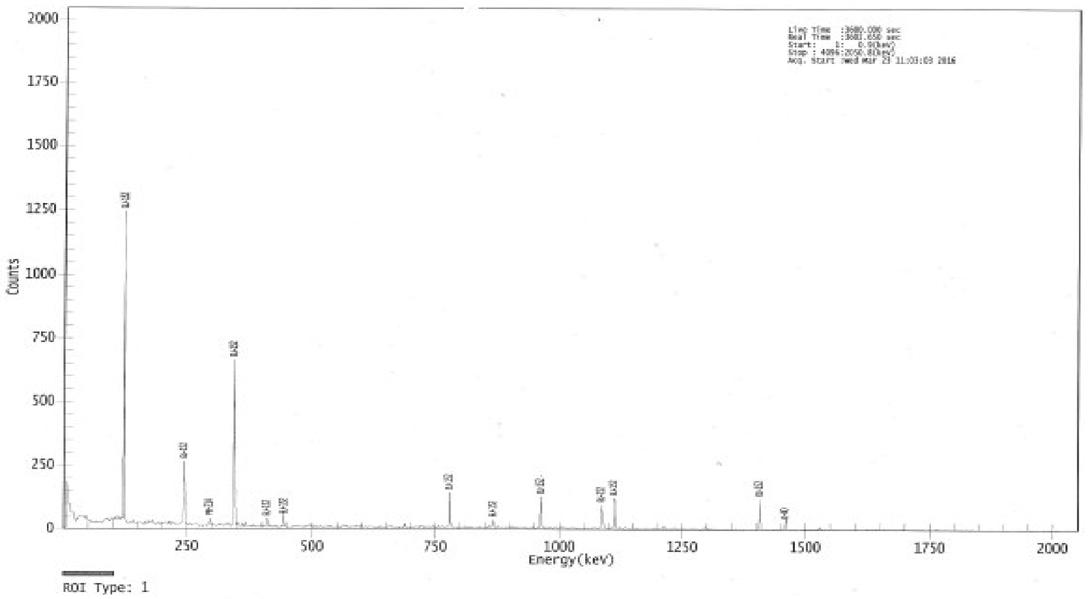
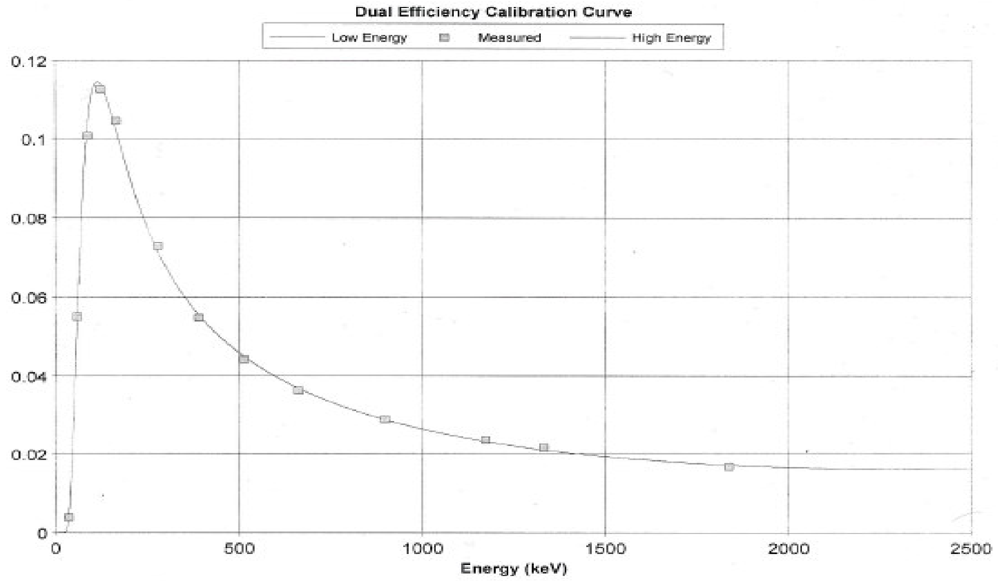


Figure 3. Spectrum of the prepared standard sample (petri dish) in the lab.2 .

C. The specific activity of the sample prepared was calculated by determining the efficiency value for each energy of the standard sample energies (Petri dish of plant) by using an efficiency curve, which has been drawn by using a program of Monte Carlo , as shown in figure (4).



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Datasource:  C:\2016\other\Eu standar Plant\23-3-2016 G050(1) pettry dish.CNF
ln(Eff)  = -3.509e+002    + 2.845e+002*ln(E)     - 9.215e+001*ln(E)^2  + 1.486e+001*ln(E)^3
                          - 1.196e+000*ln(E)^4  + 3.839e-002*ln(E)^5
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Figure 4. Efficiency curve, which has been drawn by using a program of Monte Carlo.

3. Calculations and Results

A. Through the efficiency curve equation , which has been drawn in program of Monte Carlo, efficiency values were extracted of each energy from the standard source energies (Europium-152) by using equation (1) as shown in table (1), which used in the two laboratories to calculate the specific activity of the standard sample.

$$\ln(\mathcal{E}) = -3.509 * 10^{2} + 2.845 * 10^{2} * \ln(E) - 92.15 * (\ln(E))^{2} + 14.86 * (\ln(E))^{3} - 1.196 * (\ln(E))^{4} + 3.839 * 10^{-2} * (\ln(E))^{5} \tag{1}$$

B. Through the spectrum, which has been drawn in the lab.1, the net area for each energy of the standard source the energies of Europium, was extracted as showing in the table (1), then calculated specific activity for each energy in the standard sample prepared (Petri dish) by using the following equation[**14**], then a calculation of the average as shown in table (2):

$$\text{S.A.} = \frac{N}{\varepsilon * I_\gamma * T * m} \qquad \textbf{(2)}$$

Where:
N: Net area of the standard source spectrum for Petri Dish sample , the measured in lab. (1) from the table(1).
ε: Efficiency values from the table (1).
m: Mass of the prepared sample (0.0295 kg).
T: Measurement time in lab. (1) (10800 Sec).
I_γ: Intensity of gamma energies of the standard source (^{152}E) .

Table 1. Efficiency, net area and intensity of the energies for standard sample.

No.	Energy (keV)	Iγ (intensity) **[15]**	Net area (for the spectrum in the lab.1)	ε (from eq.1)
1	121.8	0.2837	11312	0.121644
2	244.7	0.0751	2112	0.077389
3	344.3	0.2658	4262	0.056167
4	411.1	0.0223	336	0.047162
5	444.6	0.0312	435	0.043585
6	778.9	0.1296	1185	0.023811
7	964	0.1462	1071	0.018519
8	1085.8	0.1016	727	0.016032
9	1112	0.1356	894	0.015572
10	1408	0.2058	1094	0.01169

C. The results of the specific activity for each energy and the average in the lab. 2 (central laboratories / Nuclear Research Center at Tuwaitha) were reported, as shown in the table (2).

Table 2. Specific activity (S.A.) of the prepared standard sample in the lab.1 and lab.2 .

No.	Energy (keV)	S.A. (Bq/kg) in the lab. 1	S.A. (Bq/kg) in the lab. 2
1	121.8	1028.831	1029.43
2	244.7	1140.585	1084.09
3	344.3	896.0415	1170.25
4	411.1	1002.758	978.4
5	444.6	1004.038	888.27
6	778.9	1205.285	1037.5
7	964	1241.583	1143.9
8	1085.8	1400.890	1118.5
9	1112	1328.850	1313.2
10	1408	1427.239	1055.87
	Average	1167.610	1081.94

It can be seen that the average value of the specific activity of a prepared standard sample in the lab. 1 is an approach to the average value of the specific activity in the lab. 2. And the overall average is (1124.7 Bq/kg). The net weight of the plant in a petri dish is 29.5 gm , and thus the activity of the sample in a petri dish is as follows:

1124.7 Bq / kg X 0.0295 kg = 33.18 Bq

4. Conclusion

- The results of the specific activity in lab. 1 and lab. 2 for the prepared standard sample was convergent and the average for them is (1124.7 Bq / kg) and activity for Petri Dish container is (33.18 Bq).
- Can dependence on this source to calculate the radioactivity for other radionuclide in small samples (plants) are difficult to obtained in large quantities by get through a calibration spectrum for the efficiency and energy of this source.
- Can dependence on this method for the preparation of other standard samples with other shapes and sizes , such as those followed in the search for the model (Petri dish).

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