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Determining Ag in Rock Sample Using Gamma Detector and Some Different Spectral Techniques

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Abstract: The aim of this work is to examine the efficiency of a new gamma spectrometer assembled at Sudan university of science and technology using scintillation counter detector which detect backscattered gamma radiation emitted from the samples which are irradiated by two gamma sources Co^{60} and Cs^{137}. To examine the efficiency of this spectrometer , the spectrum of rock samples collected from Alobaidia at north Sudan states were displayed using cassy lab software program. The existence of silver was confirmed by displaying the spectrum of one standers made of pure silver and comparing the coincidence of their peaks with that of the rock samples. Further check was done by three other spectral techniques which are Atomic Absorption Spectrometer (AAS), Induced Coupled Plasma (ICP) and Energy Dispersive X-ray (EDX) The efficiency of these spectral techniques were also compared. The results indicated that Cs^{137} gamma spectra does not gives peak for Ag element, while the Co^{60} gamma spectra indicates existence silver radiation. The AAS, ICP and EDX techniques confirms the existence silver was confirms by EDX techniques only , while Ag appear in AAS only.

Keywords: Gamma Rays, Scintillation Counter, Cassy Lab, Rocks Samples

Introduction

Paul Villars is a French chemist and physicist, was discovered gamma radiation in 1900 while studying radiation emitted by radium. The decay of an atomic nucleus from a high energy state to a lower energy state, a process called gamma decay, produces gamma radiation. Gamma rays ionize atoms (they are ionizing radiation), and are thus biologically hazardous (Annunziata and Michael, 2017).

Human beings could be exposed to ionizing radiation through the emission of radionuclides in the contaminated rocks. The internal hazard requires the incorporation of radioactive materials into the body through ingestion or inhalation. Once incorporated, the radionuclides are distributed in the body and irradiate living tissues at close quarters by alpha, beta particle emission, and gamma photons. The doses vary depending on the concentrations of the natural radionuclides of Uranium thorium, their daughter products and potassium, present in the soils and rocks, which in turn depend upon the local geology of each region in the world. In recent time, there has been an increasing interest in the study of radioactivity in various soil, oil sludge and sand (Ahmad *et al.,* 2019).

Radioactivity can be explained as a result sources. All these Emissions are capable of ionizing air with different of spontaneous emission of Particles or rays resulted from nuclear fission. This indicates that the chemical Elements are not internally immutable and can be Trans formed in to one another by emitting such rays. The property of spontaneous emission of rays is known as radioactivity. Detailed investigations revealed that ,these spontaneously emitted Rays are of five kinds : alpha (α) particles, beta (β) particles, gamma (γ) rays, x-rays and neutrons which are considered recently as a radiation sources . All these Emissions are capable of ionizing air with different power. The ionizing power has been utilized in radioactivity measurements and other related phenomena. Most spontaneous radioactive nuclei decayed by emitting these rays, in addition to capturing an orbital electron (Sam *et al*., 2015).

Radioactive elements that are presented in the environment can be classified into three groups according to their origin: territories, Cosmo genic and man-made. The territories radionuclides include the three primordial actinide Parent nuclides, ^{238}U , ^{232}Th and ^{235}U and their respective decay products and the long-lived primordial nuclides of elements coexisting in the environment with stable counter parts. The important members in this latter category include ^{40}K and A unique feature of the three Primordial nuclides and their respective decay products is that each independent decay (Abubakr, 2017).

Naturally occurring radioactive materials (NORM) existing in soil could pose potential health risk especially if assisted by natural processes such as weathering, deposition and wind erosion. NORM can be found in many geological formation and may be brought to the surface during Oil and Gas drilling and abstraction .Human beings are exposed outdoors to the natural terrestrial radiation that originates predominantly from the upper 30cm of the soil (Narayana *et al*., 2017). Elevated radon and gamma exposures in dwellings are known to be caused primarily by enhanced concentrations of naturally occurring radionuclide in building materials and soil. The use of soil as building material could therefore cause radiation exposure to man due to inhalation of gaseous daughters of Uranium and thorium decay series in the indoor air. It can also lead to an external exposure due to gamma radiation from the primordial radio nuclide present in the soil (Isirikaye and Shitta, 2018).

Materials and Methods:

Rocks samples were collected from various types which are showing high radiation background. These samples were collected from alobaidia north Sudan state.

The samples after prepared were examined in the laboratories of the Sudan University of Science and technology research lab by means of the assembled gamma spectrometer, using cassy lab computer program. The assembled gamma spectrometer consists of a scintillation counter which act as a gamma detector beside a Co^{60} and Cs^{137} gamma source which excite samples as shown in figure (1).

A cassy lab program unit plugged with multi-channel and laser consist of programs that are attached to computer together with the detector, so as to convert detector signal into visual spectrum displayed on the computer screen.

Quantification of radionuclide present in rocks samples were obtained through accurate energy. The multi-channel analyzer (MCA) was calibrated so as to display gamma photo peaks in the applied energy range for radionuclide of interest identified with reliable regularity. The counting time was 100 s; the numbers of channel used was 256 and applied voltage 0.77kV. Each sample was placed between the detector and source of Co^{60} or Cs^{137} respectively. The energy spectrum versus number of events was determined. Also the number of events versus number of channel was found.

Figure (1) Experimental work Setup.

Results

Results of Gamma Detector

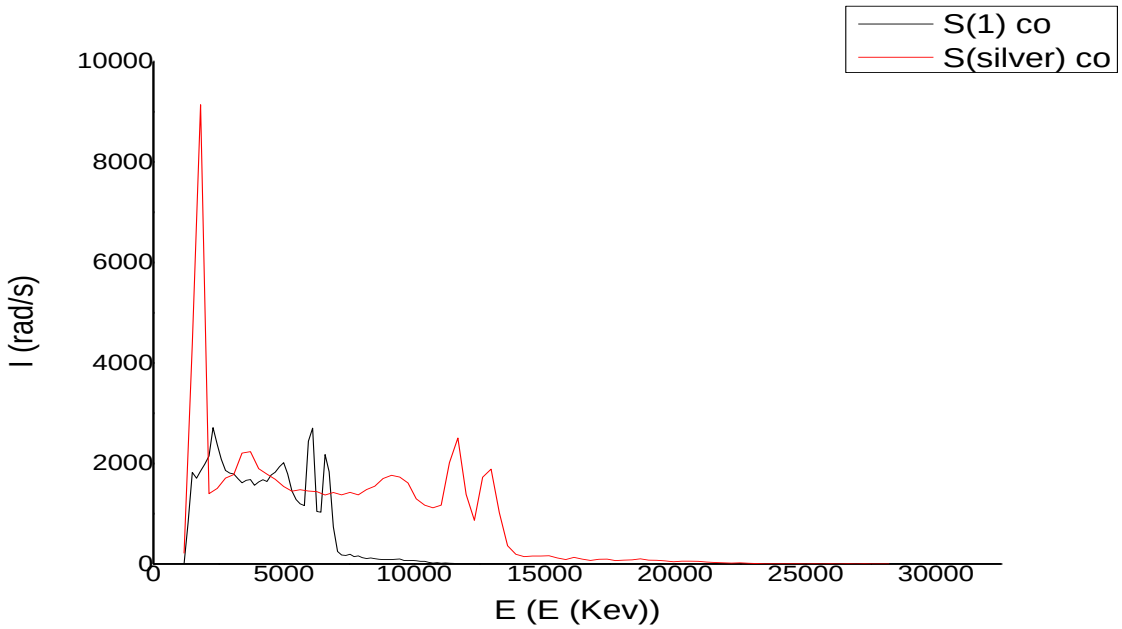

Figure (2) stander Silver sample with sample one irradiated with Co^{60}

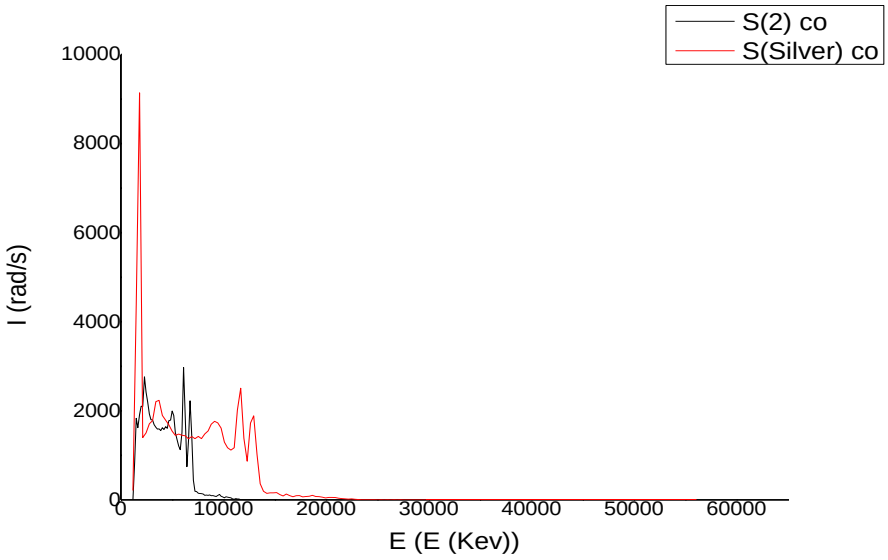

Figure (3) stander Silver sample with sample two irradiated with Co^{60}

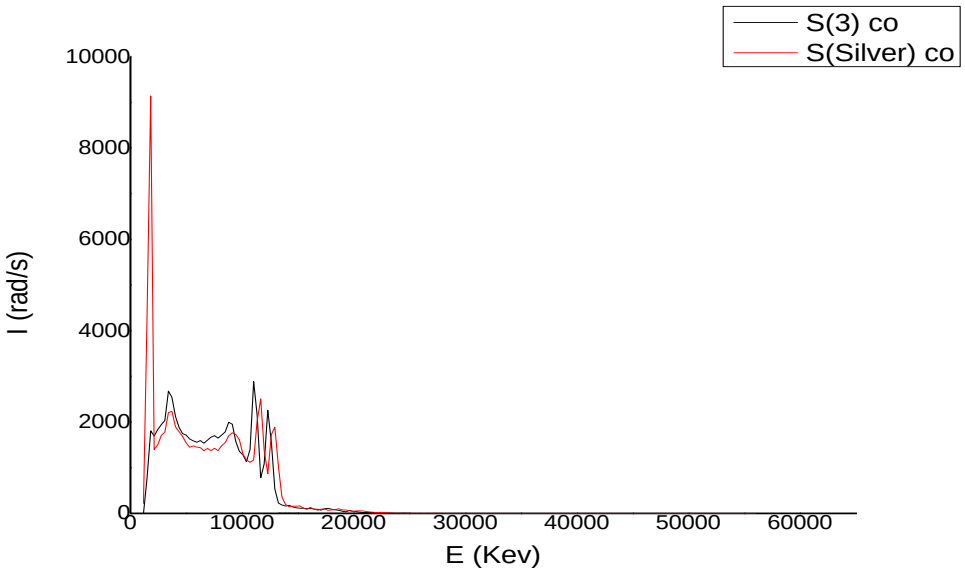

Figure (4) stander Silver sample with sample three irradiated with Co^{60}

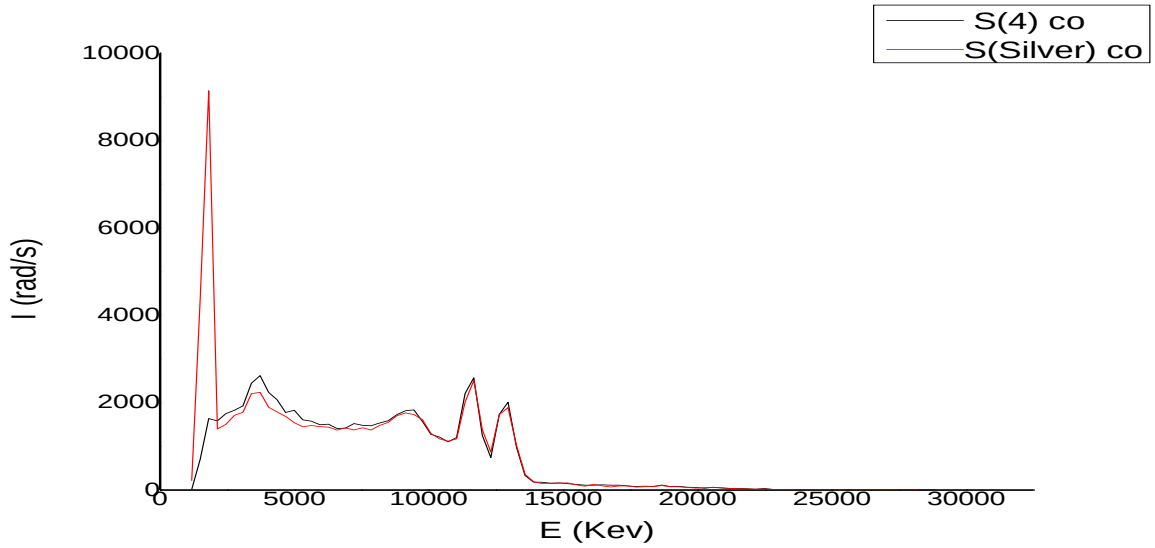

Figure (5) stander Silver sample with sample four irradiated with Co^{60}

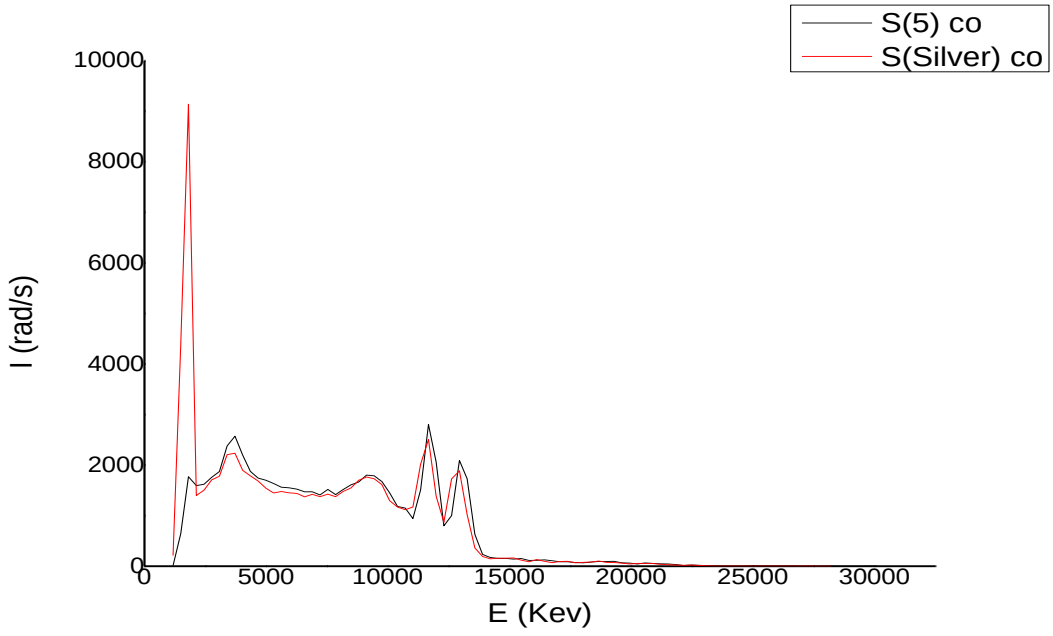

Figure (6) stander Silver sample with sample five irradiated with Co^{60}

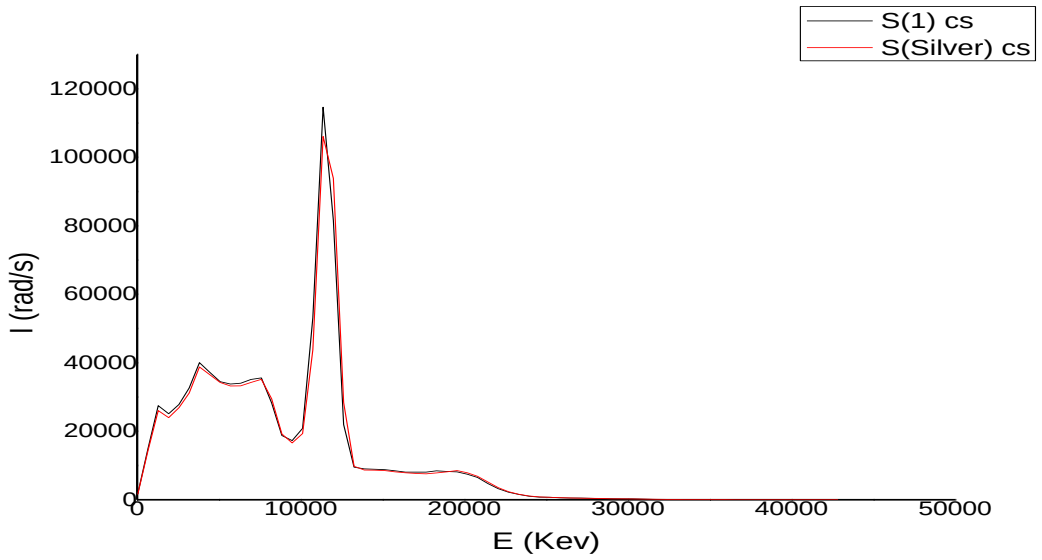

Figure (7) stander Silver sample with sample one irradiated with Cs^{137}

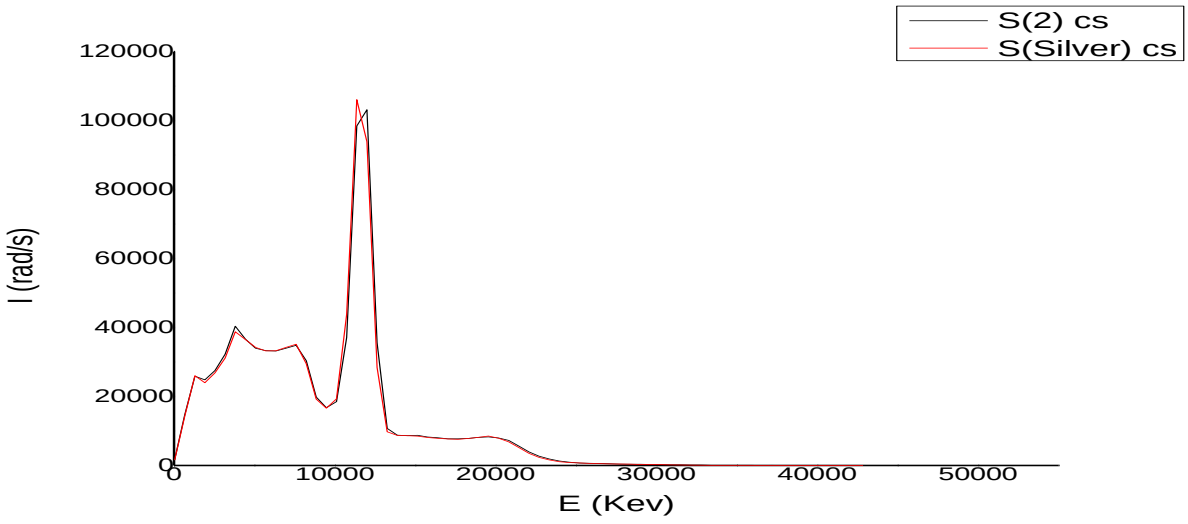

Figure (8) stander Silver sample with sample two irradiated with Cs^{137}

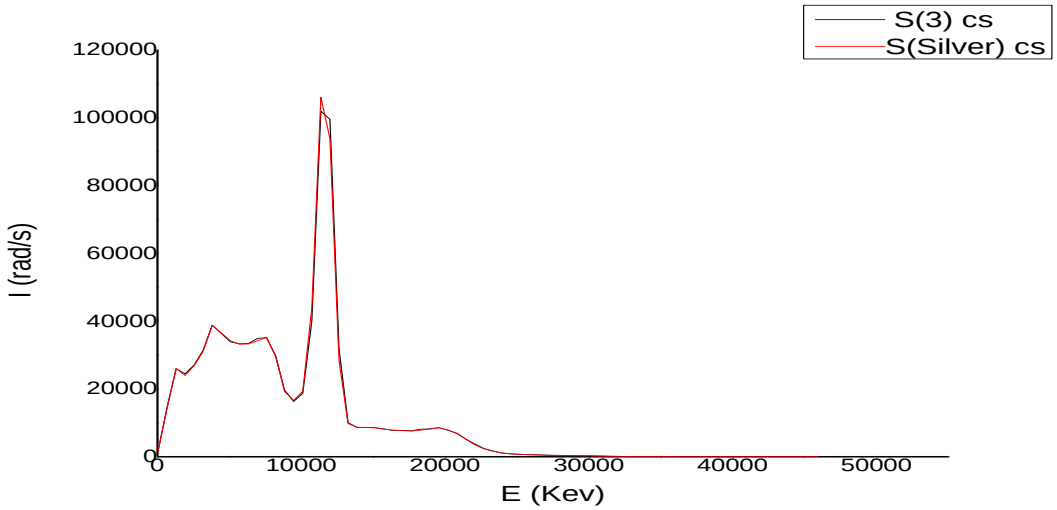

Figure (9) stander Silver sample with sample three irradiated with Cs^{137}

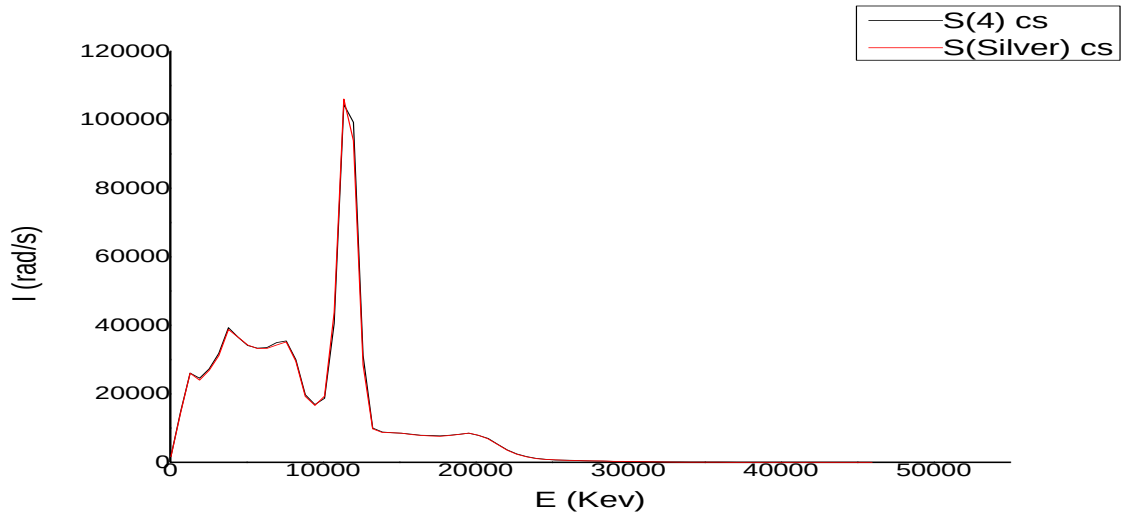

Figure (10) stander Silver sample with sample four irradiated with Cs^{137}

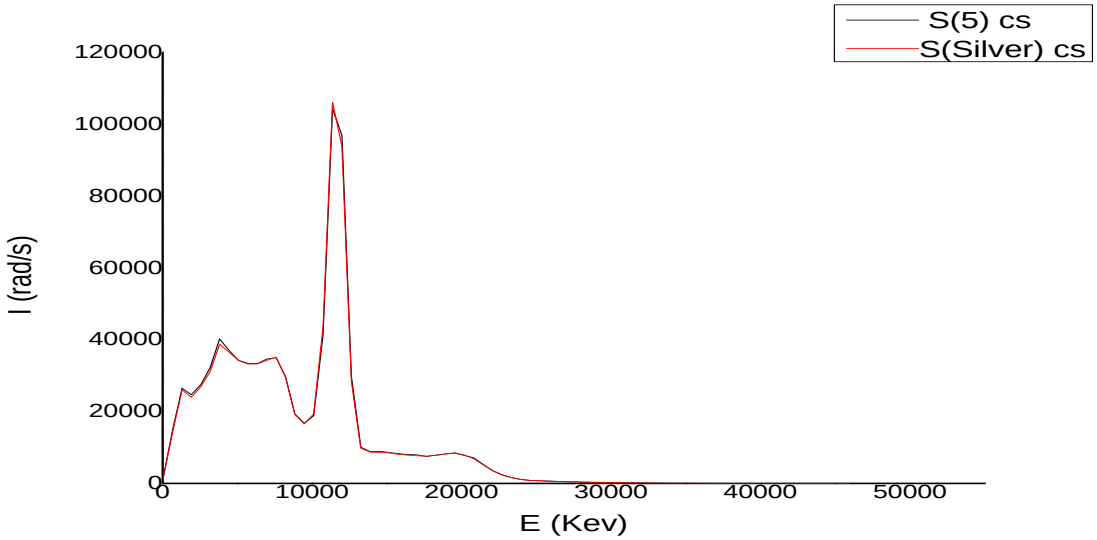

Figure (11) stander Silver sample with sample five irradiated with Cs^{137}

Results of Energy dispersive x-ray(EDX)

Table (1) Elements in sample one

Element	Si	Fe	Mn	Al	Ca	S	K
Result %	81.071	15.477	1.025	0.795	0.671	0.483	0.158
Element	Ti	Cr	Sr	Cu	Zn	-	-
Result %	0.122	0.101	0.044	0.032	0.022	-	-

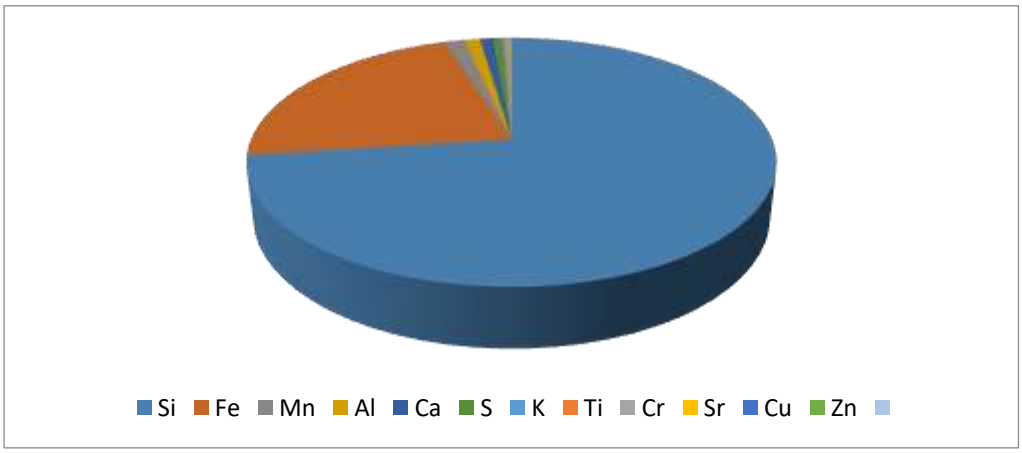

Figure (12) Elements in sample one

Table (2) Element in sample two

Element	Si	Fe	Mn	Al	Ca	S	K
Result %	81.747	14.808	1.032	0.928	0.457	0.460	0.193
Element	Ti	Cr	Sr	Cu	Zn	Pb	Au
Result %	0.146	0.108	0.043	0.041	0.024	0.0008	0.004

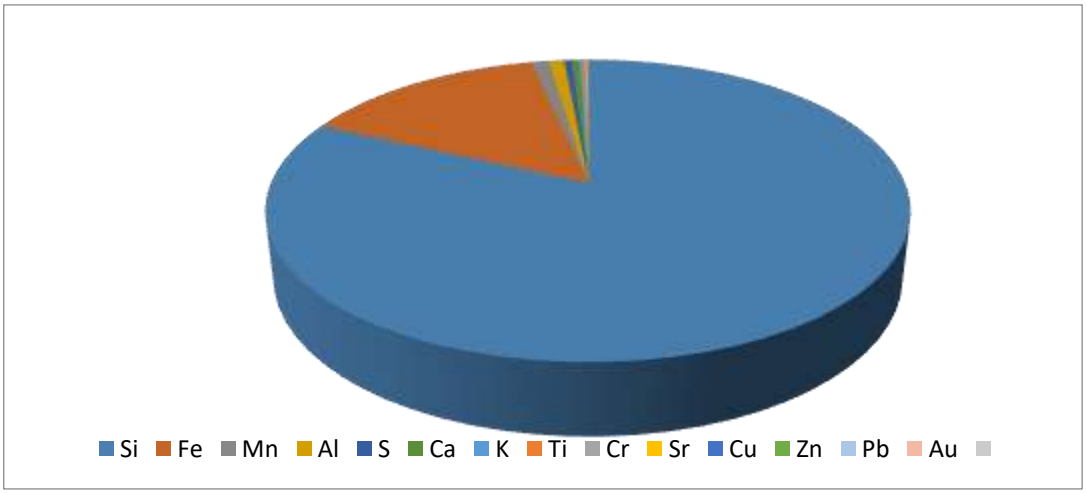

Figure (13) Elements in sample two

Table (3) Elements in sample three

Element	Si	Fe	Mn	Al	Ca	V	K
Result %	27.403	68.694	0.074	7.031	0.311	0.056	0.302
Element	Ti	Cr	Zr	Cu	Zn		
Result %	0.884	0.127	0.062	0.046	0.009		

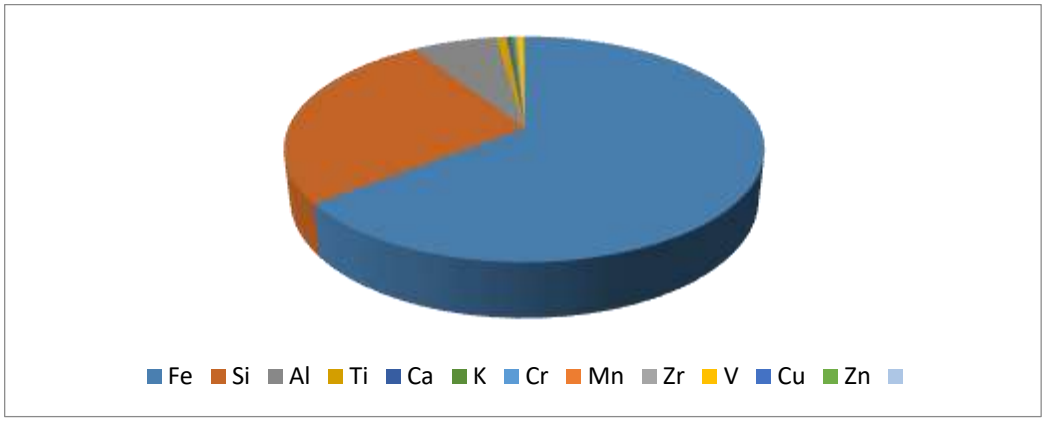

Figure (14) Elements in sample three

Table (4) Elements in sample four

Element	Si	Fe	Mn	Al	Ca	Ba	K
Result %	26.531	48.515	12.9997	7.420	0.188	2.521	0.333
Element	Ti	Cr	Zr	Cu	Zn	Sr	Os
Result %	1.117	0.119	0.057	0.130	0.039	0.025	0.009

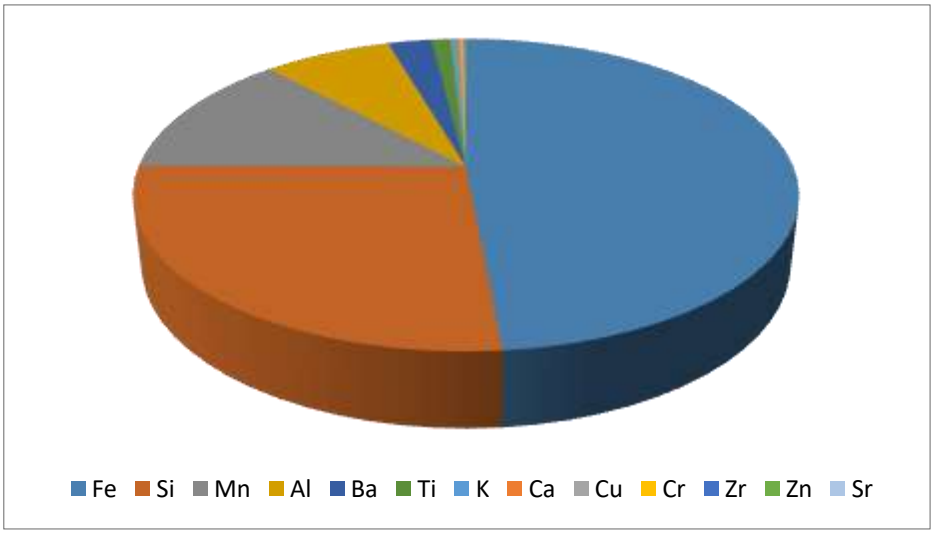

Figure (15) Elements in sample four

Table (5) Elements in sample five

Element	Cr	Fe	Si	Al	Ca	Ni	Zn	V
Result %	52.430	31.781	10.324	4.396	0.257	0.420	0.285	0.107

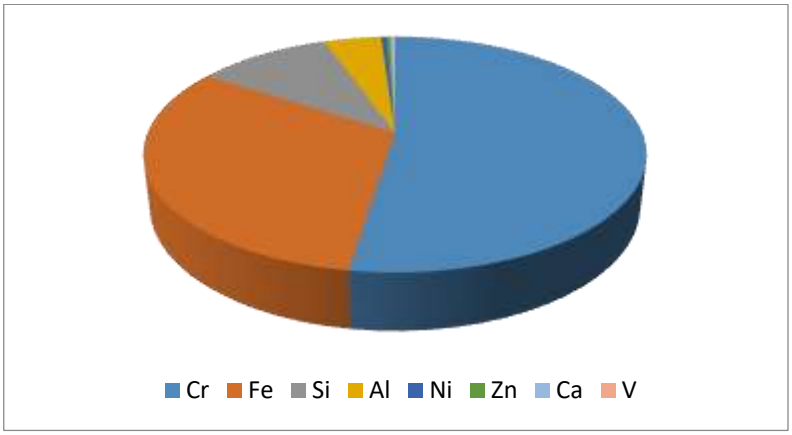

Figure (16) Elements in sample five

Results of Atomic Absorption Spectrometer (AAs) by Acid Digestion

Table (6): Elements in (sample one, two, three, four and five))

Sender No.	Au ppm	Fe%	Ag%
Sample one	ND	1.327	0.0632
sample two	ND	1.410	0.0040
sample three	ND	14.51	0.0081
sample four	ND	11.01	0.0979
sample five	ND	10.68	0.0051

*ND it is not means Zero (ND ≡ Not Detected)

Results of Indicted coupled plasma (ICP) and comparison

Table (7): Comparison between the concentration of Ag using gamma C^{60} spectrometer, AAs , ICP and EDX for all samples

Sample	Ag			
	gamma	AAs	EDX	ICP
one	0.11	0.0632	ND	ND
two	0.116	0.0040	ND	ND
three	0.112	0.0081	ND	ND
four	0.112	0.0979	ND	ND
five	0.110	0.0051	ND	ND

Discussion:

In view of figure (2) it is clear that the spectrum of silver only is more broad and intensive than that of sample one which are irradiated with Co^{60}. This may be attributed to the fact that the detector detect the back scattered gamma radiation. since silver sample is a metal thus its reflection coefficient to gamma and all electromagnetic radiation is higher than sample one which is a rock. The broadening of the metal spectrum is due to the scattering process which scatter photons variety of were lengths. Such broadening is not observed in sample one which is a rock having small reflection coefficient as far as most photons are absorbed by rock sample atoms. For silver the highest peak in the extreme left is expected to represent silver characteristic energy. The first peak in the extreme left for sample one is nearly coincident with the

characteristic are for silver thus it represent silver peak. This can be explained by the same arguments mentioned for figure (2).

Figure (3) shows that the silver peak is the second peak from the left for sample two. For sample three the silver peak is the second from the left, while the silver peak is the third from the left as shown in figure(4). For sample four the silver peak is the second one from the left as shown in figure (5). For sample five figure (6) second peak from the left represent silver peak .

When the standard of silver for the five rock samples were irradiated with Cs^{137} the spectra of all standards and samples are typical to each other. This means that no emission of characteristic photon energy takes place.

Three other spectral techniques were also used to determine the concentration of Ag. These are energy dispersive x-ray fluorescence (EDX), atomic absorption spectrometer (AAS) and induced coupled plasma (ICP). In all samples, while EDX detect it only in sample four. For Ag gamma and AAS are more sensitive and have very low detection limit for Ag detection .

Conclusion:

The four techniques which were used for Ag identification indicates gamma spectrometer using Co^{60} has high sensitivity compared to EDX, AAS and ICP techniques. while AAS is more sensitive to silver (Ag). Unfortunately gamma spectrometer using Cs^{137} as a source gives no result .

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