INVESTIGATING THE ROLE OF SWIPE SAMPLES IN STRENGTHENING NUCLEAR FORENSICS AND SUSTAINING NUCLEAR SECURITY

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Abstract

Nuclear forensics is an effective technical tool for investigating nuclear materials, its properties, and its history. The importance of nuclear forensics has emerged as a result of the spread and growing phenomenon of terrorism. To get rid of this phenomenon, the international community supports any effort to strengthen and maintain a robust nuclear security system. The work describes the robust nuclear security system from the point of view of implementing a national framework for nuclear forensic capability and technical tools and instruments required for nuclear forensics. Techniques such as gamma spectrometry, radiochemical separation, inductively coupled plasma using optical emission spectrometer or mass spectrometer are powerful for revealing information related to nuclear materials in any form. Nuclear materials can be in a form of traces such type of samples to be characterized a swipe sample should be taken and introduced to one of the above techniques. The paper focuses on assaying five environmental samples from nuclear facilities to test whether it contains nuclear material or not. The SEM and EDX tools are used to localize particles, counting the targeted particles and use x-ray to know the concentration of each element. The microscope employed for this study has 6510LV model.

Keywords: Nuclear Forensics, Nuclear Material, Environmental Samples.

1. INTRODUCTION

The process of investigating any nuclear substance to conclude for the origin, the trading, and the mass of the isotope 235-U. The substance may be retrieved from different origins, involving dust from a nuclear facility's surroundings, or from radioactive waste after a nuclear blast. Many institutions use the findings of nuclear forensic examination to make judgments. Usually, the data is paired with certain data sources like intelligence authorities as well as authorities that responsible for applying law [1].

1.1. Roles of Forensics in Preventing Nuclear Terrorism

Defining the origins of captured items may deter attacks of terrorism that would utilize content from the same origin or making them more difficult. However, the knowledge of active nuclear forensics will dissuade some of the participants who are about to be engaged in any operation of nuclear terror and provide opportunities for governments to better protect their resources and installations [2].

1.2. Nuclear forensics tools

For nuclear forensics, chemical separation methods are often used as a way to decrease interferences and promoting low-concentration radionuclide evaluation. There are many tools and techniques that are widely used in the nuclear forensic system [3]. These techniques rely on the use of tools such as electron microscopes and are used to show clear images of the particles in the samples and this technique is useful in the case of small sizes. High precision tools are also used to find out the concentration of the target element such as Inductively Coupled Plasma-Optical Emission Spectrometry. More modern tools are also used to determine the isotope ratio such as Secondary-Ion Mass Spectrometer [4-8].

2. IMPLEMENTATION OF A NATIONAL NUCLEAR FORENSIC CAPABILITY

- Countries need to get a formal response plan for countering any nuclear security actions.
- Countries will guarantee that nuclear forensic duties and responsibilities are strictly described.
- Improving a nuclear forensic infrastructure in a Country will start with the identification of existing resources, including already developed installations and related knowledge that is used for other applications, and the establishment of processes for their use in investigations.
- Countries can also create a National Library of Nuclear Forensics under their jurisdiction to allow a reliable evaluation of whether or not nuclear and other radioactive substances found under governmental control is compatible with a substance produced, utilized or deposited in the State.
- Global cooperation gives the government the chance to request and supply assistance to facilitate capability growth.

3. EXPERIMENTAL

More than (20) analysis sheets for each sample were obtained using both area and spot analysis types. Due to this big number of images and spectrums, only some representative results for each sample will be displayed.

TABLE 1. SAMPLES SPECIFICATION

No.	Sample code	Type	Physical form
1	ES.1	Swipe sample	Solid
2	ES.2	Swipe sample	Solid
3	ES.3	Swipe sample	Solid
4	ES.4	Swipe sample	Solid

5	ES.5	Swipe sample	Solid

All samples were analyzed by SEM and EDX . Each specimen was of a suitable size to suit the chamber of the specimen and was placed on a holder. All the analyzed solid samples have been collected and prepared in the EDX safeguards laboratory at ENRRA (KMP I). Many specimens can be brought into the chamber of SEM without preparation of any kind [9,10].

3. RESULTS AND DISCUSSION

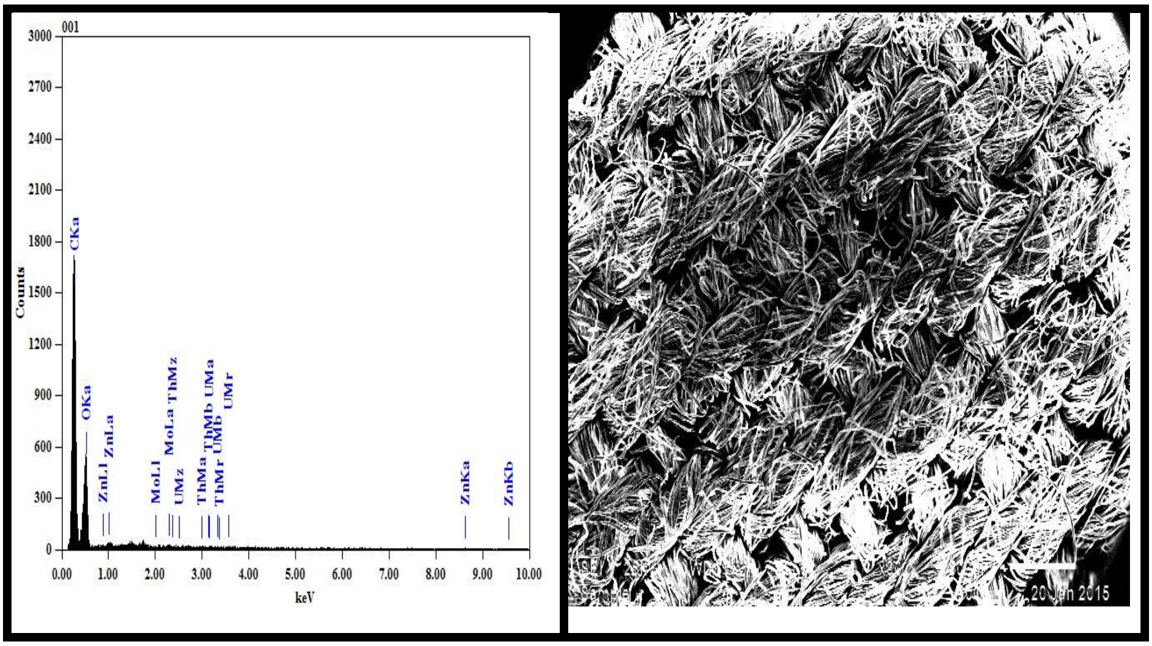

Fig.1. SEM image and x-ray spectrum for ES1 sample.

Figure (1) represent SEM images and the x-ray spectrum for ES1sample. The strategy followed here focused on performing area analysis firstly of the sample at low magnification to do a fast screening of all elements in the sample that lie within the instrument range then performing spot analysis of each particle at higher magnification to look for our target elements (uranium-thorium). Table (2) summarize EDX results concerning this sample.

TABLE 2. EDX RESULTS FOR ES1 SAMPLE.

Spot no.	**EDX results (Mass % ± σ_M)**	
	Th	**U**
1,3,4,5	------	------
2	0.110 ± 0.016	------
6	------	0.190 ± 0.013
7	------	1.330 ± 0.001
8	0.570 ± 0.017	0.120 ± 0.014
9	------	0.550 ± 0.012

10	0.020 ± 0.016	0.020 ± 0.013
11	0.080 ± 0.016	------
12	------	1.340 ± 0.010
13	0.060 ± 0.012	0.230 ± 0.010
14	0.100 ± 0.016	0.350 ± 0.013
15	------	0.150 ± 0.013
16	0.180 ± 0.017	------
17	0.260 ± 0.015	0.150 ± 0.013
18	0.150 ± 0.016	0.030 ± 0.014
19	3. 640 ± 0.017	0.690 ± 0.014

It is clear from the obtained results in table (2) that the ES1 sample contains uranium (12 positions) and thorium (10 positions) particles and these results were in an agreement with the declared IAEA results for this sample.

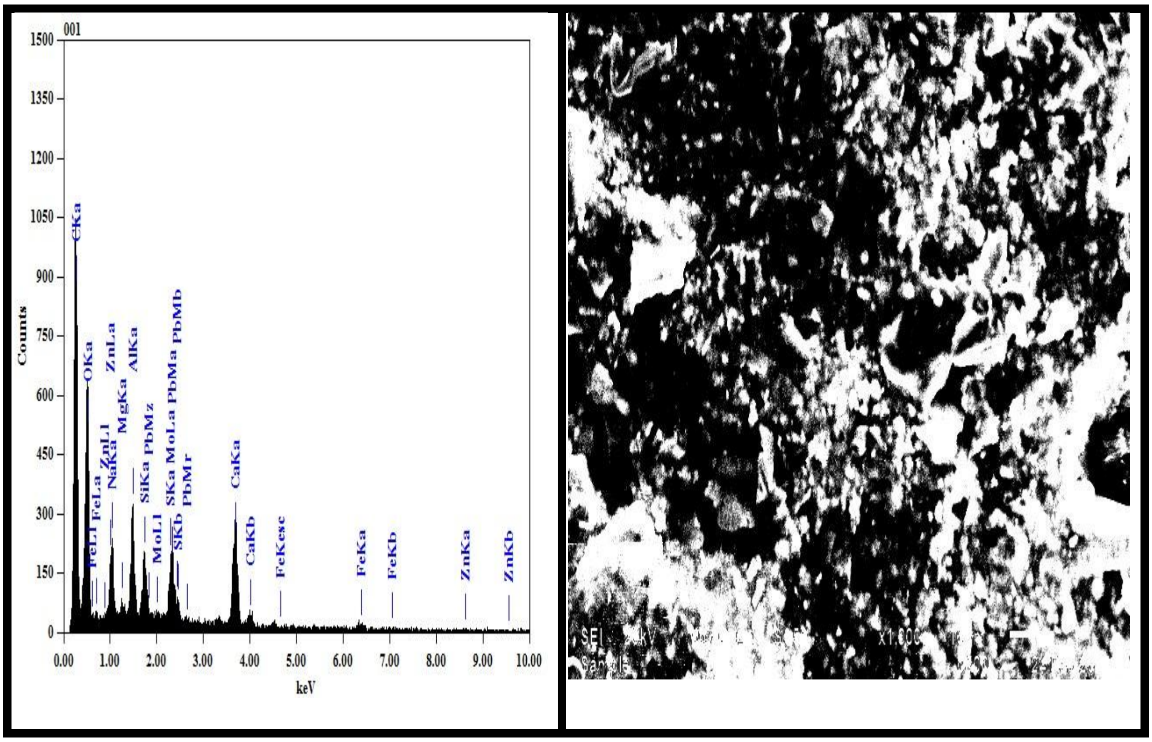

Fig. 2. SEM image and x-ray spectrum for ES2 sample.

Figure (2) represents SEM images and the x-ray spectrum for the ES2 sample. It is obvious from images that the swipe sample contains many particles greater than ES1. Table (3) summarizes EDX results concerning this sample.

TABLE 3. EDX RESULTS FOR ES2 SAMPLE.

Sample ID	EDX results (Mass % ± σ_M)	
	Th	U
1,2,3,5,6,7,8,10,13,14,15,17,18,19	------	------
4	0.420 ± 0.010	0.500 ± 0.008
9	-----	0.250 ± 0.012
11	2.010 ± 0.013	0.490 ± 0.012
12	0.200 ± 0.010	0.090 ± 0.008
16	1.040 ± 0.012	------
17	------	0.140 ± 0.013
20	0.390 ± 0.017	0.120 ± 0.014

It is clear from the mentioned results in table (3) that the ES2 sample contains uranium (6 positions) and thorium (5 positions) particles and these results were in an agreement with IAEA results for this sample.

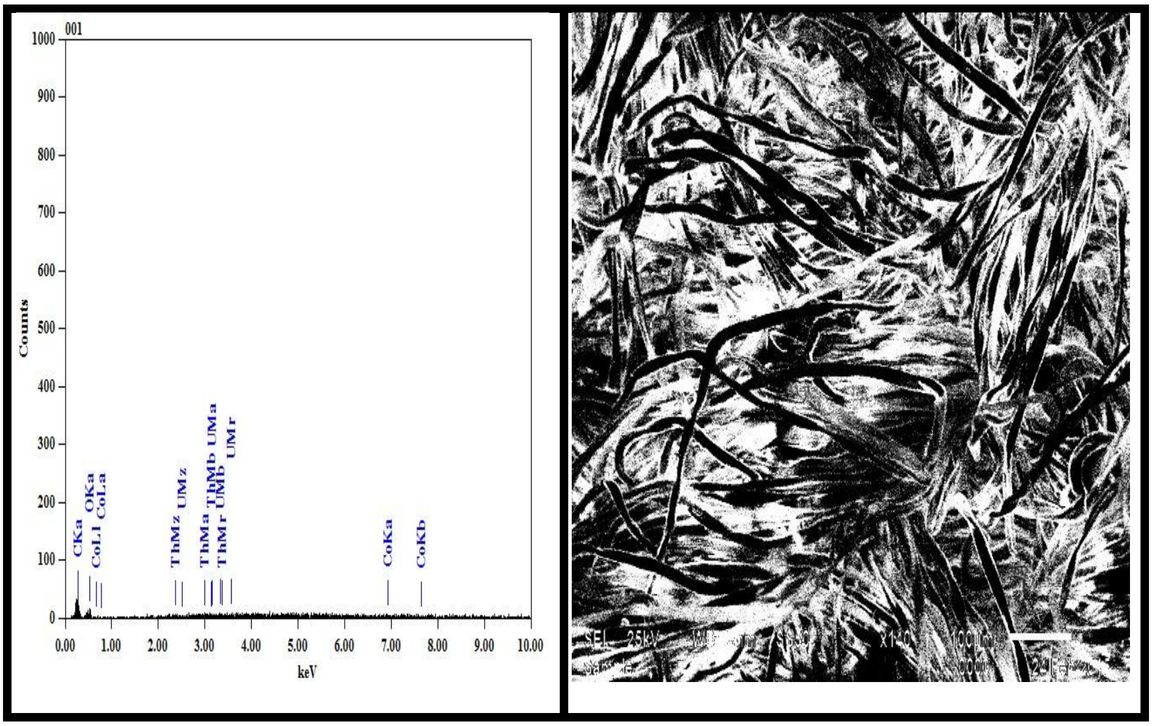

Fig. 3. SEM image and x-ray spectrum for ES3 sample.

Figure (3) represents SEM images and the x-ray spectrum for the ES3 sample. It is obvious from images that the swipe sample contains less particles than the ES2. Table (10) summarizes EDX results concerning this sample.

TABLE 4. EDX RESULTS FOR ES3 SAMPLE.

Sample ID	EDX results (Mass % ± σ_M)	
	Th	U
1,2,3,4,5,11,12	------	------
6	------	0. 230 ± 0.012
7	0.950 ± 0.025	1.630 ± 0.021
8	------	0.120 ± 0.010
9	0.170 ± 0.013	0.050 ± 0.016
10	0.030 ± 0.053	------
13	------	0.710 ± 0.012
14	------	0.290 ± 0.012
15	------	0.050 ± 0.015
16	0.200 ± 0.018	0. 170 ± 0.015
17	------	0.080 ± 0.015
18	0.210 ± 0.040	------
19	0.180 ± 0.014	------
20	0.010 ± 0.017	------

It is clear from the mentioned results in table (3) that the ES3 sample contains uranium (9 positions) and thorium (7 positions) particles and these results were in an agreement with IAEA results for this sample.

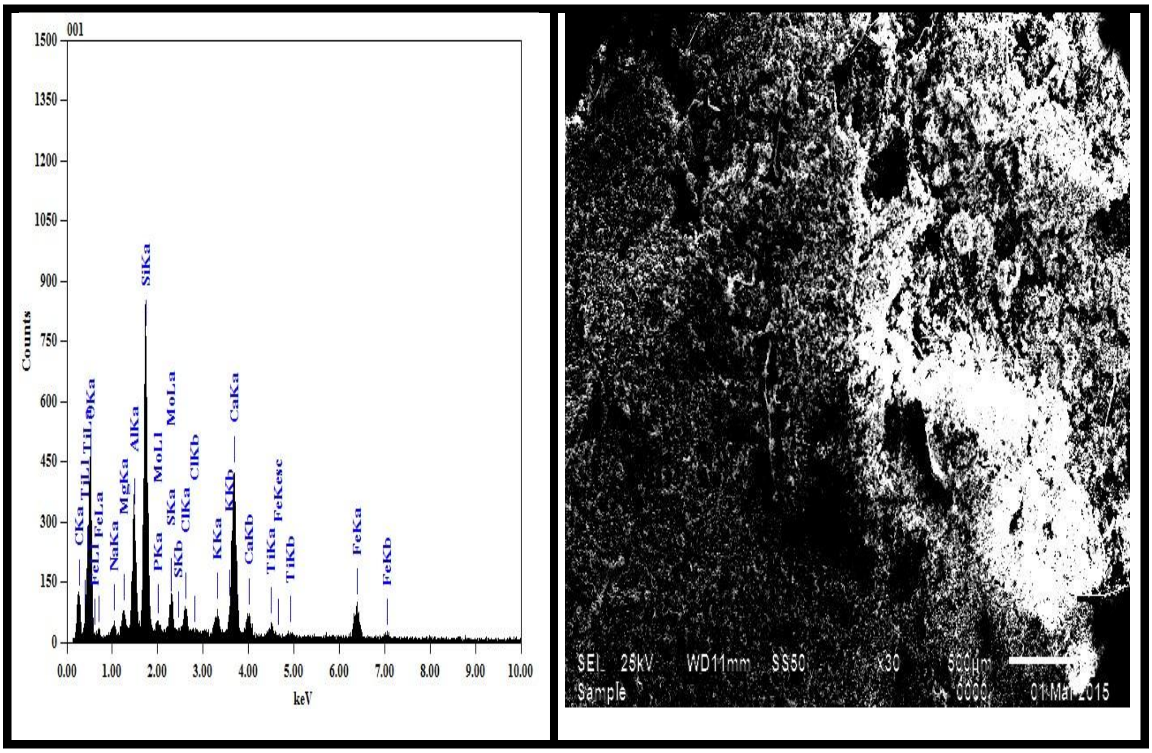

Fig. 4.SEM image and x-ray spectrum for ES4 sample.

Figure (4) represents SEM images and the x-ray spectrum for the ES4 sample. It is clear from images that the swipe sample contains many particles that were analyzed by EDX. Table (5) summarizes EDX results concerning this sample.

TABLE 5. EDX RESULTS FOR ES4 SAMPLE.

Sample ID	EDX results (Mass % ± σ_M)	
	Th	U
1,2,3,4,5,6,7,8,10,11,12,13,14,15,17,19,20,22,23	------	------
9	------	0.110 ± 0.007
16	------	0.490 ± 0.010
18	------	0.120 ± 0.009
21	------	0.240 ± 0.009

It is clear from the mentioned results in table (5) that the ES4 sample contains uranium (4 positions) and no thorium particles detected .These results have no comparison results with IAEA so it was prepared for future .

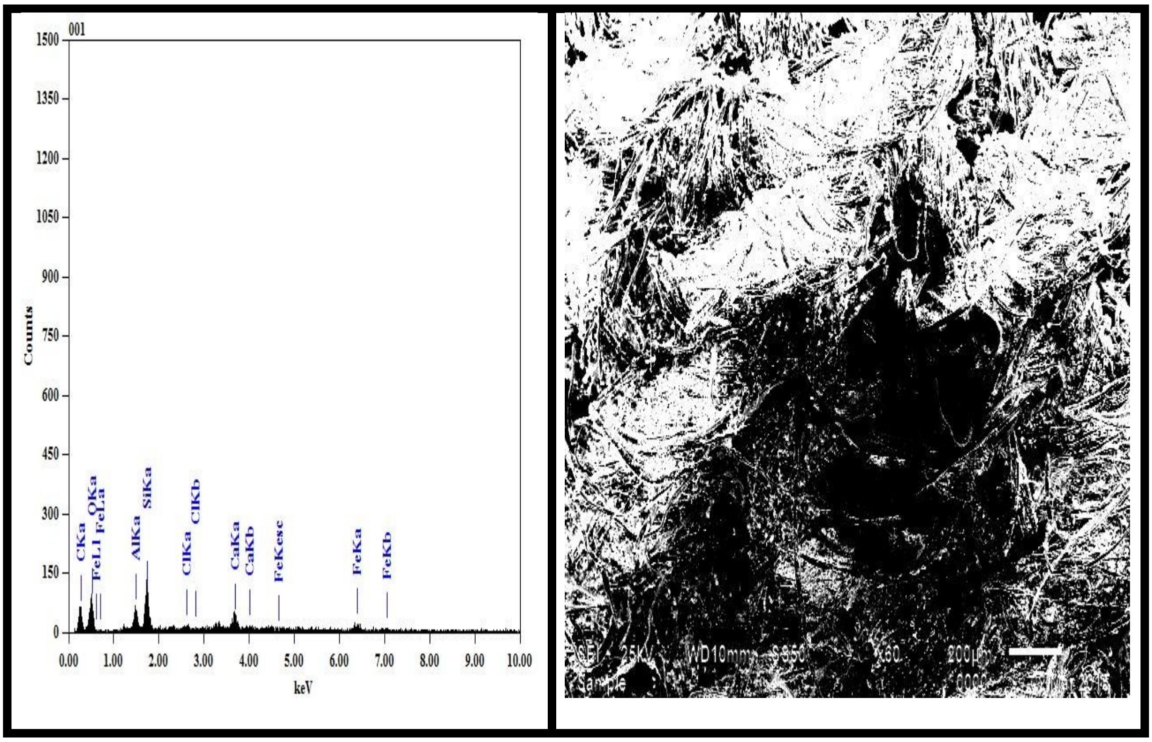

Fig. 5. SEM image and x-ray spectrum for ES5 sample.

Figure (5) represent SEM images and the x-ray spectrums for the ES5 sample. It is clear from images that the swipe sample contains particles that were analyzed by EDX especially for uranium and thorium. Table (6) summarizes EDX results concerning this sample.

TABLE 6. EDX RESULTS FOR ES5 SAMPLE.

Sample ID	EDX results (Mass % ± σ_M)	
	Th	U
1,2,3,4,5,6,7,8,9,12,13	-----	------
10	-------	0.570 ± 0.009
11	0.380 ± 0.011	0.100 ± 0.010
14	0.210 ± 0.008	0.130 ± 0.007
15	------	0.390 ± 0.009
16	------	0.130 ± 0.011

It is clear from the mentioned results in table (12) that the ES5 sample contains uranium (5 positions) and thorium (2 positions) particles detected .These results have no comparison results with IAEA so it was prepared for future.

4. CONCLUSION

Nuclear forensics has a vital role within a national nuclear security infrastructure. Government policy-makers, responsible authorities, homeland security, and technical staff should be aware of this role. Environmental samples analysis needs more sophisticated techniques like ICP-MS, an alpha spectrometer to reveal its secrets beside SEM coupled with EDX. SEM and EDX are robust techniques to localize microparticles, counting the number of uranium or thorium particles and determining the concentration of each particle within the sample.

5. REFERENCES

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