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Determination and analysis of radio-nuclei in leukaemia blood samples using SAM940TM detector

*Alaa Hayder[1] Maytham Al-Shanawa[1] Hayder A. Al. Hmudi[2]

[1]Physics Department, College of Science, University of Basrah, Basrah, Iraq
[2]Department of Biology, College of Science, University of Basrah, Basrah, Iraq.

*Corresponding Author E-mail: allaheider71@gmail.com

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ABSTRACT

Radiation pollution become a major problem threatening the life on the earth that causes many of the serious diseases, through acute or chronic effects. The leukaemia this considered to be the most serious and common disease due to the increasing of radiation pollution levels. In this study the province of Basrah was selected because this province contains many of the wars remnants due to the Gulf Wars (1991, 2003). The aim of this study is to investigate the possibility of any a relationship between the radioactivity level and leukaemia incidence; there are a direct or indirect relationship between the cancer rate and the exposure to radiation. Therefore, the levels of different radionuclide in leukaemic patients. In order to achieve our goal 75 samples were study and many techniques are utilized, such as the SAM 940 ^{TM} (Gamma ray Spectroscopy). In addition, to compare between the healthy and Leukaemic samples, the UV-Vis spectrometer has been used. The results showed that there is a big difference between the radionuclide's concentrations of the healthy and patients samples. For example, the ^{238}U concentration in several Leukaemic patients were (2.0958 Bq/Kg), whilst at healthy individuals were (0.408 Bq/Kg).

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تحديد وتحليل الانوية المشعة في عينات دم مصابة بالوكيميا باستخدام كاشف SAM 940^{TM}

علاء حيدر خلف[1] ميثم عبد الله الشناوة[1] حيدر عبد الحسين الحمودي[2]

[1]قسم الفيزياء، كلية العلوم، جامعة البصرة، العراق
[2]قسم علوم الحياة، كلية العلوم، جامعة البصرة، العراق

الكلمات المفتاحية:

التلوث الإشعاعي
اللوكيميا
البصرة
SAM 940 (مطيافية أشعة كاما)

الـــخُـــلاصــــة

أصبح التلوث الأشعاعي مشكلة كبيرة تهدد الحياة على كوكب الأرض والذي يسبب الكثير من الأمراض الخطيرة وهذا يحدث من خلال التأثير المباشر ولجرعات اشعاعية كبيرة وحادة او من خلال التأثير الغير مباشر وذلك بالتعرض الى جرعات اشعاعية منخفضة ولفترة

زمنية طويلة نسبيا. تم اختيار عدد من المصابين بمرض اللوكيميا (سرطان الدم او ابيضاض الدم) من سكنة محافظات جنوب العراق وهي محافظة البصرة و ذي قار وكذلك المثنى ومحافظة ميسان. ارتفعت نسب الأصابة بسرطان الدم في محافظة البصرة بعد حرب الخليج الاولى (١٩٩١) وكذلك حرب الخليج الثانية (٢٠٠٣) حيث ماتزال هذه المحافظات تعاني من المحلفات الحربية الملوثة اشعاعيا ولم يتم التخلص من هذه المخلفات الخطرة بشكل صحيح ولم يتم معالجة الملوثات الأشعاعية بالطرق العلمية والعملية الصحيحة. الهدف الرئيسي لهذه الدراسة هي البحث عن اي علاقة مباشرة او غير مباشرة لتلوث الأشعاعي ونسب الأصابة بسرطان الدم (اللوكيميا). من اجل تحقيق هذا الهدف تم استخدام جهاز مطيافية اشعة كاما (سام ٩٤٠TM) والتي استخدم من اجل تحديد نوع وتركيز الأنوية المشعة في عيات الدم المصابة والسليمة. حيث وجد من خلال النتائج ان تركيز الأنوية المشعة في العيات المصابة مختلفة عن تركيزها في عينات الدم السليمة. حيث كان تركيز اليورانيوم –٢٣٨ في العينات المصابة (2.0958 Bq/Kg)بينما كان لدى العينات السليمة (0.408 Bq/Kg).

1. INTRODUCTION

There are many natural radionuclides present in the soil, rocks, water and air. There are three types of natural decay chains. The uranium-radium decay series, which starts with the uranium-238 radiator. The uranium-actinium decay series, which begins with the uranium-235 radioactive counterpart and ends with the lead-207. The thorium decay series, which begins with the radioactive Thorium-232. Both isotopes Uranium-235 and Thorium-232 are primary nuclei, which have existed since the Earth's formation. There is a fourth series, the neptunium series, this series is practically extinct, except for the last phase, Bismuth-209, which gives the analogy Thallium-205. In addition to these sequences there are radioactive elements in nature such as Cesium-137, Rubidium-87 and Potassium-40 which are produced from 10 cosmic rays Ground (1,2). Radionuclides make up a large part of the total natural radiation sources. Only half-life nuclei that can be compared with Earth and present age in terrestrial materials such as ^{232}Th, ^{238}U and ^{40}K which are of great importance because they cause external and internal hazards due to gamma emission (3). Uranium is one of the most serious pollution concerns because of its radioactivity and heavy toxicity. Uranium and its compounds are highly toxic threating human health and environmental balance (4). The uranium is widely dispersed in nature, where it is found in a wide range such as in solid, liquid and gaseous compounds that easily combine with other elements to form uranium oxides, silicate, carbonate and hydroxides (5). Depleted uranium is a by-product of the nuclear industry. Its specific activity is approximately 40% lower than that of natural uranium. Because of its high density, its used in manufacturing of shells and shields in many countries (6,7), where it's used in the Gulf War in 1991. In southern Iraq, the depleted uranium remains and become a big problem of environmental pollution because the its levels raised after the first Gulf War and the second in 2003 (8,9). There are different ways that uranium can reach the human body either directly by inhaling dust particles carrying uranium or drinking water contaminated with uranium, or indirectly from the fertile soil layer through the food chain (10). The solubility of uranium varies depending on the specific compounds and solvents, and this solubility determines how quickly and efficiently the body absorbs it through the lungs and intestines (11). The uranium that is deposited in the bones and other organs then released into the bloodstream

(12,13), causing several health problems such as cancer or renal failure, respiratory disorders, congenital malformations, leukemia, skin diseases, and other unknown diseases (14,15). Researchers at the Radiology Institute of the Armed Forces Research Institute (AFRRI) in Bethesda and others have found that uranium causes mutations in DNA and increase transverse chromosomes (16,17). It is a widely accepted principle in molecular biology that mutagenic factors or damage can cause cancer (18,19). In Iraq, cancer cases recorded annually by the Iraqi Cancer Council which reported an increase in the number of cancer cases registered after the Gulf War (20). There are some areas in southern Iraq (Basrah, Muthanna and Dhi-Qar) which have increased fivefold in reported cancer cases. Most of these cases involve damage to the lungs, bronchial tubes, bladder, and skin. In addition, increased incidence of stomach cancer in males and breast cancer in females was reported, as well as a general increase in leukemia (21). This motivated us to investigate the main problem that cause these fatal diseases. Many techniques used to meet this goal, first the Gamma Spectrometer SAM940™, which consists of the NaI (TI) gamma ray detector was used to determine the normal radioactivity of (^{238}U, ^{234}Th, ^{40}K and ^{137}Cs). UV-Spectroscopy is utilized to determine the consistencies and differences in sample's continents.

2. MATERIALS AND METHODS:

75 blood samples were collected from government hospitals in the province of Basrah on three different types (leukaemic patients, healthy group and Leukaemic patients before treatment). The samples were collected in special containers with EDTA, a substance that prevents blood coagulation and was placed in a refrigerator in order to preserve the blood from damage and coded in order to distinguish between them and stored for at least two weeks before the calculations. Each sample tested and checked by SAM-940™ Spectroscopy. The specific activity of each radionuclide is calculated using the following equation (22,23)

$$A_C\left(\frac{Bq}{kg}\right) = \frac{C}{t.m.\varepsilon.I_\gamma} \quad \text{.........} \ (1)$$

Where: $\mathbf{A_C}$ the specific activity concentration of the radionuclide in (Bq/Kg), **C** is count, **ε** the counting efficiency, $\boldsymbol{I_\gamma}$ is the percentage of gamma emission probability of the radionuclide under study, **t** the counting time in (sec) and **m** the mass of the sample in (Kg).

3. MEASUREMENTS AND RESULTS:

25 samples from each group were taken (Healthy samples and Leukaemic

samples with treatment), also 25 samples from group of Leukaemic samples without treatment.

Table (1): Samples symbol and patient gender and location.

No.	Symbol	Location	Gender
1	S1	Basra centre	Female
2	S2	Basra centre	Female
3	S3	Basra centre	Female
4	S4	Basra Zubair	Male
5	S5	Basra centre	Male
6	S6	Basra Zubair	Male
7	S7	Basra Umm Qasr	Female
8	S8	Basra Umm Qasr	Female
9	S9	Basra centre	Female
10	S10	Basra centre	Female
11	S11	Dhi-Qar	Male
12	S12	Basra centre	Male
13	S13	Basra Karma Ali	Male
14	S14	Basra centre	Male
15	S15	Basra centre	Male
16	S16	Basra Zubair	Female
17	S17	Basra Zubair	Female
18	S18	Basra Zubair	Male
19	S19	Basra Zubair	Male
20	S20	Basra Zubair	Male
21	S21	Basra centre	Female
22	S22	Basra centre	Male
23	S23	Basra almdina	Male
24	S24	Basra almdina	Female
25	S25	Basra centre	Male

Table (2): Healthy blood Samples

Symbol	A_U(Bq/Kg)	A_{Th}(Bq/Kg)	A_K(Bq/Kg)	A_{Cs}(Bq/Kg)
S1	0	0	0.84359	0
S2	0	0.4821	10.297	0.061
S3	0	0.137	14.959	0
S4	0	0.43857	1.54219	0
S5	0	0	12.56	0
S6	0.089	0.6839	0	0.09
S7	0.1	0	4.005	0.4121
S8	0	0.101	0	0.157
S9	0.69	1.1165	0	0.171
S10	0.59	0	5.834	0.2729
S11	0.88	0.137	41.67	0.14
S12	0.928	0.064	0	0
S13	0.99	0	0	0.407
S14	0.362	1.033	0	0
S15	0.206	1.085	0	0.215
S16	0.654	0.0649	12.168	0
S17	0.9127	0.582	12.168	0
S18	0.4843	1.235	72.0139	0
S19	0	1.9126	93.216	0
S20	0.95	0.2379	90.6654	0
S21	0.891	0.1309	20.965	0
S22	0	0.664	50.359	0.0519
S23	0.65	0.8536	27.8279	0
S24	0	0	38.579	0
S25	0.835	0.093	28.5	0.082

The results plotted in figures showed below, as can see there are a significant different in the activity concentration of radioactive isotopes in samples groups especially for uranium isotope.

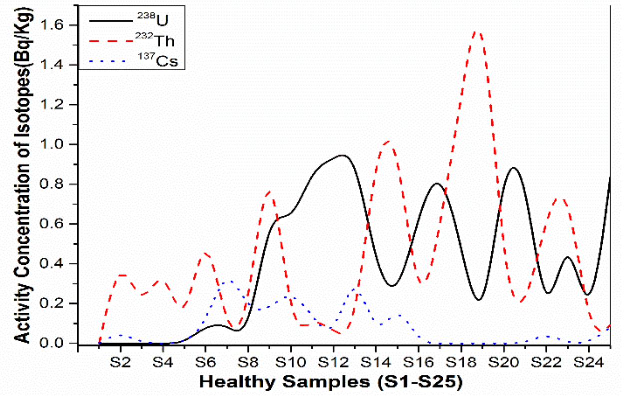

Fig (1) presenting the activity concentration of (^{238}U, ^{234}Th, ^{137}Cs) in twenty fife healthy samples.

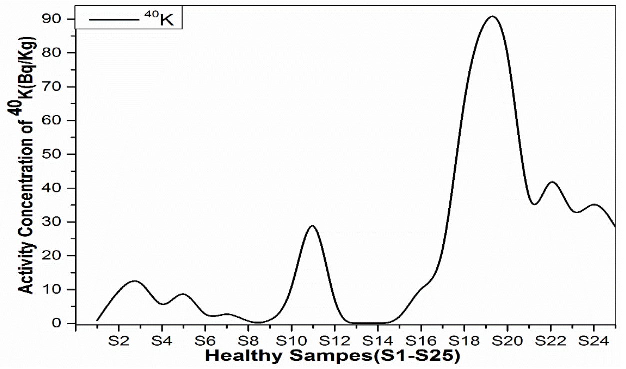

Fig (2); the activity concentration of ^{40}K in healthy samples

The curve showing the concentration of Potassium-40 is the upper one compare with the rest of isotopes, which consider very normal.

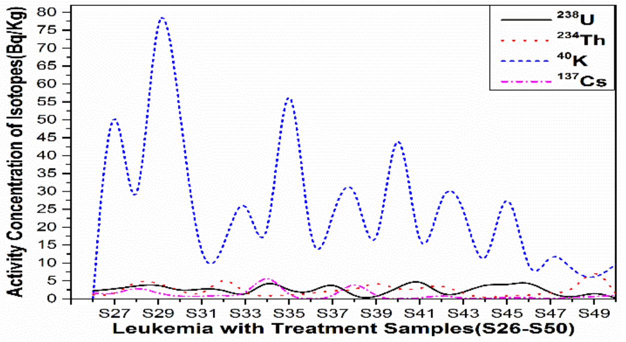

Fig (3); the activity concentration of (^{238}U, ^{234}Th, ^{40}K, ^{137}Cs) in old Leukemia samples.

Very interesting result that showed in fig (3), the concentration of ^{40}K is high as showed in healthy samples, also other interesting thing are the concentration of ^{238}U and ^{137}Cs isotopes are also high in Leukemia samples with chemical treatment, that's mean there are direct correlation between the Leukemia and exposed to the radiation pollution.

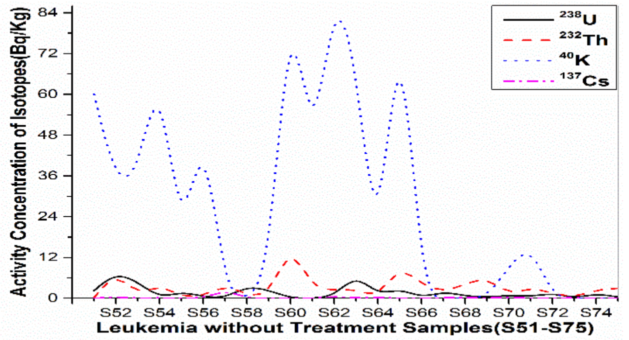

Fig (4); the activity concentration of (^{238}U, ^{234}Th, ^{40}K, ^{137}Cs) in Leukemia samples without treatment.

The interesting result that showed in fig (4), the concentration of ^{40}K being normal as found in healthy people, since the concentration of ^{238}U isotope are also high in Leukemic group without treatment. That's mean the concentration of radioactive isotopes in those participants are higher than in the healthy blood samples. Therefore, we can conclude there is a direct correlation between the leukemia and exposed to the radiation.

Accordingly, the figures above are important to focus on the activity that level of ^{238}U isotopes. Figures below showing the differentiation in concentration of Uranium isotope of seventy-five samples from three mean samples group. As you can see there are a big difference in Uranium concentration, which showing the concentration of ^{238}U up to 6 Bq/Kg in same leukemic group taking treatment. Also the concentration of ^{238}U is high in new leukemic patients without medicine. That's mean the direct effect of radiation or radioactive contaminations that causes the leukemia disease, figure (5) showing this result.

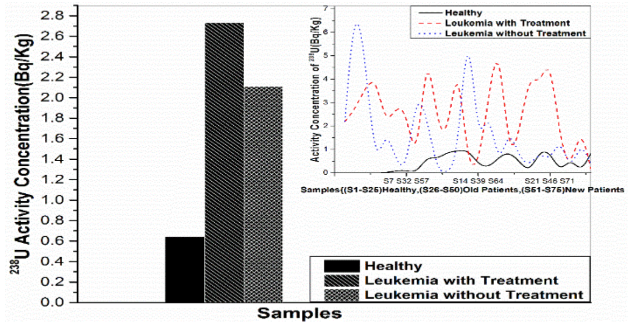

Fig (5); the activity concentration of (^{238}U) in all samples Leukemia samples with and without treatment and in the healthy samples.

Table (3): ^{238}U activity concentration

Dependent Variable: U-238 (A_c Bq/Kg)			
Groups	NO.	Min. – Max.	Mean± Std. Deviation
H	25	٠.٩٩ – ٨٩0.0	٥٢ ± 0.0٠.٤٠٨
LWT	25	٥.٩٨– ٠٦٧0.	1 ± 0.23٥2.
LWOT	25	0.0466 – 7.622	± 0.412١.٦٨
Total	75		
P > 0.000			

Table (4): ^{232}Th activity concentration

Dependent Variable: Th-232 (A_c Bq/Kg)			
Groups	NO.	Min. – Max.	Mean± Std. Deviation
H	25	0.064 – 1.91	1.006 ±0.1359
LWT	25	0.173 – 9.887	2.59±0.3752
LWOT	25	0.178 – 16.525	3.365±0.652
Total	75		
P > 0.000			

Table (5): ^{137}Cs activity concentration

Dependent Variable: Cs-137 (A_c Bq/g)			
Groups	NO.	Min. – Max.	Mean± Std. Deviation
H	25	0.052 – 0.41	0.18±0.047
LWT	25	0.1124 – 8.302	1.6 ±0.203
LWOT	25	0.0672 – 2.435	0.504±0.236
Total	75		
P > 0.000			

Table (6): ^{40}K activity concentration

Dependent Variable: K-40 (A_c Bq/g)			
Groups	NO.	Min. – Max.	Mean± Std. Deviation
H	25	0.84 – 93	29.89 ±4.843
LWT	25	4.005 – 100.48	37.35±4.103
LWOT	25	5.338 – 95.7	46.28±4.831
Total	75		
P > 0.000			

In order to compare between our result and another result than were found at:

U-238 Activity Concentration (ppm)		
	Healthy	Leukemia
Our study	0.33	1.7
1	0.1	1.4
2	------------	1.30111

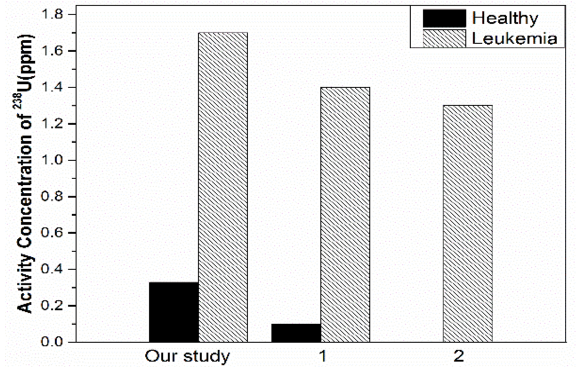

Fig (6); The Comparison between our study and another studies.

The procuring the Comparison between our study and another studies that were published

1) Iranian Journal of Medical Physics "Determination of Alpha Particles Levels in Blood Samples of Cancer Patients at Karbala Governorate, Iraq" (24),

2) College of Science City University Journal" Track Detection Technique Using CR-39 for Determining Depleted Uranium in Biological Specimens" (25).

The study showed that results were consistent with other studies.

4. UV-VIS SPECTROSCOPY:

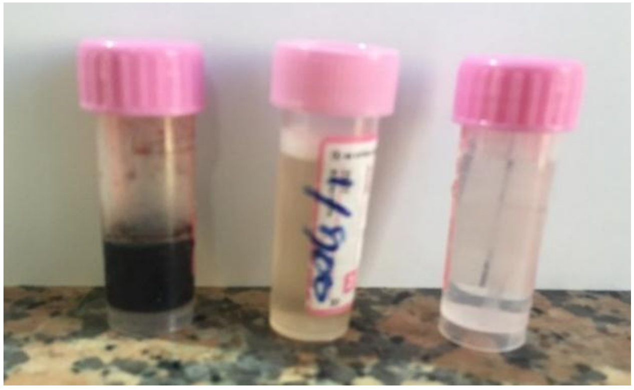

Fig (7): Blank blood, diluted blood sample and normal saline.

Blood samples were diluted by $(\frac{1}{500})$ times with Normal saline(Sodium Chloride) to be tested using UV and Vis spectroscopy (Cecil Aquarius CE 7200 Double Beam Spectrophotometer UV-Vis Spectroscopy). The main purpose of using this technique is to study and determine the continuities of the samples. Many different elements were found, the clearness and accurate absorption wavelengths were selected. In order to compare between the samples which, the results were plotted below.

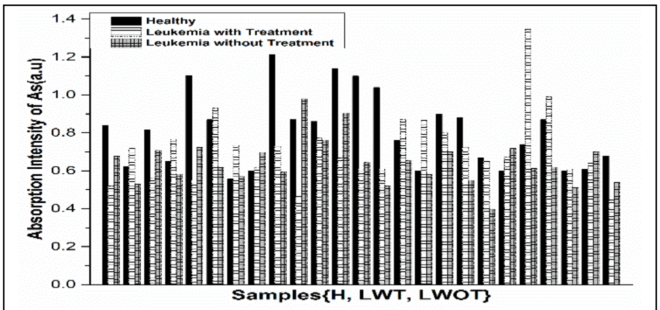

Fig (8); the Arsenic (As) element absorption intensity for all samples (Leukemia samples with and without treatment and in the healthy samples).

The results in fig (8) showed the concentration of Arsenic element is presented in all samples differently, which is highly concentrated in healthy blood samples and nearly the same at leukemic blood samples.

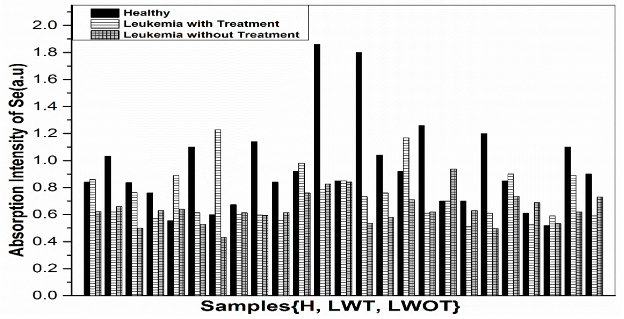

Fig (9); the Selenium (Se) element absorption intensity for all samples (Leukemia samples with and without treatment and in the healthy samples).

Fig (9) showed the Selenium elements concentration presented in some healthy samples are higher than in leukemia samples. At the same time, it does not present or appear in other healthy blood samples. This is a good indicator to support our knowledge that the continuities of healthy are leukemia samples are not the equal or the same, which is mean the leukemia maybe change and affected the blood cell continuities and that perhaps affect negatively the blood cell metabolic activity.

5. CONCLUSION:

The results are very interesting where showed that there are big differences in the concentration of the isotopes specially the ^{238}U, ^{234}Th, ^{40}K, ^{137}Cs. In addition, the activity concentration of ^{238}U is very important, which is showed the leukemic blood samples contains high concentration of Uranium isotopes that ranging from 0.046 Bq/Kg to 7.622 Bq/Kg, which consider high and encourage us to say the radioactive contamination or exposure to radiation are the main reason of leukemia disease, in contrast the concentration of Uranium isotopes in healthy samples are normal not more than 0.99 Bq/Kg. The results motivate us to find out about any relation between the cancer percentage and the life style of patients. For that many details of patient's life were recorded and the researcher looking for the relation and the reasons of these results through doing a survey and scanning of patient's life style.

The UV-Vis Spectroscopy results showed differences in the blood samples consistence, through find and pointed the differentiation between the elements types and concentration of these elements. The results showed that the concentration of Arsenic element is presented in all samples differently, which is being the highest in healthy blood samples up to 1.4 (a.u) and nearly the same at leukemic blood samples. In contrast the Selenium elements concentration is presented in some healthy samples are high up to 2.9 (a.u) that are higher than in leukemic samples. In the same time, it does not present or appear in other healthy blood samples. So we can conclude that in there the leukemic may be change in the blood cell consistence and that perhaps affect negatively the blood cell metabolic activity

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