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Determination of the activity concentration of radionuclide for human tissue (Healthy and Cancer) samples

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ABSTRACT

This study included measuring the mass radioactivity of uranium, thorium, and potassium in human tissue samples (healthy and carcinogenic) using gamma-ray spectrometer SAM940TM. A comparison was made between healthy and infected tissues, and large differences were found between them in terms of mass radioactivity. Twenty biological samples were collected from the governorates of Basra and Thi-Qar. These samples included (healthy and carcinogenic human tissues) from the human body and for the same organ (kidney, colon, and breast). This study showed that the highest value of mass radioactive activity of uranium is 97.73 Bq/Kg, while the activity of thorium was observed to be 256 Bq/Kg. It was close to the activity of healthy tissues, 2.15 Bq/Kg. As for the thorium-232 isotope, we note that the mass activity of the isotope for healthy and infected tissues is almost identical to the activity at the range of 42.78 Bq/Kg, which represents the black curve for healthy samples and the red curve for infected samples. Radon-226 isotope, it was noticed that there is a difference in radioactivity between healthy and infected samples, as the radioactivity of infected samples is greater than the activity of healthy samples, the low curved black color represents the activity of healthy samples, and the high curved red color represents the activity of infected samples, the highest value was 22 Bq/g. It also included a study of the activity of other elements present in biological samples, including (cadmium Cd-109, barium Ba-133, Cobalt Co-60, Bismuth Bi-207, Arsenic As-72 and Sodium Na-22).

Key words: activity, radionuclide, healthy, cancer, gamma ray spectroscopy

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INTRODUCTION

The environmental pollution has become of great problem of importance at the regional and global levels and has become a problem in many countries of the world at varying levels. Because of the large spread of cancer cases in Iraq, especially in the province of Basra, this matter convenience us to performance an analytical study to search for some of the causes of this disease, as the statistics of the Ministry of Health indicate that Basra records nearly more than seven thousand annually injuries. Every technological progress has positives that benefited the peoples also; theirs negatives effects that reflected on human health and the environment as well. The advantages of technological progress are evident that use for peaceful purposes at various scientific fields, the most important for medicine, industry, agriculture and others. These tremendous technological progresses were accompanied by the production of new types of chemical compounds that polluted the environment and all its elements (air, water, soil). As the increase that uses of such materials represents a serious threat of human life and other living organisms, because of exposure to their wastes of industry and technological progress of gases, dust and radiation spoil the environment in general and negatively affect all life. This lead to physical damage and sometimes be hereditary that appears in new generations [1]. Exposure to radiation has a slow-acting effect represented in stimulating the formation of malignant tumours. Therefore, it is necessary to subject the activities that involve exposure to radiation, such as the production and use of radioactive sources and radioactive materials, and the operation of nuclear facilities, including exposure to radioactive waste. At this time, the people are espousing approximately from (1msv/y) up to (100 msv/y) [1]. In order to protect people that exposed to radiation, the International Commission on Radiological Protection (ICRP) that is identifying the maximum permissible dose reaches is (10msv/y) [2].

Radiation and radioactive materials are the normal and permanent features of the environment, so the risks associated with exposure to radiation. It has become an essential means of disease control, and the use of nuclear energy and its by-product applications (radiation and radioactive materials) is increasing worldwide, benefiting millions of people [1]. People are constantly exposed to ionizing radiation from a natural radioactive source. The origin of these materials is the earth's crust, but they find their way by building their condition in air, water, food, and the human body itself [3]. All living bodies are contents the cells, which build it from atoms. Radiation can interact with these atoms in several aspects, meaning that it either ionizes the atom or interacts with its nucleus and is considered the basic level. Most important in terms of biological damage, each of these interactions can have serious consequences if they lead to a weakening of the bonds between atoms [4].

Uranium is a major contamination concern due to its radioactivity and heavy toxicity. Uranium and its compounds are highly toxic and threaten human health and environmental balance [5]. Depleted uranium is a by-product of the nuclear industry. It was used in the Gulf War in 1991. In southern Iraq, depleted uranium remained and became a major problem of environmental pollution because its levels rose after the first and second Gulf wars in 2003. Uranium can reach the human body, either directly by inhaling dust particles that carry uranium or drinking water contaminated with uranium in various ways, or indirectly from the fertile soil layer through the food chain [6]. The solubility of uranium varies with specific compounds and solvents, and this solubility determines how quickly and efficiently the body absorbs it through the lungs and intestines [7]. This prompted us to investigate the main problem that causes these deadly diseases. Several techniques were used to achieve this goal, including the use of the SAM940TM gamma ray spectrometer, which consists of a gamma ray detector (NaI (TI)) to determine the natural radioactivity of (^{238}U, ^{234}Th, ^{40}K, ^{226}Ra and ^{232}Th).

The three main types of radiation are alpha, beta and gamma radiation, but since alpha and beta radiation have particularly short penetration ranges, they are only a serious health risk in direct skin contact, or when inhaled or ingested [11]. Gamma radiation has a much wider range of effect, and threatens a health risk over a wider area. It is therefore important to be able to detect it and accurately determine its sources and concentration. Radiation damage to tissue and/or organs depends on the dose of radiation received, or the absorbed dose .The potential damage from an absorbed dose depends on the type of radiation and the sensitivity of different tissues and organs. The effective dose is a way to measure ionizing radiation in terms of the potential for causing harm. The Sv takes into account the type of radiation and sensitivity of tissues and organs.

Beyond certain thresholds, radiation can impair the functioning of tissues and/or organs and can produce acute effects such as skin redness, hair loss, radiation burns, or acute radiation syndrome. These effects are very severe at higher doses and higher dose rates. For instance, the dose threshold for acute radiation syndrome is about 1 Sv (1000 mSv). If the dose is low or delivered over a long period of time (low dose rate), there is greater likelihood for damaged cells to successfully repair themselves. However, long-term effects may still occur if the cell damage is repaired but incorporates errors, transforming an irradiated cell that still retains its capacity for cell division. This transformation may lead to cancer after years or even decades have passed. Effects of this type will not always occur, but their likelihood is proportional to the radiation dose. This risk is higher among children and adolescents, as they are significantly more sensitive to radiation exposure than adults [12]. Mechanism of radiation's effect health mentioning in figure below.

Exposed to radiation (for example atomic bomb survivors or radiotherapy patients) showed a significant increase of cancer risk at doses above 100 mSv. Prenatal exposure to ionizing radiation may induce brain damage in foetuses following an acute dose exceeding 100 mSv between 8-15 weeks of pregnancy and 200 mSv between 16-25 weeks of pregnancy. Before week 8 or after 25 week of pregnancy human studies have not shown radiation risk to fetal brain development. Epidemiological studies indicate that cancer risk after fetal exposure to radiation is similar to the risk after exposure in early childhood.

Determination and analysis of radio-nuclei in leukemia blood samples using SAM940TM detector, 2019. The researchers improve that there is a clearly significant different in the activity concentration of (^{238}U, ^{234}Th also ^{226}Ra) isotopes in the study samples [13].

Estimation of depleted uranium concentrations for different tissues of the human body using the nuclear trace detector (CR-39) and the concentrations were (1.94-0.11) ppm [14].

Wasfi Muhammad Kazem (2003) finding depleted uranium concentrations for biological models, and the ppm concentrations of uranium in blood were (0.041-0.046) and for tissues ppm (0.039-0.046) [15].

Determining depleted uranium concentrations in human tissues using the nuclear trace detector (CR-39) and the average uranium concentrations for samples collected before the war were (0.0904 ppm), (0.078 ppm, (0.073 ppm) for each of the uterine samples The average concentrations of depleted uranium for samples collected after the war are (0.991ppm), (0.817ppm), and (0.749ppm) for each of the tissues of the uterus, kidneys, and digestive system, respectively [16].

Determining uranium concentrations in biological models and the concentrations of uranium in blood samples (leukemia) were (202-66 ppb) and in tissues the concentrations were (1910-116 ppb) [17].

Determining uranium concentrations in human tissues (breast and uterus). The concentrations of uranium were in (uterus) using CR-39 and a water bath (0.062 ppm). Using the microwave (0.047 ppm), Uranium concentrations in (breast) CR-39 using water bath (0.060 ppm) and using microwave (0.039 ppm) [18].

Kazem and his group (2016), they determined the radioactivity of radioactive isotopes (^{40}K, ^{131}I, ^{134}Cs, ^{137}Cs) in the food consumed in Basra Governorate, southern Iraq, and they used the SAM940TM gamma ray spectrometer to detect and identify radioisotopes with low levels of gamma rays Emitted from foodstuffs The results showed that the effective annual dose of radioactive potassium 40K in food stuffs had the highest value in local fresh milk (0.529, 0.217 mSv/y) for adults and children, respectively, for a sample taken from Zubair district, and the lowest value (0.186, 0.076 mSv/y) for adults and children, respectively, for a sample taken from the Abu al-Khasib district [19].

METHODS

The SAM940^{TM} gamma-ray spectroscopy utilized to analyse and study spectrum of gamma ray that emitting from study samples. The SAM 940^{TM} was connected with a NaI(TI) crystal detector for detecting the gamma rays, this detector have ability to detect and measures radioactivity at low levels. The detector calculates a Region of Interest (ROI) for the optical peak and gives an accurate description of the area under the optical peak, i.e. the count, as well as the net count rate (cps) and the Minimum Radioactive Activity (MDA), in addition to measuring the Critical Level (CL).

The SAM 940 TM operates at an operating voltage (Bias=600 V) and is connected to a Multi-Channel Analyzer (MCA) that converts the linear pulses produced from the main amplifier into logical pulses by an Analogue–Digital Converter (ADC) and stored in the group size=memory. 256 channel according to its capacity in locations that depend on the amplitude of the pulse and then display it in a visual image of the differential spectrum to form the statistical distribution of the pulses or the energy spectrum according to the PHA pulse analysis pattern and by using Quadratic Compression Conversion (QCC) compression from ^{16}K to ^{256}K channels is Coarse Gain=1 and Fine Gain=1.1386 [2].

Twenty samples were collected from Al-Saadr Teaching Hospital from the Oncology Department for a sample of human tissues (healthy and cancerous) on three types of breast, kidney and colon cancer. The samples w kept in a circular container with a diameter of 2 cm containing formalin at a concentration of 10% to prevent damage to the sample and at a temperature of 4C°.

Samples preparation

1. Washing the samples with distilled water and cutting them into small pieces in order to freeze them with a lyophilized for twenty-four hours after the sample became hard.
2. The samples were ground with apulverize and a powder was obtained.
3. Then the samples pressed to make the diameter about 20 mm, as shown in the figure below (Figure 1).
4. Samples were coded to distinguish between them
5. Each sample was tested and analysed by SAM940™ after the radioactive background was measured. The specific activity for each radionuclide calculated using the following equation [8].

$$A_c\left(\frac{Bq}{kg}\right)=\frac{c}{t.m.\varepsilon.I\gamma}$$

A_c: The specific activity concentration of the radionuclide measured in units $\left(\frac{Bq}{kg}\right)$

C: count.

ε : efficiency.

t: time in seconds.

$I\gamma$: It is the percentage of the gamma emission probability of the radionuclide under study.

m: the mass of the sample in grams.

RESULTS & DISCUSSION

The radioactivity of the radioactive isotopes that including in all samples was estimated for 20 healthy tissues and 20 cancerous tissues from 20 patients of different cancers organs, for each patient from the same organ before treatment and irradiated (Table 1 and 2).

Fig. 1. Sample representation

Tab. 1. It shows the code of the healthy and infected sample, the sex of the patient, and the living areas

No.	Symbol		injured member	Age (Years)	Location	Gender
	Normal	Abnormal				
1	No1	ANo1	Breast	52	Basra	Female
2	No2	ANo2	Kidney	51	Basra	Female
3	No3	ANo3	Breast	60	Basra	Female
4	No4	ANo4	colon	50	Basra	Male
5	No5	ANo5	Kidney	50	Basra	Female
6	No6	ANo6	Breast	60	Basra	Female
7	No7	ANo7	Breast	52	Basra	Female
8	No8	ANo8	Breast	48	Basra	Female
9	No9	ANo9	kidney	48	Basra	Male
10	No10	ANo10	Breast	56	Basra	Female
11	No11	ANo11	Breast	31	Basra	Female
12	No12	ANo12	Breast	52	Basra	Female
13	No13	ANo13	Breast	40	Basra	Female
14	No14	ANo14	Breast	53	Basra	Female
15	No15	ANo15	Breast	54	Basra	Female
16	No16	ANo16	Kidney	59	DhiQar	Female
17	No17	ANo17	Breast	54	Basra	Female
18	No18	ANo18	Breast	45	Basra	Female
19	No19	ANo19	Breast	41	DhiQar	Female
20	No20	ANo20	Breast	45	Basra	Female

Tab. 2. Radioactivity of carcinogenic and healthy tissues

S. No.	$^{238}A_U$(Bq/Kg)	$^{234}A_{th}$(Bq/Kg)	$^{40}A_K$(Bq/Kg)	$^{226}A_{Ra}$(Bq/Kg)	$^{232}A_{Th}$(Bq/Kg)
AN1	12.25	13	2.15	0	0
N1	0	0	2.15	6.45	0
AN2	0	6.28	0	0	0
N2	1.17	0	0	6.5	0
AN3	0	0	0	0	25
N3	0	0	2.2	0	24.8
AN4	0	0	1.43	0	42.78
N4	0	0	0	6	42.78
AN5	0	0	0.86	0.644	25.2
N5	0.97	12.56	3	11.34	27.14
AN6	15.43	0	4.3	0	0
N6	0	0	2	0	24
AN7	97.73	0	0	0	0
N7	0	0	0	7	0
AN8	0	12.6	0	0	26
N8	0	0	0	33	30
AN9	0	0	0.72	0	0
N9	0	0	0	6.33	0
AN100	12.35	0	0	0	0
N10	0	0	0	6.48	0
AN111	0	255.88	1.43	5	22.95
N11	0	0	0	5.55	24.4
AN122	0	0	0	0	0
N12	0	0	0	0	0
AN133	4.97	0	0.85	4.3	0
N13	0	0	1.4	5	0
AN144	0	0	0.86	0	0
N14	0	4.2	0.715	0	0
AN155	0	0	0	0	16.4
N15	1.6	8.4	0	0	21.6
AN166	8.4	0	0	0	0
N16	0	0	0	0	0
AN177	8.16	0	0	0	0
N17	0	0	0	0	0
AN188	0	0	0	0	9
N18	0	0	0	4.37	10
AN199	0	256	0	22	0
N19	0	0	0	0	0
AN200	0	102.7	0	0	0
N20	0	0	2.14	0	0

Tab. 3. Mass activity of some elements in healthy and injured tissues

S	Tissue	Isotopes							
		Ac_{228} (Bq/Kg)	Ba_{133} (Bq/Kg)	Cd_{109} (Bq/Kg)	Co_{60} (Bq/Kg)	Pb_{214} (Bq/Kg)	As_{74} (Bq/Kg)	Bi_{207} (Bq/Kg)	Na_{22} (Bq/Kg)
S_1	NO	–	—	—	–	–	–	0.763	–
	ANO	3.14	2860	—	–	0.435		5.52	–
S_2	NO	2.03	—	—	—	—	—	—	—
	ANO	2.5	—	2234.24	—	—	1.053	2137.04	—
S_3	NO	—	—	—	—	—	—	—	—
	ANO	0.5	—	—	854.7	—	—	—	—
S_4	NO	–	–	–	-	-	—	0.634	—
	ANO	2.6	3170	1700.3	-	-	3.57	—	0.49
S_5	NO	1.3	—	3.684	1600.04	—	—	—	–
	ANO	—	3285.7	—	4280	0.85	1.135	—	—
S_6	NO	0.45	294	—	—	—	—	—	—
	ANO	—	—	—	—	—	0.743	—	0.18
S_7	NO	–	–		—	—	—	—	—
	ANO	–	3220	3745.5	—	—	0.743	0.534	0.545
S_8	NO	—	—	—	—	—	—	1.662	
	ANO	0.03	—	—	4120.37	1.053	—	—	0.453
S_9	NO	—	—	—	—	—	0.09	0.73	2.032
	ANO	—	—	—	—	—	—	—	0.82
S_{10}	NO	0.1643	–	–	–	-	-	-	–
	ANO	–	157.4	4304.33	4873.309	–	–	–	380.65

S_{11}	NO	–	–	–	–	–	–	–	–
	ANO	–	–	–	–	0.853	3.15	950.43	–
S_{12}	NO	–	–	–	–	–	0.436	–	–
	ANO	–	2367.4	–	–	–	3.61	–	0.24
S_{13}	NO	0.06	–	–	–	–	265	0.483	–
	ANO	0.08	–	–	–	–	–	–	0.78
S_{14}	NO	–	–	–	6.32	–	0.42	–	–
	ANO	–	–	–	3926.7	–	–	0.342	–
S_{15}	NO	–	3.602	–	–	–	–	–	–
	ANO	–	–	–	0.653	–	–	–	1.74
S_{16}	NO	–	–	–	–	–	–	–	–
	ANO	–	1.53	–	–	3.353	–	–	–
S_{17}	NO	–	–	–	–	–	–	–	–
	ANO	–	–	–	0.153	–	–	–	3.64
S_{18}	NO	–	–	–	–	–	0.043	127.04	–
	ANO	–	–	3945.832	432.54	–	1.832		–
S_{19}	NO	–	–	–	–	–	–	–	–
	ANO	–	2950	–	–	–	–	–	0.523
S_{20}	NO	–	3087.5	–	364.5	–	–	0.71	0.24
	ANO	–	–	–	–	–	–	0.432	1.73

Fig. 2. The activity concentration of (U^{238}) in normal and abnormal tissues

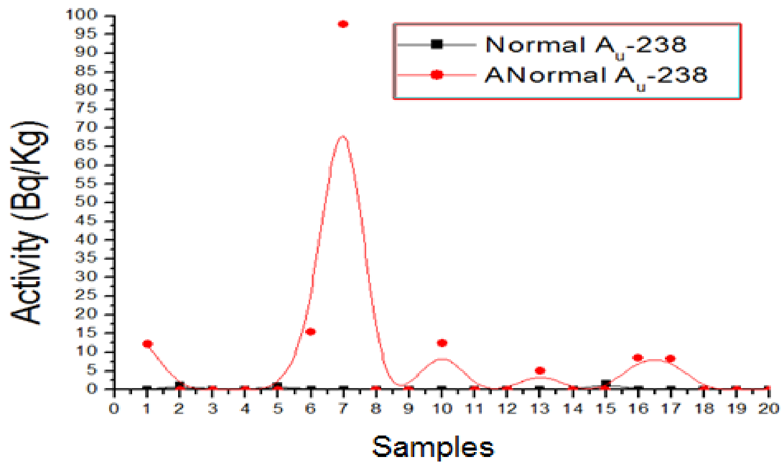
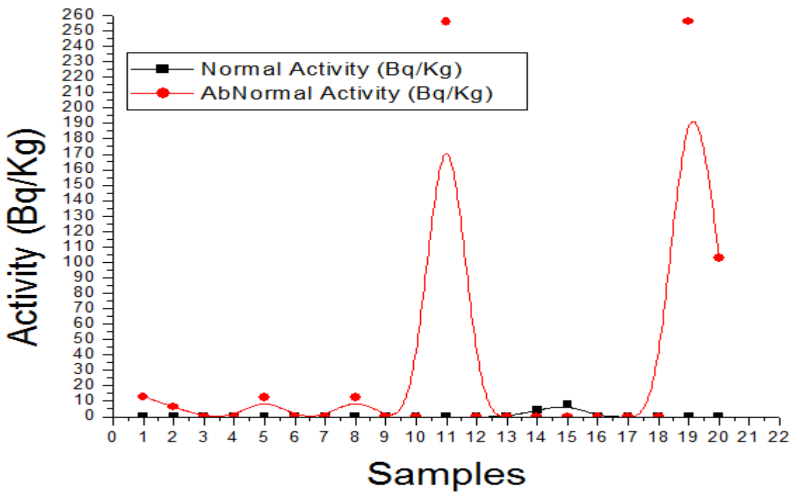


Fig. 3. The activity concentration of (Th^{234}) in normal and abnormal tissues



The result showed very interesting data that belonging the activity concentration of many isotopes, the data clearly a beer high different in emission radiation activity between the normal and abnormal tissue, these data showing in Table 3.

Figure (1); represents the activity concentration of the uraniumU238 isotope for healthy and infected tissues, as the low curve in black represents the activity of the uranium element in healthy tissues, and the high curve in red represents the activity of the uranium 238U isotope in infected tissues. From the figure (1), the one can see the activity concentration of 238U isotope is too high in sample seven (Abnormal sample she is 52 years woman suffering from breast cancer from city of Basra). That consider a high activity compeer with the activity of normal sample for the same patient, also the activity concentration of samples 1, 6, 10, 16 and 17 bit high if its compeer with its normal samples.

Figure (2) represents the activity of the thorium isotope234Th in healthy tissues in black and the activity of infected tissues in red, the activity concentrations of 234Thare clearly high in Abnormal tissue in both samples 11 and 19 compeer with their normal samples, also the activity is high in Abnormal tissue in sample 20. Figure (3), which represents the activity concentration of the Potassium isotope k40for healthy and infected tissues, the figure showing there, is no clear different in activity concentration of Potassium isotope in all study samples.

The activity concentration of Radium-226 also the Thorium-232 isotopes were estimated. Figures below showed there is a highly significant different in the activity concentration of ^{226}Ra isotope, especially in samples (8) for female at 48 years old from Basra suffering from breast cancer and sample (19) also for female at 41 years old from Thi-Qar had breast cancer, compare with hers healthy tissues. Nevertheless, there is no different in the activity concentration of ^{232}Th isotope in the study samples (Figure 4 and 5).

Fig. 4. The activity concentration of (k40) in normal and abnormal tissues

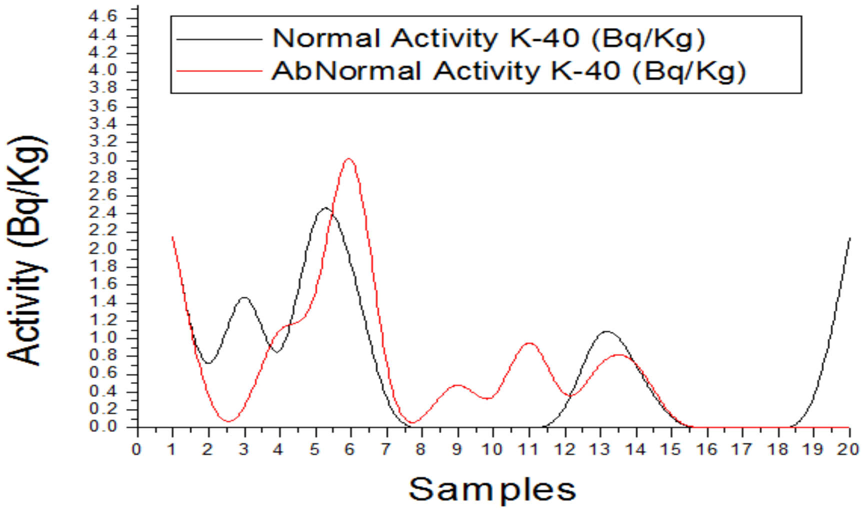


Fig. 5. The activity concentration of (^{232}Th) in normal and abnormal tissues

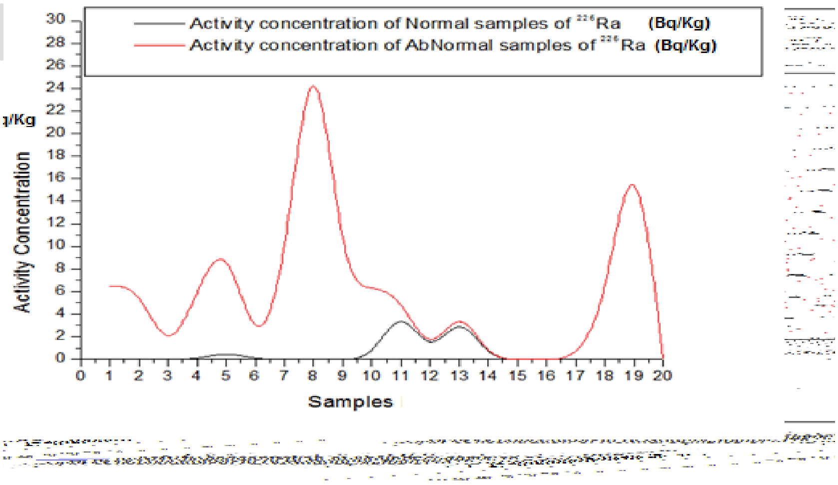
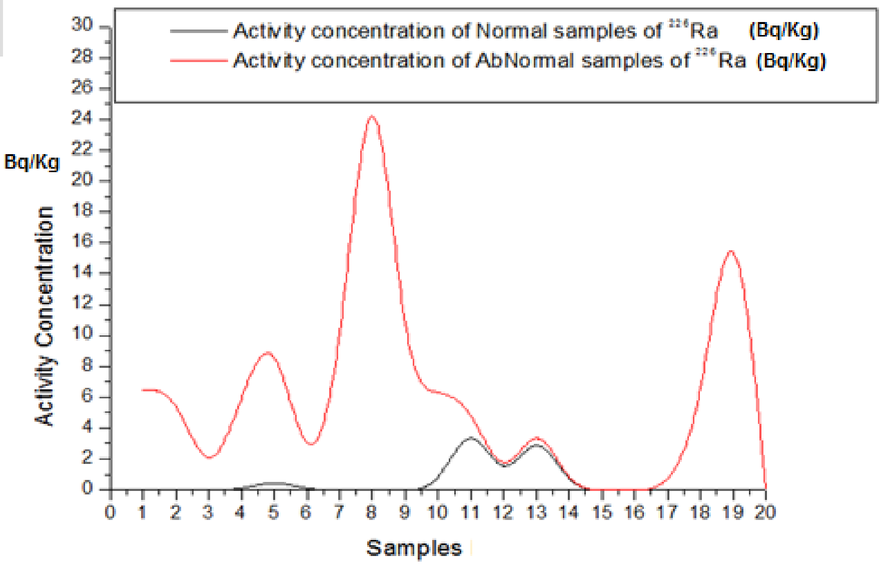


Fig. 6. The activity concentration of (^{226}Ra) in normal and abnormal tissues



CONCLUSIONS

Because of the wide spread of cancer dieses in Iraq especially in the south of Iraq for example the province of Basra, this matter encourage us to researching in an analytical study to looking for some of the reasons of this disease. The statistics data of the Ministry of Health indicate that Basra records nearly more than seven thousands cancer cases annually, so that encourage us to deal with this kind of research in order to standing on some of the series reasons of this disease. From viewing of some previous medical reports, this indicated that radioactive contaminations as well as heavy metal pollution are among the causes of these incurable diseases. By analysing the study results, which is showing of a large difference in the activity concentration of the uranium isotope, as it was found in the affected tissues, the maximum activity of uranium isotope about of $^{97.73}$Bq/g. In addition, the activity of thorium isotope it was observed to be ^{256}Bq/Kg, which is being activity in healthy tissues, and it was equal to 12.56, compared with infected tissues. While potassium has been observed that, its activity in infected tissues is close to the activity of healthy tissues through the graph which is equal to $^{2.15}$Bq/Kg. In addition, the most interesting results showed through studied the activity concentration of Ra-226 isotope, which is reached up to ^{24}Bq/Kg for sample (8) that bellowing Female at 48 years old living Basra city at south of Iraq. Also there is another sample (19) showed highly activity concentration about ^{17}Bq/Kg that is bellowing a Female at 41 years old living in Dhi-Qar. In order to go more deep to understand the relation between the activity concentration of some kind of radio-isotope inside the human body and the possibility of cancer, we need to looking for more details regarding the life style of patients, patient environment, working place and their social status and more, so that we need to do accurate analysis (Survey). On the other hand, from the conclusions that we have reached, that one of the causes of cancer is the high concentrations of the following radioactive elements (uranium, thorium and Radium), which humans are exposed through environmental pollution or exposure to radiation. Therefore, the activity of uranium in normal healthy tissues does not exceed 0.01, or it is absent in contrast it's about ^{70}Bq/Kg in cancer tissues. These results lead us to know one of the causes of infection.

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