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جمهورية العراق
وزارة التعليم العالي والبحث العلمي
جامعة النهرين / كلية العلوم
قسم الفيزياء

تحديد تراكيز اليورانيوم في الدم البشري في بعض محافظات العراق باستخدام كاشف الأثر CR-39

رسالة

مقدمة إلى كلية العلوم– جامعة النهرين

وهي جزء من متطلبات نيل درجة الماجستير في الفيزياء

من قبل

سجى فائز حسن

بكالوريوس ٢٠٠٣ (جامعة النهرين)

بأشراف

د.ندى فاضل توفيق

محرم ١٤٢٧هـ

شباط ٢٠٠٦م

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

﴿ وَأَقِيمُواْ الصَّلاَةَ وَآتُواْ الزَّكَاةَ وَمَا تُقَدِّمُواْ لأَنفُسِكُم مِّنْ

خَيْرٍ تَجِدُوهُ عِندَ اللّهِ إِنَّ اللّهَ بِمَا تَعْمَلُونَ بَصِيرٌ ﴾ صدق

اللَّهِ العظيم

﴿ البقره: ١١٠﴾

الخلاصه

في هذه الدراسه تم قياس تركيز اليورانيوم وحساب الفعاليه الاشعاعيه النوعيه في الدم البشري(اللوكيميا والاصحاء) الماخوذه من مناطق مختاره لمحافظات القطر وقد استخدمت تقنيه عد اثار شظايا الانشطار النووي الناتج من انشطار نواه اليورانيوم-٢٣٥ المقصوفه بالنيوترونات الحراريه من المصدر النيوتروني (Am-Be) بفيض نيوتني ($5 \times ١٠^{3} n.cm^{-1}.s^{-1}$) وم تحديد تراكيز اليورانيوم بالحسابات المعتمده بالمقارنه مع النماذج البيولوجيه القياسيه والتي تم تحضيرها.

ان معدل اعلى تركيز لليورنيوم في الدم كان في محافظه البصره (1.654 ppm) اما اقل معدل تركيز لليورانيوم في الدم كان في محافظه بغداد (0.135 ppm).

تم حساب الفعاليه الاشعاعيه النوعيه لنماذج الدم في تلك المناطق وقد بلغت اعلى معدل في محافظه البصره ($1.43 \times 10^{-1} Bq/g$) واقل معدل ($0.1258 \times 10^{-1} Bq/g$) في محافظه بغداد وكما تم حساب تركيز اليورانيوم في الدم للمصابين بمرض اللوكيميا وقد كان اعلى تركيز (1.841 ppm) في محافظه المثنى واقل (0.364 ppm) تركيز في محافظه ديالى.

اما بالنسبه للفعاليه الاشعاعيه النوعيه فقد كان اعلى قيمه ($١٠ \times 1.79^{-1} Bq/g$) في محافظه المثنى واقل تركيز($0.34 \times 10^{-1} Bq/g$) في محافظه ديالى.

لقد قورنت نتائج تراكيز اليورانيوم مع الحد المسموح به والمنشور من قبل الوكاله الدوليه للوقايه من الاشعاع (ICRP) وكذلك تم مقارنه نتائج حسابات الفعاليه الاشعاعيه النوعيه لنماذج الدم مع الحد المسموح به والمنشوره من قبل الوكاله الدوليه للطاقه الذريه (IAEA).

ABSTRACT

This study includes measurement of uranium concentration and calculates the specific activity in human blood samples (leukemia and health people) taken from some governorates of Iraq by using fission fragment track technique.

The nuclear reaction used as source of uranium fission fragment is U-235 (n, f), obtained by the bombardment of U-235 with thermal neutrons from (Am- Be) source which has a flux of (5×10^3 $n.cm^{-2}. s^{-1}$) , the concentration values were calculated by comparison with standard biological samples which prepared.

The highest rate of uranium concentration in human blood was (1.654 ppm) in Basrah governorate and the lowest rate of uranium concentration in human blood was (0.153 ppm) in Baghdad governorate. And also calculate the specific activity for human blood samples in those regions and found that the highest rate was (1.43×10^{-1} Bq/g) in Basrah governorate and the lowest rate was (0.1258×10^{-1} Bq/g) in Baghdad governorate.

The highest of uranium concentration was (1.841 ppm) for leukemia sample in Al-Muthana governorate and the lowest uranium concentration was (0.364 ppm) in Diyala governorate, and the specific activity was calculated for leukemia samples and found that the highest activity was (1.79×10^{-1} Bq/g) in Al-Muthana governorate and the lowest activity was (0.34×10^{-1} Bq/g) in Diyala governorate.

Uranium concentration results compared with permissible limit who purplish from ICRP agency and the specific activity calculations for human blood samples compared with permissible limit who published from IAEA agency.

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List of symbols

Symbols	Identity
SSNTDs	Solid state nuclear track detector
ppb	Part per billion
ppm	Part per million
V_B	Bulk etch rate
V_T	Track etch rate

L	Track length
D	Track diameter
H	Removal layer thickness
C	Concentration
a.m.u	Atomic mass units
ρ	Track density
θc	Critical angle
Φ	Incident angle
C.S	Cross section
S_A	Specific activity
U	Uranium
DU	Depleted uranium
IAEA	International atomic energy agency
ICRP	Intentional commission on radiological protection
NCRP	National council on radiation protection
NRC	Nuclear regulatory commission
AEPI	Army environmental policy institute
ATSDR	Agency for toxic substances and diseases registry

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DEDICATION

TO
MY FAMILY

Republic of IRAQ
Ministry of Higher Education
And Scientific Research
AL-Nahrain University
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Physical Department

DETERMINATION OF URANIUM CONCENTRATION IN HUMAN BLOOD SAMPLES IN SOME GOVERNORATES OF IRAQ BY USINGCR-39 TRACE DETECTOR

A Thesis

Submitted to the College of Science

Al-Nahrain University

In Partial Fulfillment of the Requirements for the Degree of Master of Science in

Physics

By

Saja Faez Hassan

(B.Sc. 2003)

Supervised by

Dr.Nada F. Tawfik

MUHRRAM
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2006 A.D.

Examination Committee Certificate

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February 2006.

1.1 Composition of Blood

Blood is a type of connective tissue, consisting of cells and cells fragments surrounded by a liquid matrix, which circulates through the heart and blood vessels, total blood in female (4-5) litter, male (5-6) litter cells and cell fragments it is about 45% of blood while plasma is about 55% (Berence & Veny 1987), all blood cells develop from stem or precursor cells that are produced principally in the bone marrow (WHO 2001), as shown in figure (1-1).

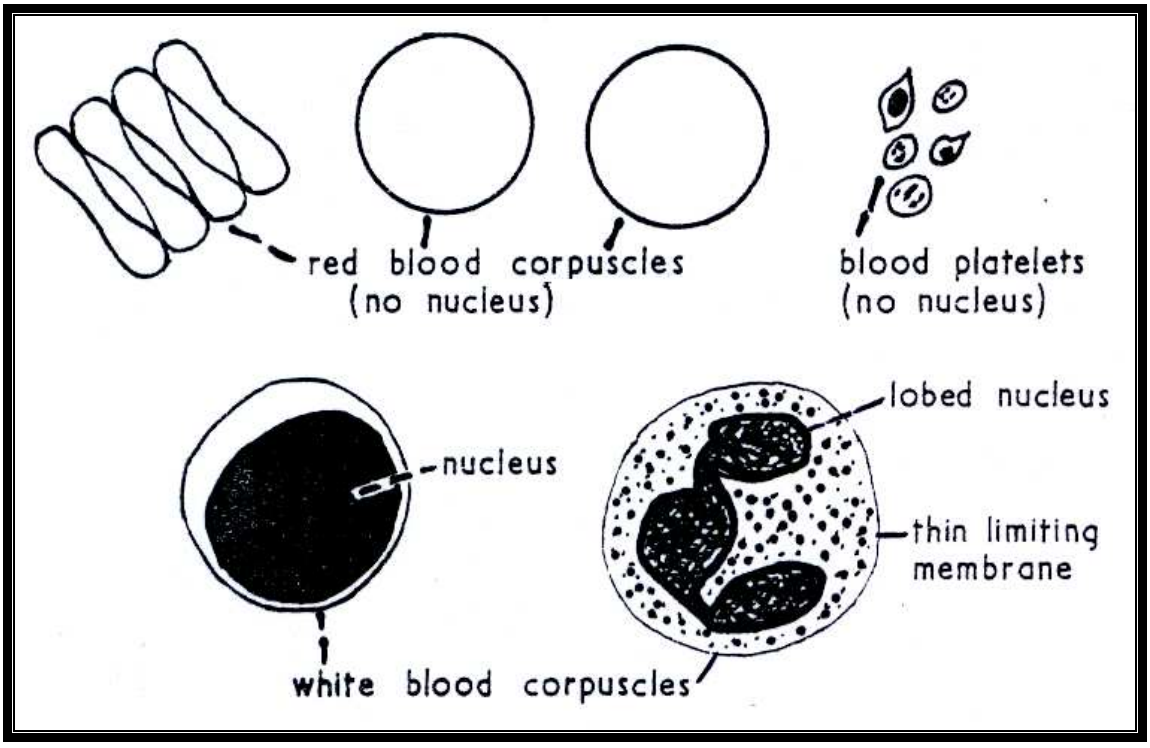

Figure (1-1) Blood cells under the microscope (2000x) (Whellock 1974).

1.1.1 White Blood Cell:

It colorless nucleated cells whose primary function is protection against invading organisms (Emmanuel 1992). They help to defend the body against infections diseases and foreign materials as part of the immune system (Whellock 1974).

White blood cells (leucocytes) are a family of cells consisting of:

- Granulocytes
- Lymphocytes
- Monocytes

They are produced in the bone marrow and lymphatic tissue. Their principal role in the blood is to identify, destroy and remove any foreign material that has entered the body. These cells are therefore important in fighting infection and in developing resistance to infection in response to natural exposure or immunization. White cells occupy less than (1 %) of the total blood volume (WHO 2001).

1.1.2 Red Blood Cell:

RBCs are disk-shaped and biconcave. Because the cell does not have a nucleus, its life span is limited by its energy supply (Emmanuel 1992). The diameter cell (8.4µm) and thickness (4.2µm), the cell contain on (71 %) water, (28%) dye, (0.7%) lipids, (0.3%) different compositions (Harris 1963, Deli 1984). The name of the red blood cell reflects the bright red color of the cell that occurs when oxygen is attached to the hemoglobin. Blood cells are responsible for carrying oxygen and carbon dioxide between lung and the tissues content in their cytoplasm.

1.1.3 Platelets:

Platelets are small fragments of cells (megakaryocytic), which are produced in the bone marrow and contain enzymes and other biologically active substances (mediator). Their function is to respond to any vascular wall damage by gathering together at the site of injury to form an initial temporary platelets plug and releasing their contents into the blood (Beck 1987), the released contents of platelets are largely responsible for the subsequent coagulation process by activating the blood clotting mechanism that results in the department deposition of a fibrin clot at the site of damage, preventing further bleeding. The cells have a life span of about 1 week (Emmanuel 1992).

1.1.4 Plasma:

Plasma is a pale yellow fluid that consist of about 91% water and 9% other substances (electrolytic, and protein). Plasma is colloidal solution, which is a liquid containing suspended substance that does not settle out of solution (Emmanuel 1992).

1.2 The Effect of Radiation on The Composition of Blood

The effect of radiation in lymph cells and platelets is fast, but it is faster than in the grains cells. The change of composition of blood in the body appears on the damage form as the following (Al-Dargazelli 1987):

1. Anemia, which is a lack of red blood cells and produces fatigue.
2. Fatigue, which occurs when the cells do not receive enough oxygen, because there are not enough cells to carry oxygen.

3. Susceptibility to infection, because there are not enough white cells to fight bacteria, viruses, and other microbes.
4. Bleeding, this can occur when there are not enough platelets to help with blood clotting.
5. Leukemia, which occurs because increasing numbers of immature white blood cells.

1.3 Leukemia

Leukemia is a form of cancer that begins in the blood-forming cells of the bone marrow-soft, inner part of the bones. Leukemia which literally means " White – Blood" in Greek- occurs when there is an excess of abnormal white blood cells in the blood, known as leukocytes, these cells are so plentiful in some individuals that the blood actually has a whitish tinge (Jeffrey 1992), the mains four types are (William & Beck 1991):

- Acute lymphocytic leukemia (ALL) the cancer begins in immature granulocytic blood cells and progresses very quickly.This type occurs in both adults and childeren. It is called acut myelocytic leukemia.
- Acute myelogenous leukemia (AML) the cancer begins in immature lymphocytic blood cells and progresses very quickly. This type occurs in highly curable in childeren. This type of leukemia is called acute lymphocytic leukemia.
- Chronic myelogenous leukemia (CML) the cancer begins in more mature granulocytic blood cells and progresses gradually. This occurs in adults, but may occur in a very small number of childeren. It is called chronic myeloid leukemia.

- Chronic lymphocytic leukemia (CLL) the cancer begins in more mature lymphocytic blood cells and progressses gradually. This type occurs mainly in adults over age 55. It is called chronic lymphoid leukema.

The most common forms in adults are AML and CLL, whereas in children ALL is more prevalent.

1.4 The Aim of Study

The aim of this study is to determine the concentration and specific activity of uranium in human blood for leukemia and other samples of blood in different regions of Iraq to assess the environmental risks associated with distribution of uranium after 1991 war.

1.5 Pervious Studies

Several studies were made using solid state detectors. Also, several techniques were applied on biological samples (like tissue, bones, and blood). Those studies were:

- Picer M., 1968 measured uranium concentration in human blood as 5×10^{-10} g/ml.
- Hamilton E. I.., 1970 measured uranium concentration in blood, the concentration was (0.25 - 1.41) ppb.
- Cheek C.H. & Carpenter B.S., 1970 they made a study in blood and plasma. The results were (8.6±5.6) ppb in blood and (60.5±12.0) ppb in plasma.
- NagPaul K.K. & Parshah R., 1979 arrived to concentration approximately (0.89±0.1- 17.9±0.15) ppb.

- Koul S.L. & Chadderton L.T., 1979 measured the uranium concentration; the results were (0.35 - 0.6) ppb in blood and (0.11- 0.82) ppb in plasma.
- Segovia N. & Romer M., 1984 they were obtained uranium concentration (1.4 - 1.5) ppb in blood and (0.96 - 1.6) ppb in plasma.
- Gaswami T.D. & Das K.C., 1986 they were found uranium concentration in blood approximately (0.33±0.023 - 0.74±0.034) ppb.
- Segovia N. & Olguin M. E., 1986 they made a study on different blood species (Normal, exposed to radiation and leukemia patients). The results were (0.91) ppb in blood, 0.98) ppb in plasma, (0.80) ppb in blood, (1.04)ppb in plasma, and (1.70) ppb in blood, (1.75) ppb in plasma respectively.
- Sultan M. F., 2001 measured uranium concentration in leukemia in Iraq was (0.066_ 0.2) ppm.
- Al-Gailani A. W., 2003 made a study on human blood. The uranium concentration was approximately (0.03 - 0.114) Bq/ml in lymph cells.

2.1 Natural Uranium

Uranium is a radioactive and chemical element, represent by (U) symbol (Harigel 2002). It was isolated in 1889 by a German chemist "Martin Heinrich Klaproth" in a sample of pitchblende from Saxony (McGraw-Hill 1987). It is named after the planet Uranus, which had been discovered eight years earlier (IAEA 1990).

Natural Uranium contains: 99.7245 % of U-238, 0.72 % of U-235, and 0.0054 % of U-234 (IAEA 1988; Riemann and Garitat 1998), they all have 92 protons in the nucleus, but 146, 143 and 142 neutrons, respectively. The half-lives of U-238, U-235, and U-234 are $4.49x10^9$, $7.10x10^8$, and 2.48x105 years, and respectively. The longer half-life the less radioactive decay products appear in a given time interval and could effect human health (Zajic 1999).

Uranium is ubiquitous throughout the natural environment, being found in varying but small amounts in rocks, soils, water, air, plants, animals and all human beings (WHO 2001).

The Total amount of natural uranium on earth stays almost the same because of the very long half –lives of the uranium isotopes. The Natural Uranium can be moved from place to place by nature or by people, and some uranium is removed from the earth by mining. When rocks are broken up by water or wind, uranium becomes apart of the soil, when it rains, the soil containing uranium can be carried into rivers and lakes, wind can blow dust that contains uranium into air (ATSDR 1999).

Natural Uranium is heavy element found in nature in different form and the human body contains (90 µg) as average result from food chain about 66% are found in the Skeleton, 16% in the liver, 8% in the kidneys, and 10% in other

tissues. The average intakes of uranium by adults are estimated to be (460 µg) from ingestion and (0.59 µg) from inhalation (WHO 2001).

Uranium is widespread in nature, in a wide variety of solid, liquid and gaseous compounds. It readily combines with other elements to form uranium oxides, silicates, carbonates and hydroxides (AEPI 1995). These compounds differ substantially in their chemical and physiological properties and in the toxicological effects they exert (Rostker 2000). The physiological behaviors of uranium compounds depend mainly on their solubility. Soluble uranium is regulated because of it is chemical toxicity; while insoluble (less uranium) uranium is regulated by it is radiological properties (Durakovi 1999).

Solubility of uranium varies greatly depending on the particular compounds and the solvent, and this solubility determines how quickly the body absorbed them from the lung and how efficiently the body absorbs them from the intestines (Rostker 2000).

It's a silver-white, lustrous, dense, and natural and commonly occurring weakly radioactive element. Uranium has physical and thermal properties (McGraw-Hill 1987), which are listed in (Table 2-1).

Table (2-1) Physical and thermal properties of Uranium

Properties	***Values***
Melting point	1123.4±0.8 ºC (2070.3+1.4 ºF)
Boiling point	3818 ºC (6904 ºF)
Vapor pressure, 1720-2340 K	$\text{Log}\,\rho$ (atm)=–6210±270/T+(5.920±0.135)
Heat of fusion	19.7 kJ / g.atom
Heat of vaporization	446.4 kJ / g.atom
Heat of sublimation (0 K)	487.9 kJ / g.atom
Heat of transition $\alpha \longrightarrow$ ß	2.791 kJ / g.atom
Heat of transition ß $\longrightarrow \gamma$	4.757 kJ / g.atom
Enthalpy at 25 ºC	6.3655 kJ / g.atom
Heat capacity at 25 ºC	27.664 J /kg.atom
Entropy at 25 ºC	50.170 ± 0.008 J / kg-atom
Thermal conductivity (70 ºC)	0.29 J /cm. s (K)
Electrical conductivity	2.4×10^{4} (ohm. cm)$^{-4}$

As such it can only very low levels of many of the naturally occurring radioactive decay products of uranium listed in tables (2-2, 2-3, and 2-4).

Table (2-2) ^{238}U decay series (Kaye & Laby 1993).

Isotope	*Half-life*	*Principle decay mode*
^{238}U	4.5×10^{9} y	alpha
^{234}Th	24 d	beta
$^{234}Pa^{m}$	1.17 m	beta
^{234}Pa	6.8 h	beta
^{234}U	2.4×10^{5} y	alpha
^{230}Th	7.3×10^{3} y	alpha
^{226}Ra	1.6×10^{3} y	alpha
^{222}Rn	3.8 d	alpha
^{218}Po	3.1 m	alpha
^{218}At	2 s	alpha
^{214}Pb	27 m	beta
^{214}Bi	20 m	beta
^{214}Po	160 µs	alpha
^{210}Ti	1.3 m	beta
^{210}Pb	22 y	beta
^{210}Bi	5 d	beta
^{210}Po	138 d	alpha
^{206}Ti	4.2 m	beta
^{206}Pb	Stable	....

Note: (y=year, m=minute, d=day, h=hour, s=second)

Table (2-3) ^{235}U decay series (Kaye &Laby 1993).

Isotope	*Half-life*	*Principle decay mode*
^{235}U	7×10^{8} y	alpha
^{231}Th	26 h	beta
^{231}Pa	3.3×10^{4} y	alpha
^{227}Ac	22 y	beta
^{227}Th	19 d	alpha
^{223}Fr	21.8 m	alpha
^{223}Ra	11.4 m	alpha
^{219}Rn	4 s	alpha
^{215}Po	1.8 ms	alpha
^{215}At	1×10^{-4} s	alpha
^{211}Pb	36.1 m	beta
^{211}Bi	2.2 m	alpha
^{211}PO	0.5 s	alpha
^{207}Ti	4.8 m	Beta
^{207}Pb	Stable	

Table (2-4) ^{232}Th decay series (Kaye &Laby 1993)

Isotopes	*Half-life*	*Principle decay mode*
^{232}Th	1.39×10^{10} y	alpha
^{228}Ra	6.7 y	beta
^{228}Ac	6.13 h	beta
^{228}Th	1.9 y	alpha
^{224}Ra	3.64 d	alpha
^{220}Rn	54.5 s	alpha
^{216}Po	0.158 s	alpha
^{212}Pb	10.6 h	beta
^{212}Bi	60.6 m	beta
^{208}Ti	3.1 m	Beta
^{212}Po	3.0×0^{-7} s	alpha
^{208}Pb	Stable	-

2.2 Depleted Uranium

Depleted Uranium (DU) is a toxic and radioactive Produced by-product of the uranium enrichment process used to enrich natural uranium ore for use in nuclear reactors and in nuclear weapons. It is distinguished from natural uranium by differing concentrations of certain uranium isotopes.

Uranium is classed as DU when the abundances of U-235 and U-234 are reduced relative to U-238. Depleted Uranium typically has around 0.3 % to 0.2 % U-235 by mass, although the nuclear regulatory commission in the US defines DU as uranium in which the percentage of U-235 is less than 0.711 % (NRC 2000). Consequently, DU has a marginally higher percentage of U-238 (99.8%) than naturally occurring uranium (99.3%). The isotopic composition of DU typically used by the US Department of Defense as quoted in (CHPPM 2000) is U-234 (0.0006%), U-235 (0.2%), U-236 (0.0003%), and U-238 (99.8%).

DU was used as ammunition by USA and UK troops in an open environment for the first time in history against Iraqi civilians and military target during 1991. These weapons were used to destroy tanks, light armored vehicles, and bankers (Fahey 1997; zajic 1999). DU considered a new source of radioactivity that introduced into environmental (Fahey 1998), and contaminated Iraq Environment (Marouf 2002). U-238 has a longer half-life than either U-235 or U-234 and it is present in a much greater abundance in natural and DU than U-235 or U-234. The number of alpha particles produced per year in one milligram of natural uranium from the decay of U-238, U-235 and U-234 may be calculated to be $3.9x10^{11}$, $1.7x10^{10}$ and 3.9×10^{11}, respectively. Specific activities and data related to isotopes commonly found in DU are given in Table (2-5). DU has a specific activity of 14.8 Bq/mg which is approximately 60% that of natural uranium (25.4 Bq/mg) due to the partial removal of U-234.

Table (2-5) Specific activity of Uranium and other radionuclide associated with DU (Ledere et al. 1978; Kaye and Laby 1993)

Radionuclide (Decay Mode)	***Half-life (million years)***	***Atomic weight (MW)***	***Specific activity as Bq/mg***
Natural U	-	-	25.4
U- 238(α)+(strafe)U-236(α)	4470	238	12.4
U-235 (α and γ)	704	235	80
U-234(α)	0.245	234	$2.31x10^{5}$
U-232(α)	0.000072	232	$7.92x10^{8}$
Pa-231(α & γ)			
$Pa-234^{m}$(ß)	$3.28x10^{-2}$	231	$1.75x10^{6}$
Th-231(ß&γ)	$2.29x10^{-12}$	234	$2.47x10^{16}$

Both uranium and DU and their immediate decay products e.g. Th-234, Pa-234m and Th-231) emit alpha and beta particles with a very small amount of gamma radiation. Alpha and beta radiation are not very penetrating and are easily absorbed in the air and the skin.

Many nuclear techniques used to determination-depleted uranium, which are (Al-Timimi 2003; Bajo 1979):

1. Induced fission track (IFT).
2. Laser Induced Fluorescence (LF).
3. Flourimetery (F).

4. Mass Spectrometry (MS).
5. Neutrons Activation Analysis (NAA).
6. Paleography (P).
7. Colorimetry (C).
8. Delayed Neutrons (DN).
9. X-Ray Fluorescence (XRF).

Therefore, to prefer Induced Fission Track technique (IFT) because it is distinguish from simplest and ;as well as it is high ability to the detection about the concentration very lower to the uranium (part per billion).

2.3 Properties Of Depleted Uranium

DU is a low cost material that is readily available. DU has a high density (19.05g / cm^3), which is 2.54 more than for Iron, 2.14 more than for copper, 1.68 more than for lead, and slightly lower than that of tungsten, so it has a high penetrating power (Guenther 1995). It has a high atomic number Z = 92 and high melting point. DU has a high density and a low cost makes it a material of choice for aircraft counterweights. DU is also a highly effective material for military armor and anti-armor munitions (Zajic, 1999).

The following are the major characteristics of DU metal (Bukowski 1993; Catalinotto 1998):

1. The prophetic nature of DU metal and the extreme flash temperatures are generated on impact lead to burn through the target armor.
2. DU is a radioactive waste. This makes it cheap and useful as a shell and shield.

3. Its specific activity is (12429 Bq / g).

DU is extremely hazardous to health because of its radioactivity and its toxic nature as a heavy metal.

2.4 Applications Of Depleted Uranium

DU is used in application where it is combination of a high density, fabricability; relatively good mechanical properties and availability give it an advantage over other materials. There are several commercial and military non-nuclear uses of DU. ***Commercial*** the main civilian uses of DU include counterweights in aircraft, micrometers/detectors, flywheels, and sinker bars, (WHO 2001). ***Military*** due to it is high density, about twice that of Lead, and other properties, DU is used in munitions designed to penetrate armor plate and for protection at military vehicles such as tank, kinetic energy penetrates, shape charge liners and explosively formed penetrate lenses, and armor.

2.5 Behavior Of Depleted Uranium Inside The Body

Absorption of inhaled uranium into the systemic circulation will depend on the rate at which the particle is dissolved in the lungs and on their interactions with lung legend (Harley 1999). Soluble DU particles deposited in the lungs usually dissolve, and the DU moves into the blood within days or weeks, while the insoluble particles tend to remain in the Lungs or lymph nodes for months or years (Muller 1989; Rostker 2000).

The soluble particles will be absorbed in the blood and remove from it to other organs where these particles accumulate (Morris 1990; Rostker 2000). Absorption through the gut depends upon the availability of the various DU compounds to which an individual has been exposed (WHO 2001).

After entry into the blood, uranium particles will be accumulated in the skeleton, so that this element called "bone seeker" (Harely&Fisenne 1990). Small fraction of these particles will be distributed to the soft tissue such as kidney, liver, and spleen (Kathren et al. 1989; Muller et al., 1989; Harely&fisenne 1990) and a substantial fraction rapidly excreted (IAEA 1990). Uranium deposited in the bones and other organs is subsequently released back to the blood stream (ICRP 1978). Clearance from the skeleton is considerably slower, half-lives of 300 and 5000 days have been estimated (Kathren et al. 1989). Biochemical processes cause the blood to reabsorb DU from the organs to start the process over again (IAEA 1995; Rostker 2000). The schematic presentation in (figure 2-1) depicts how uranium interacts with the body. Inhaled, ingested, or embedded fragments reach the blood after solubilizing either at the site of entry or at some other location in the body where they end up (Harley et al. 1999), and injury, insult and dermal sorption (Hooper et al. 1999).

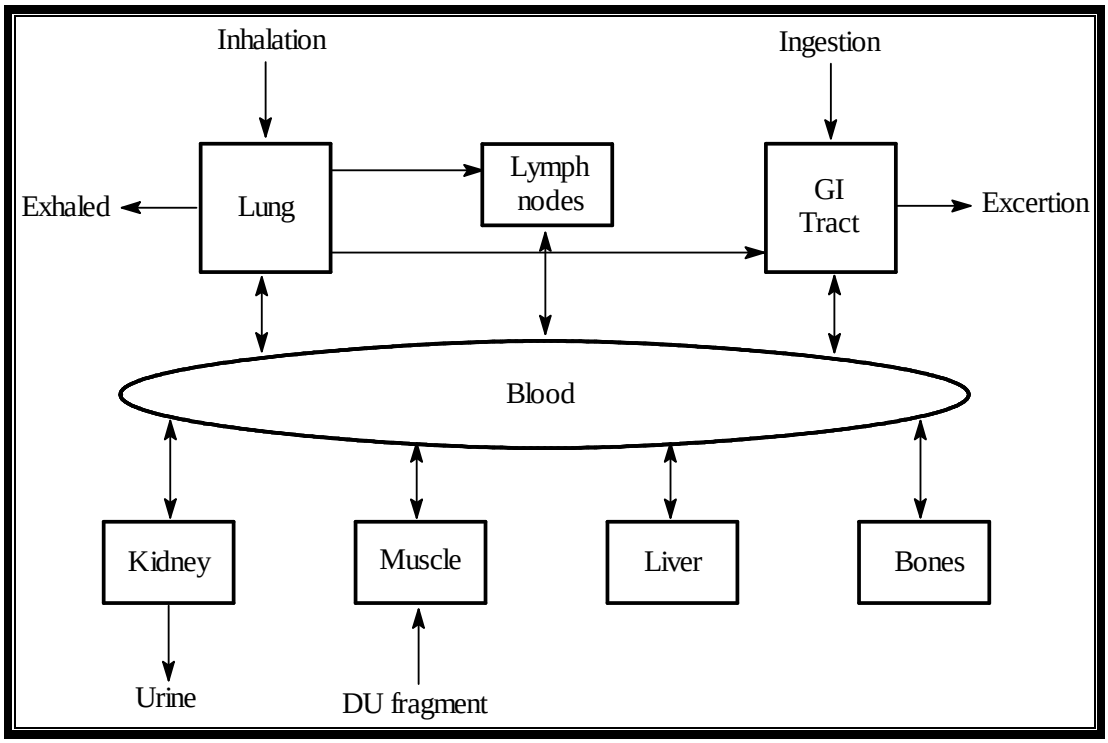

Figure (2-1) The schematic presentation of the behavior of DU inside the body (Harley et al. 1999).

2.6 How Can Uranium Enter And Leave The Body

Uranium enters the bodies through the food we eat, water we drink, and air we breathe. When you breathe uranium dust, some of it is exhaled and some stays in your lung. The size of the uranium dust particles and how easily they dissolve determines where in the body the uranium goes and how it leaves you body. Uranium dust may consist of small, fine particles and coarse, big particles. The big particles are caught in the nose, sinuses, and upper part of the lung where they are blown out or pushed to the throat and swallowed. The small particles are inhaled down to the lower part of lung. If they do not dissolve easily, they stay there for years and cause most of the radiation dose to the lungs from uranium; they may gradually dissolve and go into blood. If the particles do

dissolve easily, they go into blood more quickly. A small part of the uranium you swallow will also go into the blood, and blood carries uranium throughout the body. Most of it leaves in the urine in a few days, but a little stays in the kidneys and bones. When eat foods and drink liquids containing uranium, most of it leaves within a few days in the feces and never enters blood; a small portion will get into the blood and will leave the body through urine within a few days. The rest can stay in you bones, kidneys, or other soft tissues; a small amount goes to the bones and may stay there for years. Most people have a very small amount of uranium in the bodies, mainly in bones. Although uranium is weakly radioactive, most of the radiation it gives off cannot travel far from its source. If the uranium is outside the body, such as in soil, most of its radiation can penetrate skin and enter the body. If uranium transformation products are also present, you can be exposed to their radiation at a distance (ATSDR 1999), as shown in Figure (2-2).

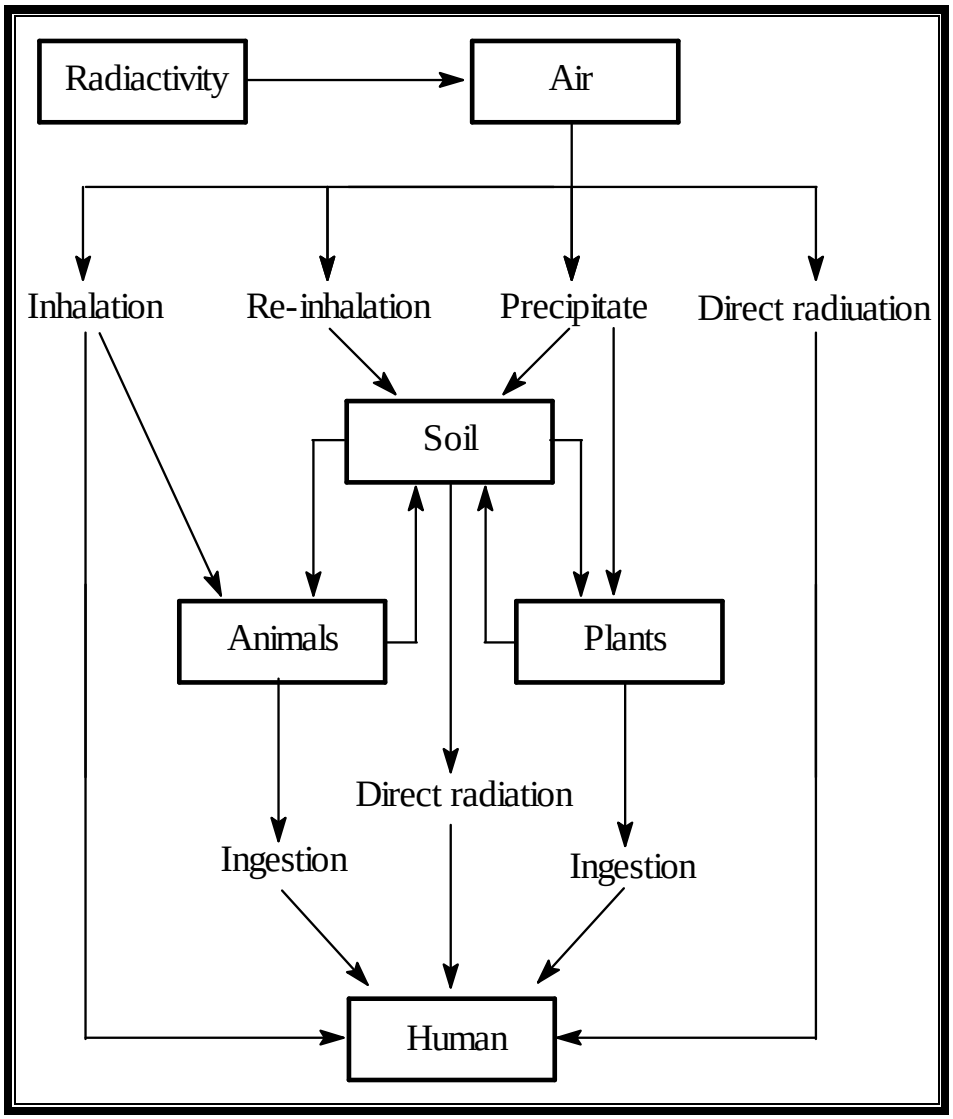

Figure (2-2) Design translation radioactivity from air to human.

2.7 Health Effects Of Depleted Uranium

There are many outstanding sings and symptoms that may result from DU as a systemic chemical toxicant such as: headaches, cold sweat, hypertension, anemia, hematological changes, numbness in the extremities, diarrhea, insomnia, bronchitis, renal disorder (may increase the infections disease), damage the kidney tubular cell, focal necrosis of the Liver, lymph nodes fibrosis, sever

muscle weakness, loss of body weight, Damage in the gastrointestinal system, low birth weight, skeletal abnormalities, and others (Zajic 1999;Rosalie 1999).

An estimate for exposure of veteran from the Gulf War is difficult to make and studies on the illness came not yet to a final conclusion. More than 10.000 veterans reported mysterious illness, like muscle and joint pain, chronic fatigue, depressed immune system, neurological disorders, memory loss, chemical sensitivities, and rashes (Harigel 2002).

The most important health effect of DU is leukemia, the latent period of this disease is 2-5 years (Pochin 1985; Kellerer 1990), the percentage of this disease increases in the last years in Iraq and becomes 43% for age lower than 15 years, in the last years the percentage of breast cancer in woman increases in spite of it is latent period is 25 years.

After inhalation or ingestion, uranium can be transported around the body in the blood stream, thus, exposing other organs and blood cells to it is carcinogenic effect (Livingstone 1999), in inhalation, toxic and radioactive particles are trapped permanently in the lung increasing the risk of cancer, and then travel in the blood stream and deposited in the brain, kidneys, bone, reproductive organ, muscle, and spleen (Fahey 1999).

DU crosses the placenta during pregnancy (Diel and Peter 1999). The fetus is most susceptible to the formation of anomalies attributed to radiation exposure when the exposure occurs between weeks six to seventeenths of gestation because during this period most of the organs of the body are under going major differentiation and development, damage may result following any radiation exposure, however small (NCRP 1985). Children is particularly vulnerable to it is toxic effects because their cells are dividing rapidly as they grow (Lymburner 1997).

Potential medical testing for DU contamination includes: chemical analysis of uranium in urine, feces, blood and hair; tests of damage to kidney, including analysis for protein, glucose and non-protein nitrogen in urine; radioactivity counting; or more invasive tests such as bone marrow (Rosalie 1999).

2.8 Biological Effects Of Radiation

The actions of ionizing radiation on cells are two types: - Direct and Indirect action (Walden 1989). Both actions are involved when a charged particle passes through a cell, both actions can cause damage to the cell but by different mechanisms (Martin and Harrison 1986).

1. Direct Action:

When a molecule is ionized and/or excited by the incident radiation, as it has been already stated, only a protein of the energy of the ionizing particle is used to remove an electron from a molecule, the remaining energy excites the molecule and the exciting energy can actually break the molecules into smaller units that are identical because many larger molecules are composed of a chain of smaller molecules bond together chemically, it appears that the damages occur at the same bond, further, since it is highly unlikely that the radiation would strike the same bond each time, it is highly suggestive that the energy is absorbed anywhere in the molecules and transfers down the molecular to the weakest bond (Guebert 1995).

For any significant effect to the cell, the molecule must be of extreme importance to the continued existence of the cell, such molecules would be the deoxyribonucleic acid (DNA) molecules and the ribonucleic acid (RNA)

molecules of the cell (Saha 2001), changes in these and other important molecules can temporarily or permanently alter cellular function.

Direct action was occurred within milliseconds following irradiation, this type of action causes a number of physical and chemical events are used to describe the death of the cell (Walden and Farzaneh 1990).

2. Indirect Action:

Indirect action occurs when a molecule reacts with a molecule or the product of a molecule that has undergoes direct action.

Since the human body is an aqueous solution containing approximately 80% water molecules. When ionizing radiation interacts with water molecules, they dissociate into other molecular products, and this action termed the radiolysis of water.

When pure water is irradiated it is ionized producing a fast moving free electron and a positively charge water molecule (Coggle 1973).

$$H_2O \longrightarrow H_2O^+ + e^- \quad \text{..... (2-1)}$$

Following this initial ionization, a number of reactions can happen:

- First, the ion pair may rejoin into a stable water molecule, in this case no damage occurs.
- Second, if these ions do not rejoin, then this electron (e^-) will travel through the water until it is captured by another water molecule converting the latter into a negative charged molecule:

$$H_2O + e^- \longrightarrow H_2O^- \quad \text{..... (2-2)}$$

H_2O^- and H_2O^+ ions are relatively unstable and each dissociates to give an ion and a free radical.

$H_2O^+ \longrightarrow H^+ + OH\bullet$ ..... (2-3)

$H_2O^- \longrightarrow H\bullet^{\cdot} + OH^-$ ..... (2-4)

The final result of the water radiolysis is therefore the formation of an ion pair, H^+ and OH^- and two free radicals, $H\bullet^{\cdot}$ and $OH\bullet$

The ions can recombine; therefore no biological damage would occur (Wallace 1998).

$OH^{\cdot}$ Free radical can join with a similar molecule and form hydrogen Peroxide (H_2O_2), which is poisonous to the cell and therefore acts as a toxic agent (Kuwabara 1991).

$OH\bullet^{\cdot} + OH\bullet \longrightarrow H_2O_2$ ..... (2-5)

$H\bullet^{\cdot}$ Free radical can interact with molecular oxygen if present to form the hydroperoxyl radical.

$H\bullet + O_2 \longrightarrow HO_2$ ..... (2-6)

HO_2 along with H_2O_2, considered it damaging product following radiolysis of water. More than 95% of the effects of radiation occur via indirect action (Bushong 1993).

A significant fraction (60% to 70%) of cellular DNA damage is caused by free radicals generated from water, notable the hydroxyl radical (Wallace 1998). At last; the chance of getting cancer is greater if you are exposed to enriched uranium, because it is more radioactive than natural uranium. Cancer may become apparent until many years after a person is exposed to a radioactive material (from swallowing or breathing it). Just being near uranium is not dangerous to your health because uranium gives off very little of the penetrating gamma radiation.

2.9 Radiation Exposure

Exposure is an act or condition of being subjected to irradiation. Exposure can be either external exposure (irradiation by sources outside the body) or internal exposure (irradiation by sources inside the body), exposure can be classified as either normal exposure or potential exposure; occupational, medical or public exposure; and, in intervention situations, either emergency exposure or chronic exposure (IAEA 1993).

2.10 Exposure Pathways

The routs by which radioactive material can reach or irradiate human is called "Exposure Pathways" (IAEA 1996).

The exposure pathways of DU are:

1. External Exposure:

DU outside the body acts exclusively via the emitted gamma and beta radiation, since the alpha radiation is absorbed by the dermis layers of the skin and therefore does not affect the living tissue. The dose-rate in the vicinity of DU is very low (Keller et al. 2000).

2. Internal Exposure

The process of taking radionuclide into the body by inhalation or Ingestion or through the skin is called "Intake" (IAEA 1996).

Individual can be exposed to DU in the same way they are routinely exposed to natural uranium through: inhalation, ingestion, dermal contact or injury (e.g. embedded fragments) (WHO 2001).

4.1 The Apparatuses and The Present Materials

• Preparing Materials

4.1.1 Oven:

Using oven type of THELCO to measure temperature between (room temperature – 375 ^{o}C) made in England.

4.1.2 Hand Mill:

It is made from ceramic mortar

4.1.3 Sensitive Balance:

Using the sensitive balance from type of (Mettler Garantia AE163) industrialization in Switzerland.

4.1.4 Piston:

Using piston from type (SPECAC), which the strength of piston approach to (1000 tans).

• Measurement Materials

4.1.5 Detector:

CR-39 nuclear track detector in thickness (250 μ m) and area approximate to (1×1 cm^2) were used.

4.1.6 Irradiation Source:

An (Am–Be) source with flux ($5x10^3$ n/cm^2.s) was used. It emits fast neutrons from the (α, n) reaction such as:

$$^{9}Be + ^{4}_{2}He \longrightarrow ^{12}C + ^{1}n + 5.76\ MeV \quad \text{.....(4-1)}$$

This source consists of a rod of (Am–Be) surrounded by a paraffin wax. The paraffin wax is usually used for moderating the fast neutrons to thermal neutrons energies.

4.1.7 Enchant Solution:

Sodium hydroxide solution with (6.25 N) normality has been used for the etching process, which prepared as:

$$W = Weq \times N \times V \quad \text{.....(4-2)}$$

Where:

W = the weight of NaOH needed to prepare the given normality.

Weq = equivalent weight of NaOH = addition of the atomic weight of Na, O and H = 40.

N = normality = 6.25.

V = volume of distilled water = 250 ml.

The enchant compartment has a volume of about 250 ml contains the NaOH solution with 6.25 N. This apparatus is closed assembly, except for small vent at the top of the condenser tube, which prevents any change of etchant normality (concentration) during the experiment due to evaporation. The etching was performed at 60^0C while the etching time was 5 hr.

4.1.8 Water Bath:

Water bath of the type "Labsco" (Germany) was used in the present work. It includes a thermostat, which can be operated over a range of 20 ^{o}C to 110 ^{o}C. However, in this study the chemical etching was carried out at 60 ^{o}C, and distilled water was used as the bath liquid. The accuracy of regulation of temperature is better than ± 0.1 ^{o}C.

4.1.9 Optical Microscope:

The optical microscope is type of (Olympus) industrialization in Japan. It is capable of giving magnifications of up to (400x) and eye piece (10x) to measure number of track density, the calculation track density from equation:

Track density (ρ) = average of total pits / area of field view …… (4-3)

4.2 Collections & Preparing Of Samples

The sites which human blood samples collected from it:

a. The teaching hospital in Al- Kadhamia region.

b. The teaching hospital in Basrah city.

c. The teaching hospital in Yarmook region.

d. The general AL- Ramadi hospital.

e. The radiation and nuclear medicine hospital.

f. International centre to searches and treatment blood diseases in Yarmok region.

Taking special data in all samples and relate by (age, gender, and place) and probability exposure to uranium or not exposure to uranium,

samples are heated at (300 ^{o}C) for six hour to dry it and oxidize organic material and reconcentration of samples, than collected powder samples and standard samples were pressed into a pellets in diameter (1 cm) and thickness (1 mm).

4.3 Irradiation Of Blood Samples

The blood samples of powder were (0.5g) pressed into a pellet of (1cm) diameter and (1mm) thickness. The standard blood samples of different uranium concentration were prepared. The pellets covered with CR-39 track detectors on both sides and put in a plate of paraffin wax at a distance of (5cm) from the neutron source (Am-Be) with thermal flux (5000 n. cm^{-2}. s^{-1}), as shown figure (4-1), obtain the fission fragments from equation:

$$^{235}\mathbf{U} + {}^{1}_{0}\mathbf{n}_{\ \mathbf{thermal}} \longrightarrow \mathbf{fission\ fragments + energy\ \ MeV} \quad .....(4\text{-}4)$$

The irradiation time was seven days with fluence of thermal neutron (3.02×10^{9} n. cm^{-2}) (Berger 1973).

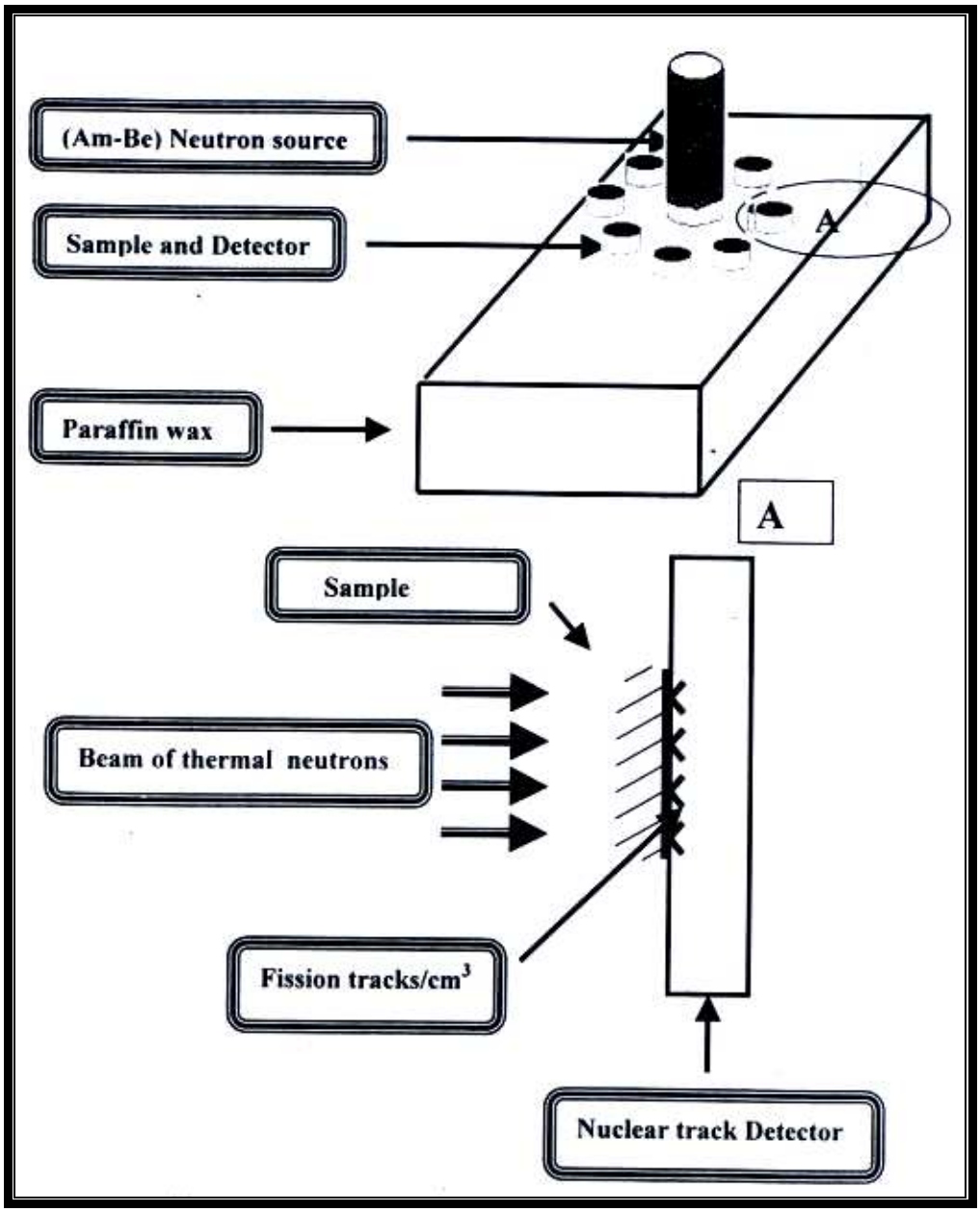

Figure (4-1) The irradiation of the detectors and samples to the neutron source (Rostker 2000)

4.4 Chemical Etching

The CR-39 detectors were etched in (6.25 N) of NaOH at temperature of (60 ^{o}C) for (5 hr). The induced fission tracks density was recorded using an optical microscope.

4.5 Calculations Of Uranium Concentrations

Determine uranium concentration by comparative method from this equation:

$$\mathbf{C_x = C_{s.}\ \rho_x\ / \rho_s . I_s / I_x . R_s / R} \quad \textbf{...(}4\text{-}5)$$

Where:

C_x: uranium concentration for unknown samples.

C_s: uranium concentration for standard samples.

ρ_x : induced fission tracks density for unknown samples.

ρ_s : induced fission tracks density for standard samples.

I_x: The ratios between abundance of uranium (^{283} U / ^{235} U) for unknown samples.

I_s: the ratio between abundance of uranium (^{283} U / ^{235} U) for standard samples.

R_x: the range of fission fragments of unknown samples.

R_s: the range of fission fragments of standard samples.

where Rs/Rx equal one because to correspond between natural uranium in standard samples and unknown samples pressed it, when I_s represented the ratio between the standard samples contain on the known concentration of natural uranium which contains ^{238} U 99.27 % and ^{235} U 0.72 % to produce (137.87), but I_x represented the ratio between of unknown samples which contain ^{238} U 99.79 and ^{235} U 0.2 to product (498.25). Therefore, the ratio I_s/I_x equal to (0.278) (Sultan 2001).

4.6 Calculations The Specific Activity Of Blood Samples

Determination of specific activity from equation:

$$\mathbf{SA = A / Mass \ (Bq/g)} \quad \text{……(4-6)}$$

$$\mathbf{N = W \times NA / atomic\ number} \quad \text{.....(4-7)}$$

$$\mathbf{A = N / \lambda \ (Bq)} \quad \text{.....(4-8)}$$

$$\mathbf{\lambda = 0.693 / T_{1/2} \ (constant)} \quad \text{.....(4-9)}$$

Where:

SA: the specific activity (Bq/g).

A: Activity of sample at time t (Bq).

W: weight of standard sample (g).

$T_{1/2}$: half-life of (^{235}U).

NA: Avogadro number.

λ : Decay constant of (^{235}U).

5.1 Results And Discussion

5.1.1 Uranium Concentration:

The relation between uranium concentrations and tracks density of standard samples are shown in figure (5-1). And uranium concentrations in human blood for Baghdad city shows in table (5-1), the maximum concentration was (0.229 ppm) in Taji region and minimum concentration was (0.073 ppm) in Habibya region, as shown in figure (5-2) and by comparing these values with allowed limit from ICRP agency we found that uranium concentrations were in the range (0.115 ppm). The results for Al-Ramadi city shows in table(5-2), the maximum concentration was (1.174 ppm) in Qam region and minimum concentration was (0.149 ppm) in Al-Ramadi region, as shown in figure (5-3) and the results were more than the allowed limit from ICRP agency because the geography natural for city as well as the phosphate factory in that city. And for Basrah city shows in table (5-3), the maximum concentration was (1.992 ppm) in Abu Alkaseeb region and minimum concentration was (0.265 ppm) in Jazerat Alsindibad region, as shown in figure (5-4) and the results were more than the allowed limit from ICRP agency because this city was military practices theater through 1991 war and weapons waste in still being in this region. And for leukemia samples for different regions in Iraq shows in table (5-4), the maximum concentration was (1.841 ppm) in Muthana region and minimum concentration was (0.364 ppm) in Diyala region, as shown in figure (5-5) and the results were more than the allowed limit from ICRP agency that explain uranium has great reason to cases leukemia diseases as well as the existence of natural uranium in environment, and man - made activities.

5.1.2 Specific Activity:

The relation between the specific activities and tracks density in the standard samples are shown in figure (5-6). And the specific activity values in human blood for Baghdad city shows in table (5-5), the maximum value was (0.2041 x10 $^{-1}$ Bq/g) and minimum value was (0.068 x 10 $^{-1}$ Bq/g), as shown in figure (5-7) and by comparing these values with permissible limit from IAEA agency were more than (0.148 *10 $^{-1}$ Bq/g). and for leukemia samples shows in table (5-6), The maximum value was (1.79 x 10 $^{-1}$ Bq/g) and minimum value was (0.34 x 10 $^{-1}$ Bq/g), as shown in figure (5-8) and the results were more than the permissible limit from IAEA agency. And for Al-Ramadi city shows in table (5-7), the maximum value was (1.09 x 10 $^{-1}$ Bq/g) and minimum value was (0.14 x10 $^{-1}$ Bq/g), as shown in figure (5-9) and the results were more than the permissible limit from IAEA agency. And Basrah city shows in table (5-8), the maximum value was (1.863 x 10 $^{-1}$ Bq/g) and minimum value was (0.661 x 10 $^{-1}$ Bq/g), as shown in figure (5-10) and the results were more than the permissible limit from IAEA agency.

The average results of uranium concentrations for three governorates in Iraq (Baghdad, Ramadi, Basrah) respectively, as shown in figure (5-11), and the average results of specific activity for three governorates in Iraq as shown in figure (5-12).

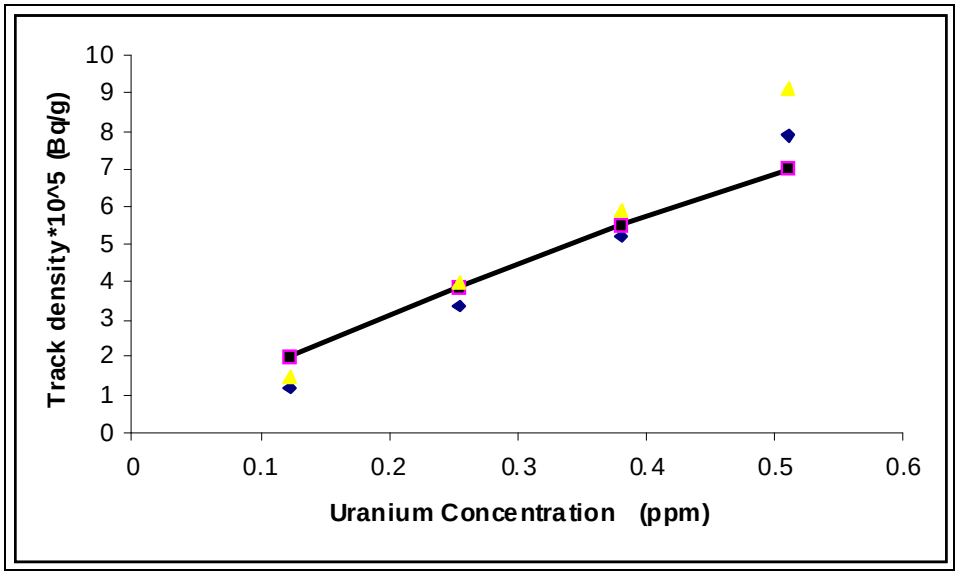

Figure (5-1) The relation of uranium concentrations and tracks density of standard samples

Table (5-1) Uranium concentration in blood samples of Baghdad city

No.	*Regions*	*The gender*	*The age (Y)*	*Track density $\rho *10^5$ track.mm^{-2}*	*C x(ppm)*
1	Saba alboor	female	51	10.0 ± 2.1	0.106
2	yarmook	male	43	12.1± 2.56	0.129
3	Gazalia	male	36	10.1± 2.03	0.109
4	Tarmia	female	21	11.6 ±2.68	0.119
5	Huriya	male	65	14.9 ±2.47	0.168
6	Baghdad aljadida	male	22	8.5 ± 1.51	0.095
7	Hay ala'amil	male	26	8.8 ±2.32	0.088
8	Baya'a	female	45	12.1±1.79	0.139
9	Sha'ab	female	44	10.5± 3.57	0.093
10	Taji	female	60	19.0±3.02	0.216
11	Rahmaniya	female	45	13.2 ±2.51	0.143
12	Shula	female	23	19.3 ± 3.13	0.219
13	Habibya	female	43	10.7 ±5.38	0.073
14	Taji	female	70	17.9 ± 1.65	0.229
15	Alshurtah alkahamsa	female	42	13.1 ± 2.56	0.142
16	Kadhamia	female	19	10.1± 1.91	0.111
					The average= 0.135

Table (5-2) Uranium concentration in blood samples of Al-Ramadi city

No.	*Regions*	*The gender*	*The age (Y)*	*Track density* $\rho * 10^5$ *track.mm*$^{-2}$	C_x *(ppm)*
1	Ukhashat	male	63	50.5 ± 7.0	0.588
2	Heet	male	20	48.0 ±5.79	0.571
3	Ramadi	female	45	14.16± 3.18	0.149
4	Ramadi	male	36	38.16± 8.2	0.405
5	Ramadi	male	65	48.5 ± 11.7	0.497
6	Ramadi	male	33	31.16±4.4	0.362
7	Shirkat	female	17	49.3± 7.89	0.564
8	Shirkat	female	23	60.67±3.88	0.768
9	Falluja	male	29	92.16 ± 11.5	1.094
10	Falluja	female	15	77.5± 10.87	0.901
11	Qam	male	42	93.0 ± 62.9	1.174
12	Qam	female	53	69.0± 7.46	0.835
					The average= 0.728

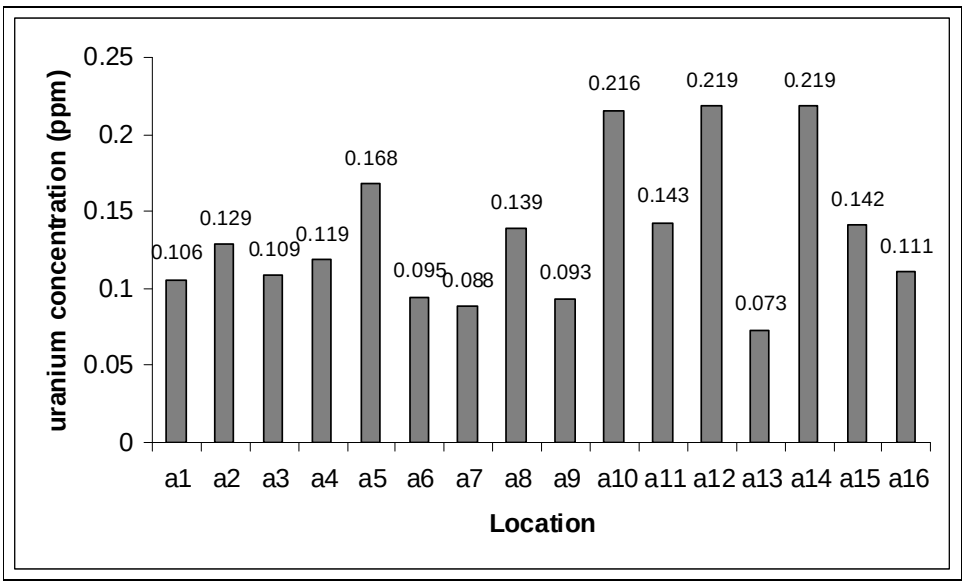

Figure (5-2) Uranium concentration in Baghdad city

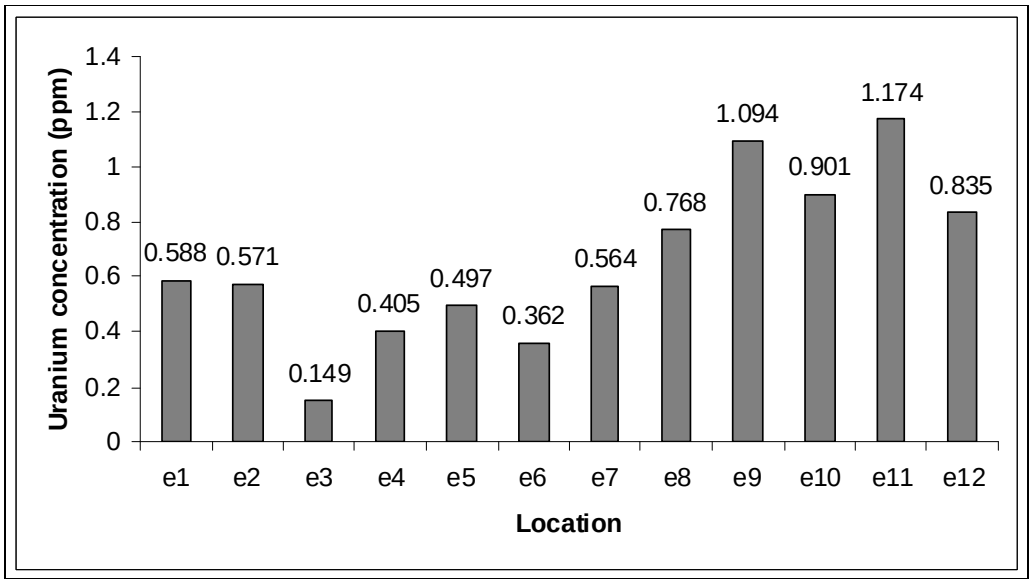

Figure (5-3) Uranium concentration in Al- Ramadi city

Table (5-3) Uranium concentration in blood samples of Basrah city

No.	*Regions*	*The gender*	*The age (Y)*	*Track density* $\rho * 10^5$ *track.mm*$^{-2}$	*Cx (ppm)*
1	Abu alkhaseeb	male	36	195.5± 48.05	1.992
2	Aldeer	male	33	115.33 ± 21.0	1.274
3	Jazert alsindibad	male	32	81.67± 8.9	0.965
4	Tanuma	male	34	118.0 ±13.72	1.407
5	Zubair	female	38	149.67 ± 19.5	1.758
6	Alshuyaba	male	24	58.67±6.38	1.706
7	Shalamta	female	25	162.33 ±28.38	1.809
8	Ijrashan	female	36	165.67± 30.7	1.823
9	Alhadeed & sulib	male	26	235.33 ±18.28	1.974
10	Um qaser	male	20	294.0 ±10.33	1.832
					The average= 1.654

Table (5-4) Uranium concentration for leukemia samples in different cities of Iraq

No.	*Regions*	*The gender*	*The age (Y)*	*Track density* $\rho * 10^5$ *track.mm*$^{-2}$	C_x *(ppm)*
1	Taji	male	55	56.66 ± 7.71	0.780
2	Washash	female	67	30.5±3.27	0.367
3	Ramadi	male	61	56.33± 5.43	0.689
4	Hay Al-a'amil	male	65	44.6± 8.08	0.494
5	Kut	male	18	47.83± 10.3	0.507
6	Falluja	female	72	63.0 ± 6.16	0.763
7	Diyala	male	19	32.0± 5.09	0.364
8	Diyala	female	20	50.83±3.48	0.639
9	Alyusifiya	male	22	74.17± 9.98	0.869
10	Basrah	male	60	74.67± 9.18	0.888
11	Ramadi	female	55	68.83± 11.37	0.776
12	Qam	female	65	64.66 ±10.68	0.731
13	Altalibiya	female	23	65.0 ± 8.06	0.769
14	Bani Sa'ad	male	19	76.5 ± 7.28	0.934
15	Alnasiriya	female	21	60.66± 14.2	0.628
16	Omarah	female	36	34.16± 4.99	0.396
17	Thawra	male	34	115.66± 21.08	1.279
18	Muthana	female	63	173.33± 36.79	1.841
					The average= 0.760

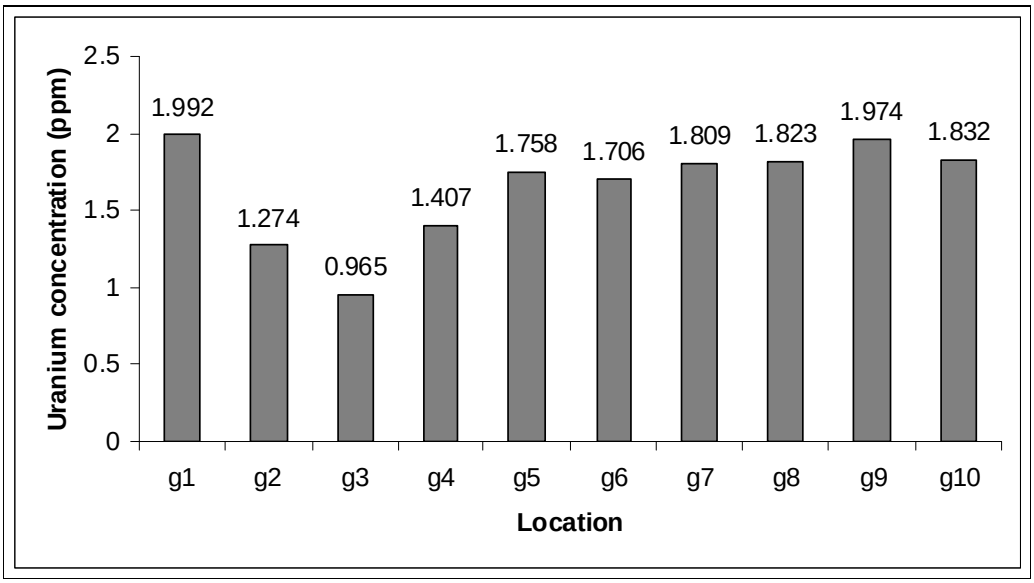

Figure (5-4) Uranium concentration in Basra city

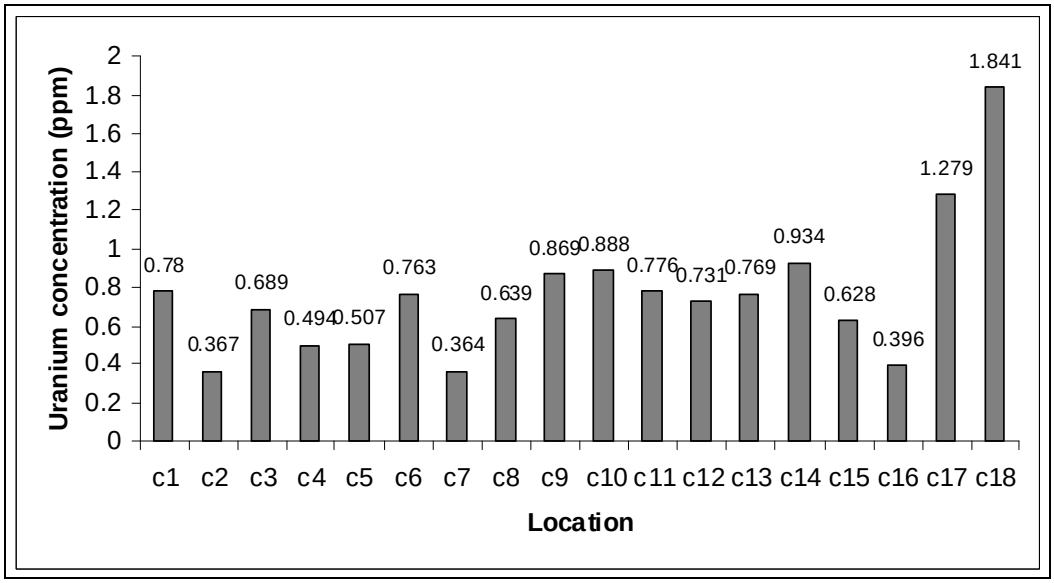

Figure (5-5) Uranium concentration for leukemia samples

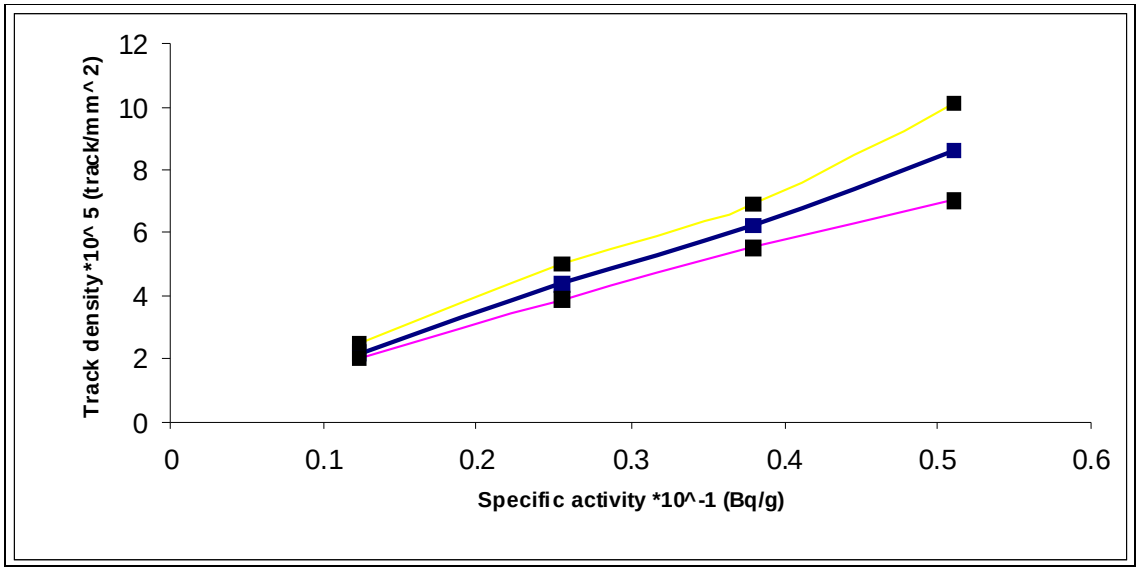

Figure (5-6) the relation of specific activities and tracks density of standard samples

Table (5-5) Specific activity in blood samples of Baghdad city

No.	*symbol*	*The gender*	*The age (Y)*	*Track density* $\rho *10^5$ *track.mm*$^{-2}$	$A*10^{-1}$ *Bq.g*$^{-1}$
1	b1	female	51	10.0 ± 2.1	0.0998
2	b2	male	43	12.1± 2.56	0.1207
3	b3	male	36	10.1± 2.03	0.1020
4	b4	female	21	11. 6± 2.68	0.1127
5	b5	male	65	14.9± 2.47	0.1571
6	b6	male	22	8.5 ± 1.51	0.0884
7	b7	male	26	8.8± 2.32	0.0820
8	b8	female	45	12.1± 1.79	0.1299
9	b9	female	44	10.5± 3.57	0.0873
10	b10	female	60	19.0 ± 3.02	0.2018
11	b11	female	45	13.2 ±2.51	0.1337
12	b12	female	23	19.3± 3.13	0.2043
13	b13	female	43	10.7 ± 5.38	0.0681
14	b14	female	70	17.9± 1.65	0.2041
15	b15	female	42	13.1± 2.56	0.1325
16	b16	female	19	10.1± 1.91	0.1034
					The average= 0.1258

Table (5-6) Specific activity for leukemia samples in different cities of Iraq

No.	*symbol*	*The gender*	*The age (Y)*	*Track density ρ *10^5 track.mm^{-2}*	*A*10^{-1} Bq.g^{-1}*
1	d1	male	55	56.66± 7.71	0.73
2	d2	female	67	30.5 ±3.27	0.34
3	d3	male	61	56.33± 5.43	0.64
4	d4	male	65	44.6 ± 8.08	0.46
5	d5	male	18	47.83±10.3	0.47
6	d6	female	72	63.0± 6.16	0.72
7	d7	male	19	32.0± 5.09	0.34
8	d8	female	20	50.83±3.48	0.59
9	d9	male	22	74.17 ± 9.98	0.81
10	d10	male	60	74.67 ±9.18	0.83
11	d11	female	55	68.83 ±11.37	0.72
12	d12	female	65	64.66± 10.68	0.68
13	d13	female	23	65.0± 8.06	0.71
14	d14	male	19	76.5 ±7.28	0.87
15	d15	female	21	60.66 ± 14.2	0.58
16	d16	female	36	34.16 ±4.99	0.36
17	d17	male	34	115.66 ± 21.08	1.19
18	d18	female	63	173.33± 36.79	1.79
					The average= 0.708

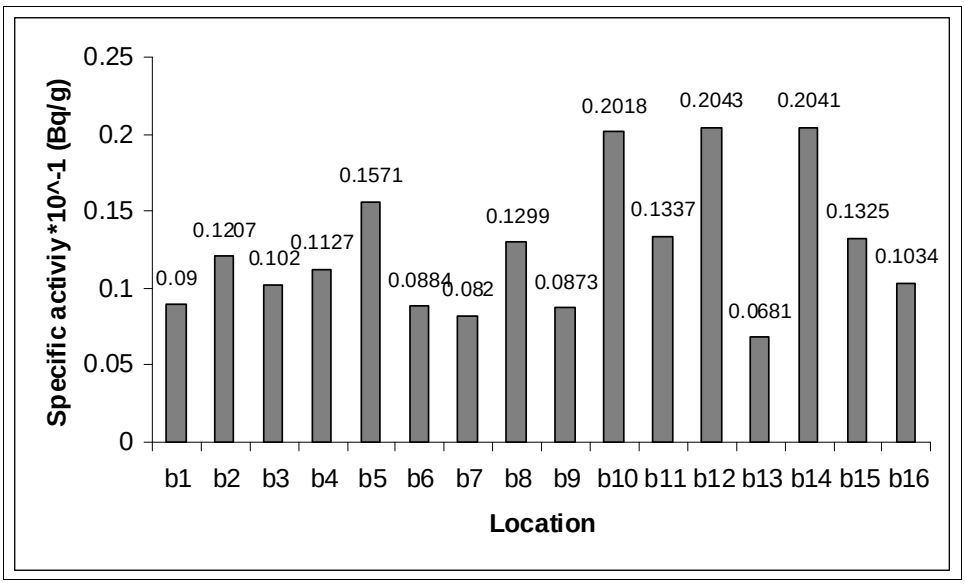

Figure (5-7) Specific activity in Baghdad city

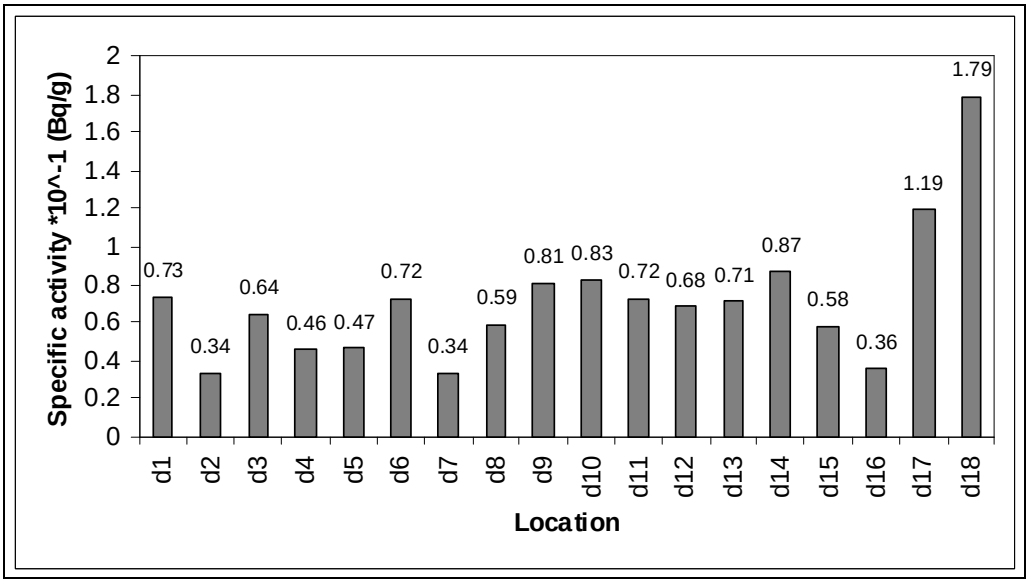

Figure (5-8) Specific activity for leukemia samples

Table (5-7) Specific activity in blood samples of Al-Ramadi city

No.	*Symbol*	*The gender*	*The age (Y)*	*Track density ρ *10^5 track.mm^{-2}*	*A*10^{-1} Bq.g^{-1}*
1	f1	male	63	50.5 +- 7.0	0.55
2	f2	male	20	48.0 +- 5.79	0.53
3	f3	female	45	14.16 +- 3.18	0.14
4	f4	male	36	38.16 +- 8.2	0.38
5	f5	male	65	48.5 +- 11.7	0.46
6	f6	male	33	31.16 +- 4.4	0.34
7	f7	female	17	49.3 +- 7.89	0.52
8	f8	female	23	60.67 +- 3.88	0.72
9	f9	male	29	92.16 +- 11.5	1.02
10	f10	female	15	77.5 +- 10.87	0.84
11	f11	male	42	93.0 +- 62.9	1.09
12	f12	female	53	69.0 +- 7.46	0.78
					The average= 0.613

Table (5-8) Specific activity in blood samples of Basrah city

No.	*Symbol*	*The gender*	*The age (Y)*	*Track density ρ *10^5 track.mm^{-2}*	*A*10^{-1} Bq.g^{-1}*
1	h1	male	36	195.5± 48.05	1.863
2	h2	male	33	115.33±21.0	1.192
3	h3	male	32	81.67 ± 8.9	0.923
4	h4	male	34	118.0± 13.72	1.318
5	h5	female	38	149.67± 19.5	1.645
6	h6	male	24	58.67 ± 6.38	0.661
7	h7	female	25	162.33 ±28.38	1.693
8	h8	female	36	165.67± 30.7	1.705
9	h9	male	26	235.33 ±18.28	1.779
10	h10	male	20	294.0± 10.33	1.585
					The Average= 1.436

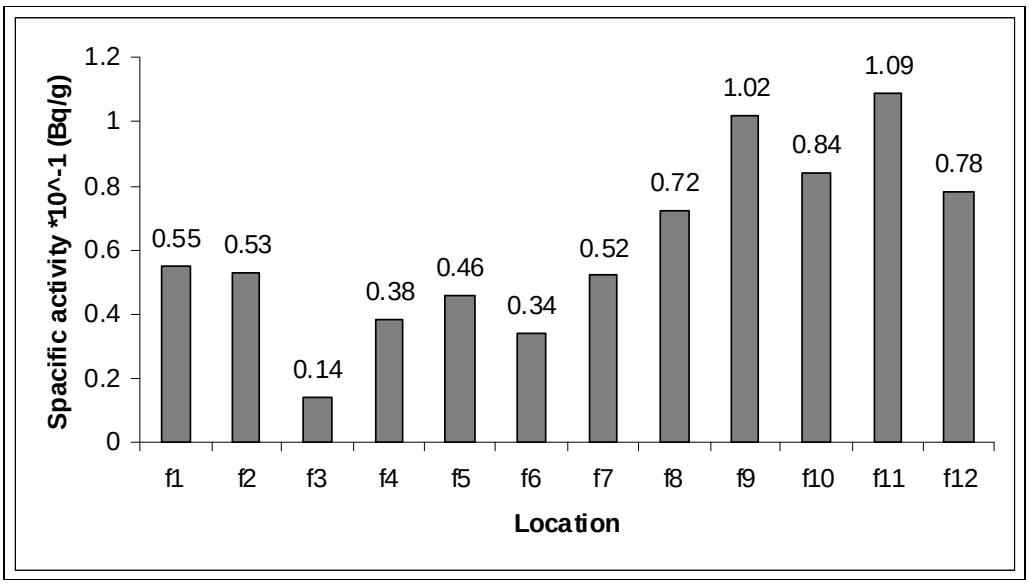

Figure (5-9) Specific activity in Al- Ramadi city

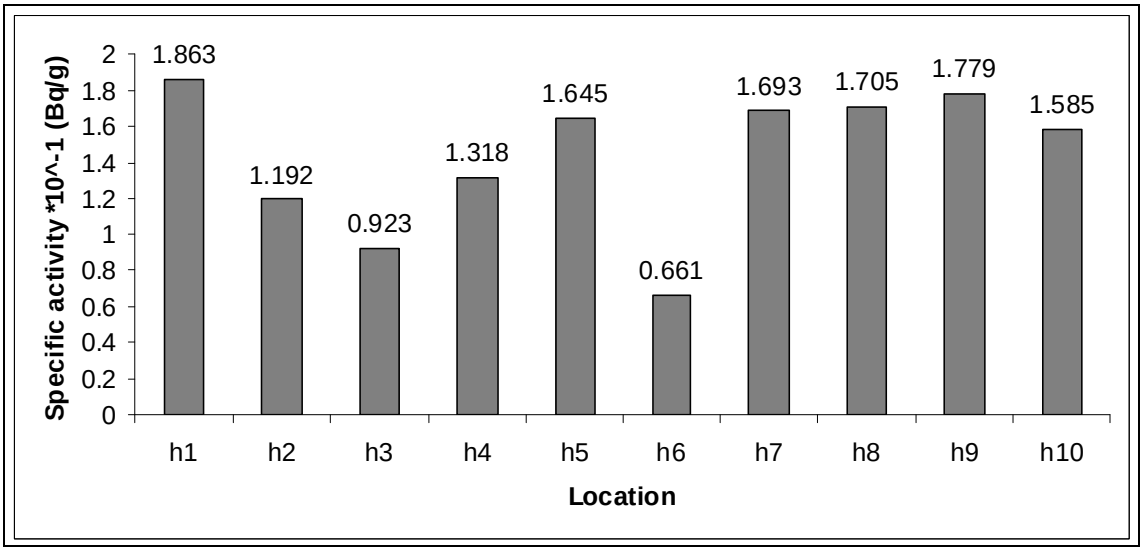

Figure (5-10) Specific activity in Basra city

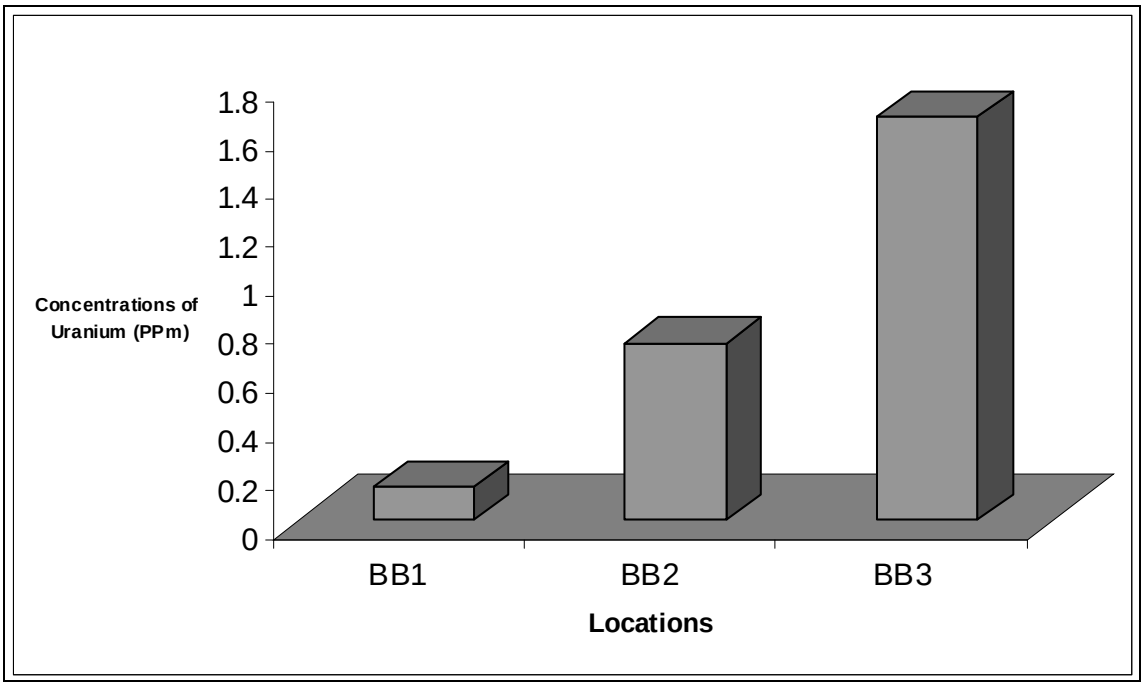

Figure (5-11) Averages of uranium concentrations for different regions of Iraq

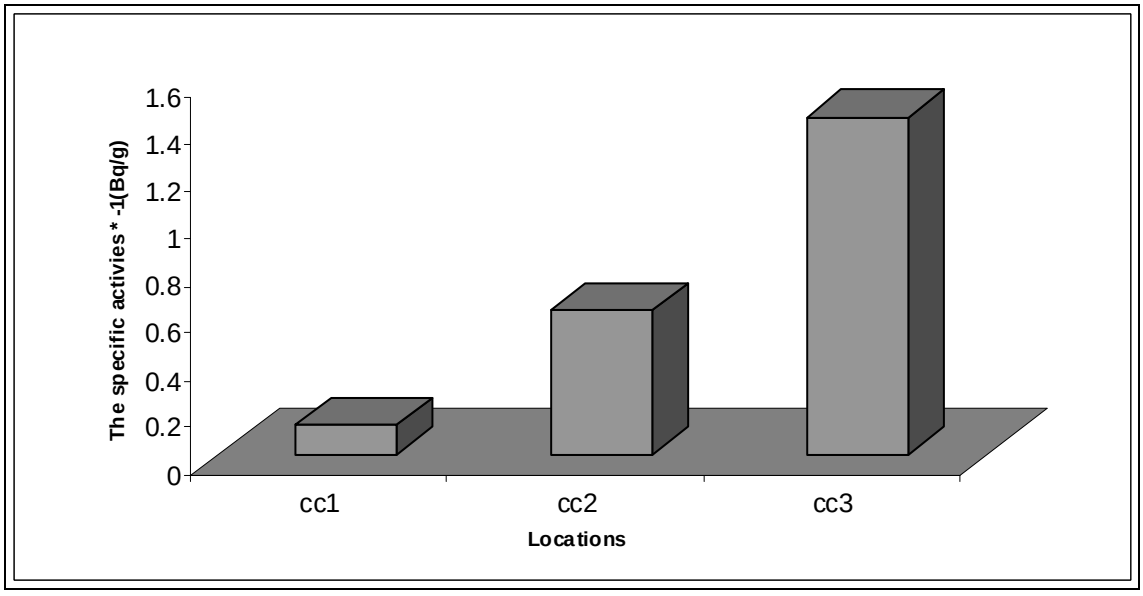

Figure (5-12) Averages of specific activity for different regions of Iraq

5.2 Conclusions

1. The maximum concentration of uranium human blood samples indicates that there is direct relation with leukemia and other diseases increasing after the distribution of uranium in south region.

2. Uranium concentration in human blood samples stricken by cancer as a result exposure to uranium in the environment are (0.731-1.841 ppm).

3. The highest rate of uranium concentration was found in Basrah governorate was (1.664 ppm), the lowest rate of uranium concentration was in Baghdad governorates was (0.153 ppm).

4. The maximum of uranium concentration in Basrah governorate was (1.992 ppm), the minimum of uranium concentration in Baghdad governorate was (0.073 ppm).

5.The maximum of uranium concentration for leukemia samples was (1.841 ppm in Al-Muthana governorate and the minimum of uranium concentration was (0.364 ppm) in Diyala governorate.

5.3Future Works

1.Measurement of uranium concentration in human blood samples in middle and north governorates of Iraq.

2.Studying uranium concentration using other techniques such as gamma spectroscopy in order to compare it with induced fission fragment technique in future studies.

3.Suggestion for training courses in the field radiation protection.

4.Cooperation with an international center for research and treatment of blood diseases and work to complete wide studies for the blood samples in order to reach exact results which useful the country.

3.1 Historical Review

The usability of solid-state nuclear track detectors (SSNTDs) technique has been enhanced by various methods of track visualization and evaluation introduced over the past one – decade or more (Morsy 1997).

Starting with the observation of few feeble trails of damage in sheet of mica exposed to fission fragments some forty years ago, the discipline based on their correct interpretation has emblazoned resounding success story in the second half of the 20^{th} century (Young 1958).

The first documentation of etch able tracks in dielectrics was reported in 1958 by Young, working at Atomic Energy Research Establishment (AERE) at Harwell in England. He discovered that LiF crystal held contact with uranium foil irradiated with thermal neutrons, revealed a number of etch pits after treatment with a chemical reagent. He seasoned that with respect to the chemical properties, the damage trial of a fission fragment is similar to that of dislocation.

Also, working at AERE reported direct observation of this damaged region in mica. They published for the first time the electron photomicrograph of the tracks of fission fragments in natural mica (Silk & Barnes 1959).

Introduced fission fragments and other heavy charged particles in many solids (mica, plastic …etc), and observed their tracks directly by an electron microscope as well as after selective chemical etching by an optical microscope (Price & Walker 1969). Subsequently, they showed that this was a general phenomenon, were observed in many other dielectrics including other minerals, glasses and polymers (Price & Walker 1962; Fleischer & Price 1963).

More directly useful researches have included medical and biological used as well as industrial applications (Durrani 2000).

As a standard reference book on nuclear tracks is the book "Nuclear Tracks in Solids: Principles and Applications (Fleischer et al. 1979)" This book reviews nuclear track work published until about 1975 and has been the entrance in the field for many workers since then. The genuinely multi disciplinary nature of this technique has been highlighted by the periodic gatherings at the international series of conferences on SSNTDs (Durrani & Bull 1987). The 20th International Conference on nuclear tracks in solids was held in Slovenia (Benton & Mekeever 2001).

3.2 Solid State Nuclear Track Detectors (SSNTDs)

Solid state nuclear track detectors are insulating materials have the capabilities for measuring concentration and spatial distribution of isotopes if they emit heavy nuclear particles, either directly or as a result of specific nuclear reactions (Velickovic 1981).

The damage of these particles along their path is called track (latent track), may become visible under an ordinary optical microscope after etching with suitable chemicals (Gohn & Goldn 1972). There are two types of SSNTDs:

1. Organic detectors (polymers), and

2. Inorganic detectors (glasses or crystals).

These types differ in their sensitivity which increasing with increasing the atomic number of the incident particle than 20. Table (3-1) presents some of types of detectors and the relative sensitivity record tracks (Monnin 1980).

Table (3-1) The relative sensitivities of various Detectors

A. Inorganic Detectors.

Detector	***Atomic composition***	***Least Ionizing Ion seen***
Hypersthene Olivine	$Mg_{1.5}Fe_{0.5}Si_2O_6$ $MgFeSiO_4$	100 Mev ^{56}Fe
Labradorite Zircon	$Na_2Ca_3Al_8Si_{12}O_{40}$ $ZrSiO_4$	
Diopside	$CaMg(SiO_3)_2$	170 Mev ^{56}Fe
Oligoclase Quartz	$Na_4\ CaAl_6\ Si_{14}\ O_{40}$ SiO_2	4 Mev ^{28}Si 100 Mev ^{40}Ar
Muscovite Mica	$Kal_3Si_3O_{10}(OH)_2$	
Silica Glass Flint Glass	SiO_2 $18SiO_2{:}4PbO{:}1.5Na_2O{:}K_2O$	16 Mev ^{40}Ar 2-4 Mev ^{20}Ne
Soda Lime Glass	$23SiO_2{:}5Na_2O{:}5CaO{:}Al_2O_3$	20 Mev ^{20}Ne

Table (3-1) (Continued)

B. Organic Detectors

Detector	***Atomic Composition***	***Least Ion Seen***
Amber Phenoplaste Polyethylene	$C_2H_3O_2$ C_7H_6O CH_2	Full – energy fission fragments fission fragments
Polyvinylacetochlocide Polyvinyichloride-polyvinyle	$C_6H_9O_2Cl$ $C_2H_3Cl + C_2H_2Cl$	42 Mev ^{32}S 42 Mev ^{32}S
Biphenyl A-polycarbonate (Lexan, Makrofol)	$C_{16}H_{14}O_3$	0.3 Mev ^{4}He
Polyoxymethylene (Delrin)	CH_2O	28 Mev ^{11}B
Polypropylene	CH_2	1 Mev ^{4}He
Cellulose Triacetate	$C_{12}H_4O_2$	
Cellulose Nitrate	$C_6H_8O_9N_2$	
Polyallyldigolycol Carbonate	$C_{12}H_{18}O_7$ (CR-39)	

To take the radiations damage in the solid-state nuclear track detector two forms:

1. Crystals: the atomic displaces is consist of continuous disorder composed of vacant lattice sites and of interstitial ions or atoms.
2. Polymers: the radiation damage leads to break molecular series and to be formed free radicals (Fleischer et. al. 1975).

3.3 Track Formation Mechanisms In Dielectric Media

The formation of etchable track, besides being a function of the detection material, and the nature of the incoming particle depends upon the exposure geometry and the environmental condition (Zamani 1978).It is related to the production of dense regions of ionization by charged particle. The track formation can be regarded as occurring when the number of ions exceeds certain threshold value (Durrani 1976).The existence of this threshold is one of the most valuable characteristics of track detectors (Somogyi 1996),also, it should be sufficient to summarize the main characteristics of the solid state nuclear track detection technique as follows:

1. Heavy, charged particles (from protons upwards), but not β-particles – nor γ-rays, etc., - can leave latent quasi-continuous trials of damage in dielectric media (but not in most metal and semiconductors), which are relatively long-lived at normal (and sub-zero ^{o}C) temperatures. These 'latent tracks' can survive even high temperature, depending on the medium and the intensity of ionization (i.e. the linear density of displaced electrons): The higher the latter, the more stable (or temperature - resistant) the track or part there of close to the 'Bragg peak' (q.V.), which occurs to wards the end of the charged particle's trajectory. The latent tracks can only be seen by Transmission Electron Microscopy (TEM), being only some tens of (nm) in diameter, or less.

2. The latent tracks can be etched with the help of a suitable etchant (often a simple alkdli or acid, e.g. NaOH or KOH; HF or HNO_3), thereby not only 'fixed' them – i.e. making them permanent – but also enlarging them sufficiently, so that they become visible under an optical microscope. (with diameter of a (μm) or more).

3. Different dielectric have different 'registration threshold' such only those particles which, in a given part of their trajectory as they

slowdown, have linear rates of energy loss (dE/dX), or primary ionization rate (J), above a 'critical value', or threshold, will be registered in a given dielectric medium (see figure (3-1)). Thus polymers (Plastic) far lower registration thresholds than glasses and mineral crystals, and can therefore often record tracks of such low Z ions as α-particles(Z being the a atomic number).The widely used polymer CR-39 (polallyl diglycol carbonate) can record even proton tracks. Crystalline media (minerals), by contrast, can only record high Z- ions (say, with Z > 10 and that only towards the very end of their range in the case of very energy particles such as cosmic rays). This property is often a useful discriminatory tool in the case of mixed radiation field. Different annealing (before the etching process) can also help by preferentially eliminating the latent tracks (or the less stable particles there of) produced by low linear energy transfer rates (Durrani and Bull 1987).

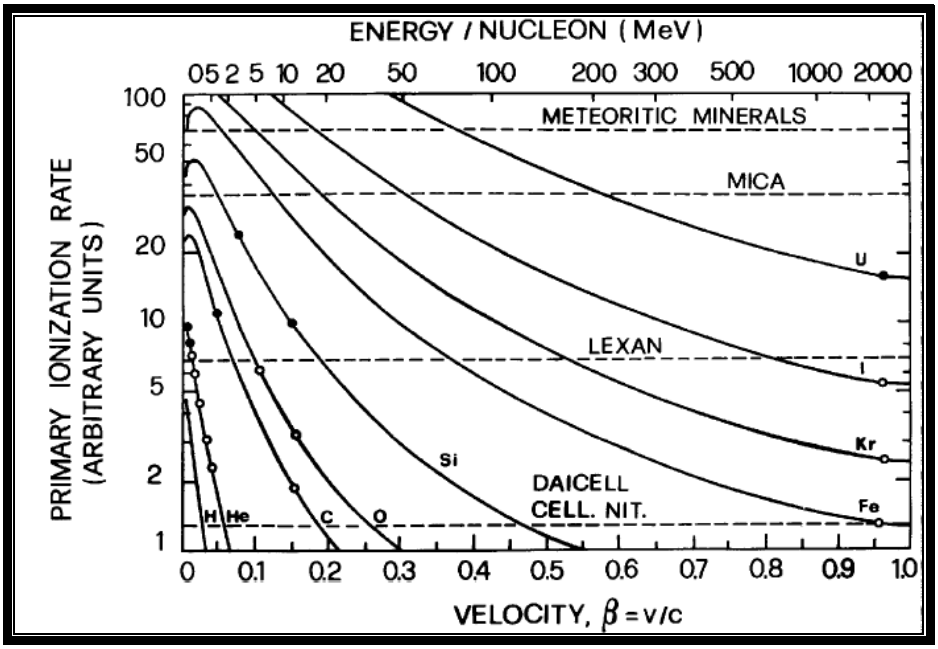

Figure (3-1) Primary ionization rate for various heavy ions (solid curves) versus particle velocity and track etch threshold for various materials (Fleischer et al. 1967)

3.4 Track Affecting Parameters

There are two factors affected on the manifestation of a track:

3.4.1The Track Etch Rate Velocity (V_T):

The track etch rate velocity can be defined as the ratio of dissolution of a detector along the line of the track (Hepburn at.el..1980). Its value depends on the detector type, etching conditions, the particle velocity and its energy. Experiments (Price 1973; Somogyi 1966) prove that V_T increased with increasing the rate of ionization for different organic and inorganic detectors.

The relation between V_T and the temperature of the etching solution is (Durrani & Bull 1987):

$$V_T = B \exp. (-E_T / KT) \quad \text{.....(3-1)}$$

where:

B = constant.

K = Boltzman constant.

T = temperature of the etch ant solution.

E_T = activation energy of the track etch.

3.4.2 The Bulk Etch Rate Velocity (V_B):

The bulk etch rate velocity is the rate of dissolution of the stored detector normal to the surface and energy remote from any track (Hepburn at. al. 1980). It is an important parameter for determining the track sensitivity of SSNTD (Yammamoto 1997). It depends on the construction of the plastic, the constituent of the etching solution, its concentration and temperature

(Blanford et. al. 1970). It is found that for a given homogenous and isotropic solid, the bulk etch rate velocity V_T increases exponentially with etching temperature and concentration of the etching solution (Fleischer et. al. 1975).

The bulk etch rate is found to satisfy the following relation (Yammamoto 1970):

$$\mathbf{V_B = A \exp.(-E_B/KT)} \quad \text{(3-2)}$$

where:

A = constant.

K = Boltzman constant.

T = absolute temperature of the etching solution.

E_B = activation energy of the bulk etching.

3.5 Charged-Particles Tracks In Polymers

Polymeric are the most widely used nuclear track detectors in all fields, their simplicity, good geometry because of their small size, and ability to integrate the response over long periods are amongst the reasons for their popularity. As stated above, plastics are in fact the most sensitive of all known nuclear track detectors – for some of them can register low – charge particles down to proton. The last remark is true of CR-39 and also cellulose nitrates - at last for low energy protons; while all the cellulose nitrates can record α-particles (within certain energy depending on the etching condition). The CR-39 plastic can also exposed to thermal neutrons, which yield α-particles from the (n, α) reaction on the boron (or on the lithium).

The etched tracks are also, through the enlargement, rendered visible under an ordinary optical microscope. The amount of damage, and hence the

etchability and size, etc…, of the etched track, depend on the rate linear energy transfer (LET) of the charge particle over its trajectory (Iliac & Durrani 2003).

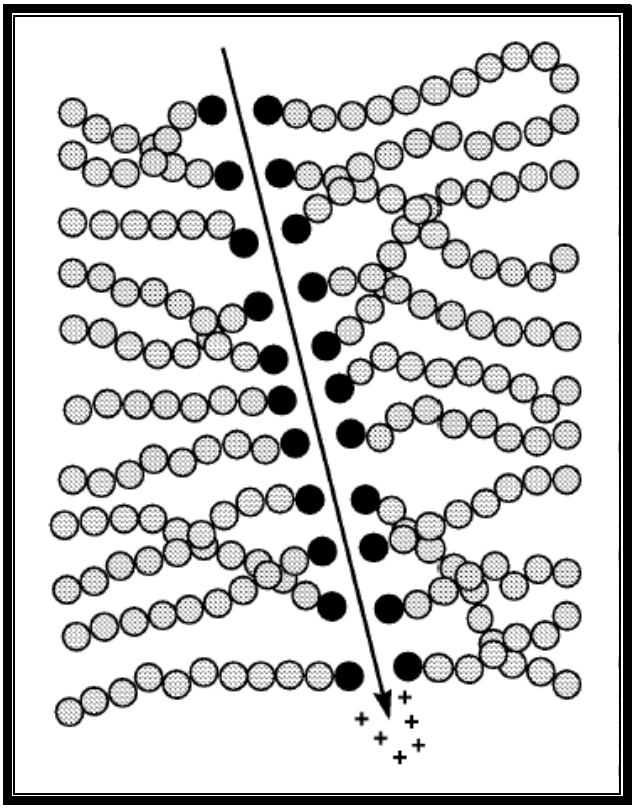

Figure (3-2) Schematic diagram of chain scission in polymers caused by the passage of heavily charged particles. A thermal spike along the trajectory of the charged particle causes localized melting: and this together with excitation caused by the ionization, leads to chain – breaking and production of new chain ends. **(Iliac & Durrani 2003**)

3.6 Track Geometry

Some parameters are used to describe the geometry of etched tracks (Durrani and Bull 1987); the full length of the latent track, L, the thickness of the surface removed by etching, h, and the diameter of the etch pit, D. In the simple instance is a particle penetrating a detector material normal to its original surface as shown in figure (3-3). The linear rate of attack down the

track, i.e. V_B, so that in an etching time t, the etch pit will extend to a distance L from the point of origin (Fleischer and et. al. 1975):

$$\mathbf{L = V_T . t.} \quad \text{.....(3-4)}$$

The surface is also being removed at a rate V_B, so the full length of the etch pit is:

$$\mathbf{L_e = V_T\, t - V_B\, t} \quad \text{.....(3-5)}$$

The diameter of the etch pit is related to V_B and V_T according to the equation:

$$\mathbf{D = 2V_B.t\ \{(V_T - V_B)/\ (V_T + V_B)\}^{1/2}} \quad \text{.....(3-6)}$$

and the removed surface thickness h is:

$$\mathbf{h = V_B .\ t} \quad \text{.....(3-7)}$$

It is clear from these equations that, the track diameters d, and the length of the etched track Le, depend essentially on the competitive effects of V_T and V_B. When $V_B = V_T$, both L and d vanishes, then no track produces.

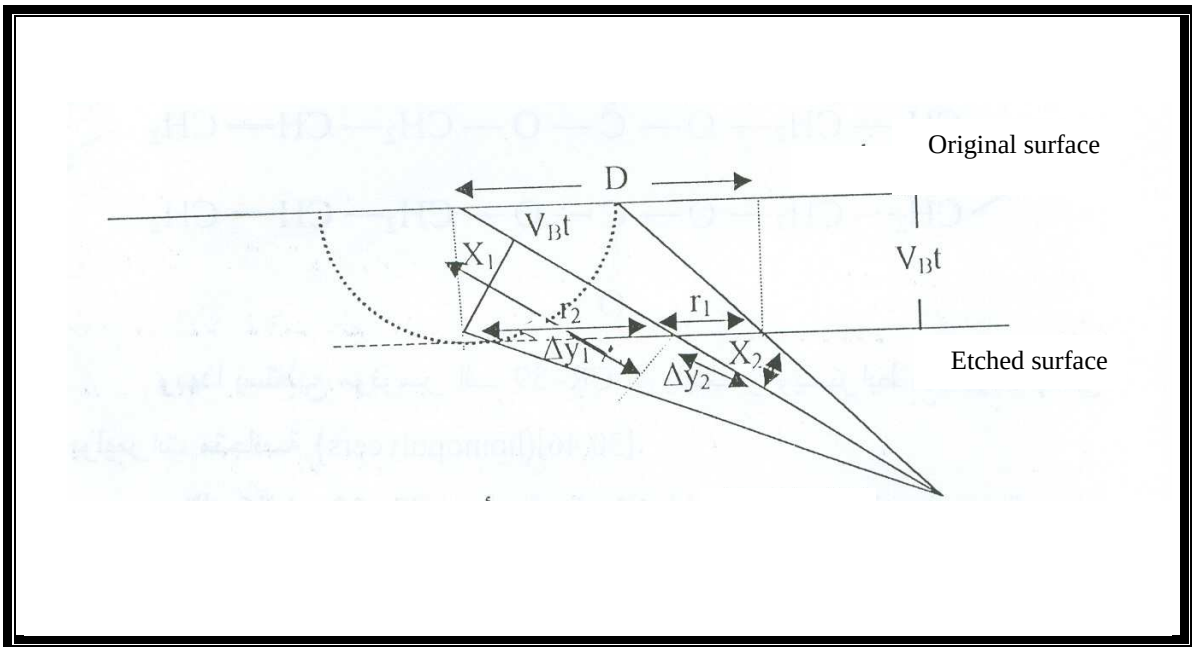

Figure (3-3) Track geometry for incident non-normally

3.7 The Critical Angle (θ_C)

Is a certain minimum angle called the "critical angle" measured from the detector surface below which if the particle enters the detector surface, its track can not be observed after etching because in that case the surface etches faster than the track formation (Fleischer and et. al. 1964). This limitation is due to the geometry of track etching. It is easy to see from the geometry of track etching in Figure (3-4) for constants V_B and V_T:

$$\theta_c = \sin^{-1}(V_B/V_T) \quad \text{.....(3-8)}$$

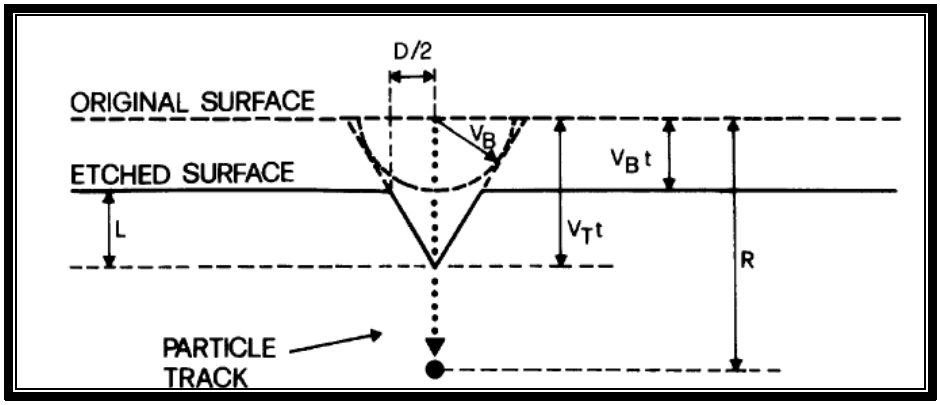

Figure (3-4) The critical angle and Track geometry for particle penetrates a detector material normally. (Durrani and Bull 1987).

3.8 The Chemical Etching

Ionizing particles passing through polymeric track detectors produce latent track, which are trails of radiation damage (Kobayashi 1988).The best means of observing the tracks is by etching the SSNTDs material with a chemical solution, which preferentially attacks the damaged material and enlarges the original track (Nichulas 1987), to a size, which is visible in the optical microscope. In general, etchants for polymeric detectors are frequently solutions of alkali hydroxides such as NaOH or KOH with 1-12 M at 40^0 – 60^0 C (Fleischer 1965). for glasses and minerals crystals such as quartz, mica, and certain pyroxenes etched in aqueous solutions of acids such as HF with ~ 48% concentration at 20^0C (Hushemi 1981).

Etch times can vary from few seconds to many hours. It varies according to the exact etching conditions; the temperature and the concentration of the etchant.

At the end of etching, the detectors are removed, washed in running water, and preferably placed in a small water bath of distilled water for a few minutes to remove the etching residue from the etch pits. After drying, the detectors are ready to be counted under an optical microscope.

3.9 CHEMICAL ETCHING PARAMETERS (Sultan 2001)

1. Type and composition etching solution.

2. The concentration of the etching solution.

3. Temperature of the etching solution.

4. Etching time

3.10 The Etching Efficiency

The etching efficiency is defined as the ratio of the counted tracks and the particle flounce impinge on the detector surface (Durrani 1976).

Etching efficiency = (No. of etched track / No. of incident particles)

The efficiency depends on the track etched rate velocity V_T and the bulk etched rate velocity V_B as represent in equation (3.9) (Monnin 1980):

$$\eta = 1 - (V_B / V_T) \quad \text{.....(3-9)}$$

Since: $\text{Sin } \theta_c = V_B / V$

$$\eta = 1 - \sin \theta_c \quad \text{.....(3-10)}$$

The organic detectors have to recorded high efficiency near between (58 % … 95 %), although the inorganic detectors near value of efficiency between (40 % … 60 %) (Khan 1980).

3.11 Cr-39 Track Detector

CR – 39 is the most sensitive of the nuclear track recording plastics (Maged 1997). It was first discovered by Cartwright et al. (Price and Cartwright 1978). This detector consists of short polyallyle chains joined by links containing carbonate and die ethylene glycol groups into a dense three

dimensional net work (Setjny and Partwood 1986). The chemical form of CR-39 is $C_{12}\ H_{18}\ O_7$. It is illustrated in figure (3-5).

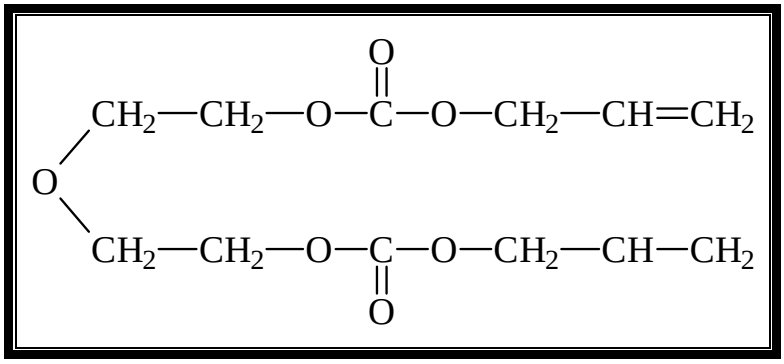

Figure (3-5) the chemical form of CR-39 plastic

When CR-39 is etched, the etching cuts the carbonate links and liberates the polyallyle chains, which then makes an amenable to common analytical methods. Since the publication of the radiation detection properties of CR – 39 in 1978, a number of groups have been using it for the study of track registration of protons, alpha – particles … etc (Stejny & Partwood 1986).

3.12 The Characteristic Cr-39 Organic Track Detector

1. Sensitive to heavy ion damage $Z/\beta > 10$ (Gassou and Benton 1978) where β is the ratio of particle velocity to the velocity of light and uniformity.
2. Amorphous polymer (Stejny and Partwood 1986).
3. Having high Optically Transparency and clear (Fujii et. at. 1990).
4. Environmentally very stable (Durrani and Najjar 1980).
5. The resolution ability is high (e. g. divider α-particles having near energy clear) (Hussien 2001).
6. Having non – solvent chemical etchant (Tommasino 1988).

7. Not sensitive to light and temperature (Sultan 2001).
8. Having high homogenous and isotropic (Hussein 2001).
9. Having threshold less which to be (Z/B ~ 6).
10. Detection α-emission energies from isotopes sources (0.1Mev to more than 20 Mev) (Durrani 1982).

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