A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF ÇANKIRI KARATEKİN UNIVERSITY

A COMPARATIVE STUDY OF THE EFFECTS OF LOW DOSES GAMMA RAYS ON BLOOD FOR HEALTHY PEOPLE AND DIABETES

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
PHYSICS

BY

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ÇANKIRI

2023

A COMPARATIVE STUDY OF THE EFFECTS OF LOW DOSES GAMMA RAYS ON BLOOD FOR HEALTHY PEOPLE AND DIABETES

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May 2023

We certify that we have read this thesis and that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science

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Aseel Murad Radhi AL-ZUBAIDI

ABSTRACT

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Aseel Murad Radhi AL-ZUBAIDI

Master of Science in Physics

Advisor: Prof. Dr. İlyas İNCİ

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May 2023

The objective of this study was to explore the effect of gamma irradiation on the hematological and biochemical parameters of complete blood counts for diabetic and healthy persons This study is conducted at the Blood unit, Department of Diagnostic Laboratory Services of Al-Nasiriya Heart Centre (NHC) A total of 20 blood samples were collected from diabetic persons, and the same number was collected from healthy persons of different ages. The samples were analyzed before and after irradiation (0.5 mCi Cs-137 Gamma-ray standard source) using a Hematology analyzer to determine the hematological and biochemical parameters. Significant changes were observed between the control samples before irradiation and the samples after irradiation. The results show a significant change in the number of RBC at 18.863 mGy/hr compared with the control sample in healthy and diabetic from 4.47x10^6 µL to 1.82x10^6 µL and from 4.32x10^6 µL to 1.05x10^6 µL, respectively. The results appear also a significant change in all hematological and biochemical parameters such as WBC, PLT, Hb, Hct, Mcv, McH, and HcHc after irradiation, especially at a high dose rate of more than 5 mGy/hr In comparison between healthy persons and diabetic, the results appear that diabetic persons have more affected by gamma radiation within the used dose rate than the healthy. The recommendation of the current study for diabetics is to avoid electromagnetic radiation (gamma ray and X-ray) whose dose rate exceeds 5 mGy/hr. The obtained results are in good agreement with the data and recommendations of recognized international organizations and agencies such as the EPA, IAEA, WHO, UNSCEAR, and ICRP.

2023, 63 pages

Keywords: Gamma ray, Blood, Urine, Diabetes, Hematology

ÖZET

SAĞLIKLI İNSANLAR VE DİYABET İÇİN DÜŞÜK DOZ GAMA IŞINLARININ KAN ÜZERINDEKİ ETKİLERİNİN KARŞILAŞTIRMALI BİR ÇALIŞMASI

Aseel Murad Radhi AL-ZUBAIDI

Fizik, Yüksek Lisans

Tez Danışmanı: Prof. Dr. İlyas İNCİ

Eş Danışman: Dr. Öğr. Üyesi Jabbar M. Rashid

Mayıs 2023

Bu çalışmanın amacı, gama ışınlamasının diyabetik hastalarda tam kan sayımının hematolojik ve biyokimyasal parametreleri üzerindeki etkisini araştırmaktı ve sağlıklı kişiler bu çalışma, Al-Nasiriya Kalp Merkezi'nin (NHC) Teşhis Laboratuvarı Hizmetleri Departmanı Kan ünitesinde yürütülmektedir. Diyabetik kişilerden toplam 20 kan örneği toplandı ve farklı yaşlardaki sağlıklı kişilerden aynı sayıda kan örneği alındı. Numuneler ışınlamadan önce ve sonra analiz edildi (0.5 mCi Cs-137 Gama ışını standart kaynağı) hematolojik ve biyokimyasal parametreleri belirlemek için bir Hematoloji analiz cihazı kullanılarak. Önemli değişiklikler ışınlama öncesi kontrol numuneleri ile ışınlama sonrası numuneler arasında gözlendi. Sonuçlar, 4,47x10^6 µL olan sağlıklı ve diyabetiklerde kontrol numunesi ile karşılaştırıldığında 18,863 mGy/saatte RBC sayısında önemli bir değişiklik olduğunu göstermektedir sırasıyla 1,82x10^6 µL'ye ve 4,32x10^6 µL'den 1,05x10^6 µL'ye. Sonuçlar ayrıca, özellikle 5 mGy/saat'in üzerindeki yüksek doz hızında ışınlamadan sonra WBC, PLT, Hb, Hct, Mcv, McH ve HcHc gibi tüm hematolojik ve biyokimyasal parametrelerde önemli bir değişiklik gösterir Sağlıklı kişilerle diyabetikler karşılaştırıldığında, sonuçlar diyabetik kişilerin kullanılan doz oranı içinde gama radyasyonundan daha fazla etkilendiklerini göstermektedir sağlıklı Mevcut çalışmanın diyabet hastalarına tavsiyesi, doz hızı 5 mGy/saat'i aşan elektromanyetik radyasyondan (gama ışını ve X-ışını) kaçınılmasıdır. Elde edilen sonuçlar, EPA, IAEA, WHO, UNSCEAR ve ICRP gibi tanınmış uluslararası kurum ve kuruluşların verileri ve tavsiyeleri ile iyi bir uyum içindedir.

2022, 63 sayfa

Anahtar Kelimeler: Gama ışınları, Kan, İdrar, Diyabet, Hematoloji

PREFACE AND ACKNOWLEDGEMENTS

I would like to thank my thesis advisor, Prof. Dr. İlyas İNCİ, and Asst. Prof. Dr. Jabbar M. Rashid for thier patience, guidance and understanding.

Aseel Murad Radhi AL-ZUBAIDI

Çankırı-2023

CONTENTS

LIST OF SYMBOLS

Dr	Dose rate
Γ	Gamma factor
A	Source activiy (mci)

LIST OF ABBREVIATIONS

CBC	Completes blood count
DM	Diabetes mellitus
E	Energy
Hb	Hemoglobin
HcT	Hematocrit
LET	Linear energy transition
Lym	Lemphocytes
MCH	Mean corpuscular hemoglobin
MCHC	Mean corpuscular hemoglobin concentration
MCV	Mean corpuscular volume
MPV	Mean platelet volum
Neu	Neutrophils
PCT	Procalcitonin
PDW	Platelet distribution width
P-LCR	Platelet – Large cell ration
PLT	Blood platelts
RBC	Red blood cells
RDW	Red cell distribution width
WBC	White blood cells

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1. INTRODUCTION

The majority of diseases, regardless of the body organ systems they primarily affect, cause alterations in the blood at some point or over time (Talwar and Srivastava, 2006). Diabetes mellitus (DM), among the most prevalent of these illnesses, can lead to As the prevalence of diabetes, particularly type 2, is increasing, end-stage renal disease (ESRD) has become more common (American Diabetes Association, 2004). specific changes to kidney anatomy are brought on by diabetes, and hyaline arteriosclerosis, diffuse mesangial sclerosis, and increased glomerular basement membrane width are the hallmarks of classic glomerulosclerosis (Mauer *et al*. 1981) Diabetic nephropathy, African Americans, Asians, and Native Americans are all affected by one of the most severe consequences of diabetes mellitus more frequently unlike Caucasians (Young *et al*. 2003). Most patients with kidney disease have normocytic, normochromic anemia, which is primarily caused by decreased renal erythropoietin production. Practically speaking About 90% of an individual's erythropoietin production occurs in the kidney., reduced Hb, hematocrit, or any combination thereof or RBC count—occurs, anemia is thought to exist (Tkachuk and Hirschmann, 2007) Prior to Anaemia and erythropoietin have been associated to the onset of advanced renal failure (serum creatinine 1.8 mg/dl). insufficiency in patients with diabetic nephropathy (Bosman *et al*. 2001). Target Hb levels for diabetic individuals need to be 12–13 g/dl, and the chance that erythropoietin treatment could cause blood pressure to rise should be considered (Sinclair *et al*. 2003). Patients with CKD who have diabetes may experience anemia due to one or more reasons. Iron and erythropoietin deficiency, as well as The primary factors that lead to anaemia in CKD patients include hyporesponsiveness to erythropoietin's actions. The reason for these people's lack of erythropoietin is (Mehdi and Toto 2009). When Hb is less than 11 g/dl in diabetic and renal illness patients, the NKF advises doctors to think about treating anemia (Mehdi and Toto 2009). The kidneys are two separate tissues that provide a number of vital bodily functions. The most essential functions include glyconeogenesis, Homeostasis is the maintenance of equilibrium in the body's electrolyte, acid-base, and water balances as well as the removal of surplus and waste compounds from plasma. A crucial test for keeping track of the renal system is a complete blood count. function and is routinely performed during some jurisdictions

need yearly physicals (Talwar and Srivastava 2006) In order to accurately assess hematological function and diagnose associated diseases, careful blood analysis is frequently the first step. Many hematological problems are also identified by certain blood tests. Critical diagnostic information on cellular morphology, quantification of the blood cellular components, and evaluation of cellular size and shape are obtained from the analysis of blood smears and haematological parameters, allowing the creation of broad differential diagnostic impressions and directing further testing (Greer *et al*. 2013).

1.1 The Aim of Present Work

In this study objective is to to assess the the parameters of a complete blood and urine image taken after low-dose gamma radiation treatment in diabetic patients and compare the findings to those obtained in controls in the same setting. The goals of this study are to: 1- Measure and quantify the parameters of the full blood and urine picture of diabetic patients following exposure to modest doses of gamma radiation and compare the outcomes with those of healthy individuals in the same setting in a Nasiriya city.

2. Ascertain the impact of radiation on the blood parameters related to diabetes.

3. To determine how low-dose gamma radiation affects living cells in blood and urine.

Measure the type 2 complete blood count as a general aim.

Objectives in detail: To compare test and control groups for Hb, PCV, red blood cell count and its indices (MCV, MCH, MCHC), white blood cell count, all differential leukocyte count, and platelet count. Hb, PCV, RBC count and its indicators (MCV, MCH, MCHC), WBC count, all differential leukocyte count, and platelet count should be compared between the test and control groups. to ascertain the test group's gender distribution.

2. LITERATURE REVIEW

2.1 Radiation

Our cosmos is made up of two elements: mass and energy. Fundamentally, these two things stand for a single reality that, at various moments, takes the forms of mass and energy. $E = mc^2$, Einstein's well-known mass-energy relation, binds them together irrevocably. Energy is a physical substance, much as matter. Particles or waves can be used to carry energy from one location to another in space. Radiation is the name of the transmission process (Ahmed 2007).

2.1.1 Type of radiation

Ionizing and Non-ionizing radiation is a real thing. Radiation that isn't ionising is less energetic because it has a lower frequency and a longer wavelength. Ionizing radiation has a greater frequency and a shorter wavelength.

2.1.1.1 Non–ionizing radiation

radio waves, infrared, and visible light microwaves, and sunshine all emit radiation that isn't ionising, which is less energetic than ionizing radiation and therefore unable to create ions. The electromagnetic spectrum is depicted in (Figure 2.1) (Ng 2003).

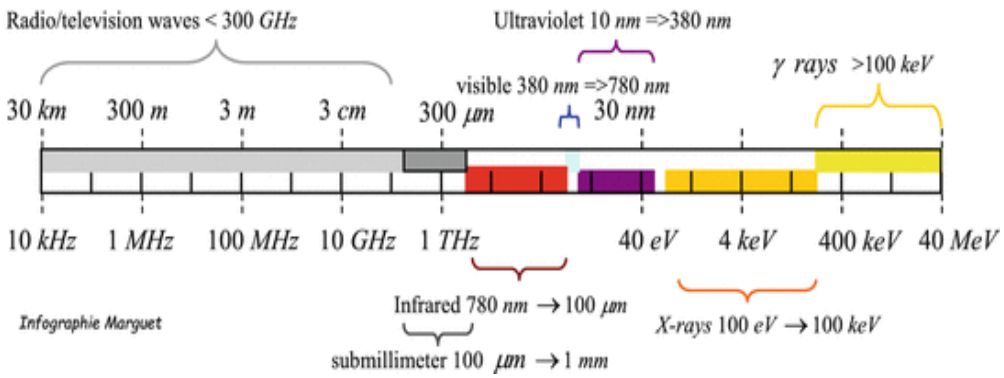

Figure 2.1 ELECTROMAGNETIC -SPECTRUM

2.1.1.2 Ionizing radiation

Radiation can ionize atoms by removing their electrons and creating ions when it has a high enough energy. Ionization happens when one electron from an atom is knocked out or ejected, leaving the atom with a net positive charge. in light of ionising radiation can damage live cells and, more crucially, the DNA within those cells, it is believed to raise the risk of developing cancer. "Ionizing radiation" is therefore artificially created because of its high potential for causing biological harm. isolated from electromagnetic and particle radiation. Low to moderate radiation strengths will only ionize a small part of the trillions of atoms that make up each cell. Ionising radiation's potential for harm (equivalent dose) and the sensitivity of the organism or tissue being exposed to radiation both affect the dose of radiation that is absorbed and the possibility that it may cause cancer (effective dose) (Zarkooshi 2015). X-rays, gamma rays, beta particles, and alpha particles are all types of ionizing radiation.

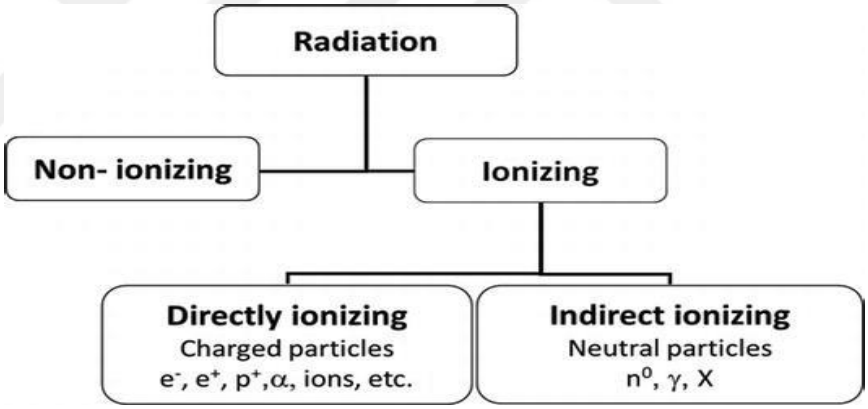

Figure 2.2 Types of radiations

2.1.2 Sources of radiation

Background radiation is always around us; it permeates everything. Since the earth's genesis and the emergence of life, The effects of ionising radiation a constant threat all life on earth. Background radiation is produced by radionuclides, or radioactive atoms, which can be either naturally occurring or made artificially. Actually, the main source of radiation in the environment is naturally occurring radiation.

2.1.2.1 Natural Radiation Sources (Cosmic Radiation)

The term "cosmic radiation" refers to radiation that originates from the sun and space. As potentially energetic particles and electromagnetic waves from space pass through the earth's atmosphere, they generate more radiation and cosmogenic radionuclides. The bulk of them penetrate near to the poles where the magnetic field's shielding is weakest, but some of them penetrate when the earth's atmosphere is thin at high elevations is thinnest and reach the surface of the planet. Most cosmogenic radionuclides are tritium (hydrogen-3), carbon (14), and beryllium (7). The cosmogenic nuclides are listed in Table 1-1. 10Be, 26AL, 36Cl, 80Kr, 32Si, 39Ar, 22Na, 35S, 37Ar, 33P, 32P, 28Mg, 24Na, 38S, 31Si, 18F, 39Cl, 38Cl, and 34mCl are some other cosmogenic radionuclides (Paleari *et al*. 2022).

Table 2.1 Cosmogenic Nuclides

Nuclide	Half-life	Source	Specific Activity
C-14	5730 yr	Cosmic-ray interactions, $^{14}N(n,p)^{14}C$	~15 Bq/g
Tritium	12.3 yr	Cosmic-ray interactions with N and O; spallation from cosmic-rays, $^{6}Li(n,alpha)^{3}H$	1.2×10^{-3} Bq/kg
Be-7	53.28 days	Cosmic-ray interactions with N and O	0.01 Bq/kg

2.1.3 Biological effects of radiation

Two categories biological nature consequences the radiation.The first section illustrates exposure to high radiation doses for brief intervals that result in immediate or acute consequences. The second phase involves prolonged low-dose radiation exposure that results in chronic or long-lasting consequences. Low amounts frequently alter or harm cells, whereas Cell death is commonly induced by excessive dosages. Large-scale cell

death can have negative effects on tissues and organs. The body tries to repair the damage, but in rare cases the injury is too severe, acute, or diffuse to be repaired.

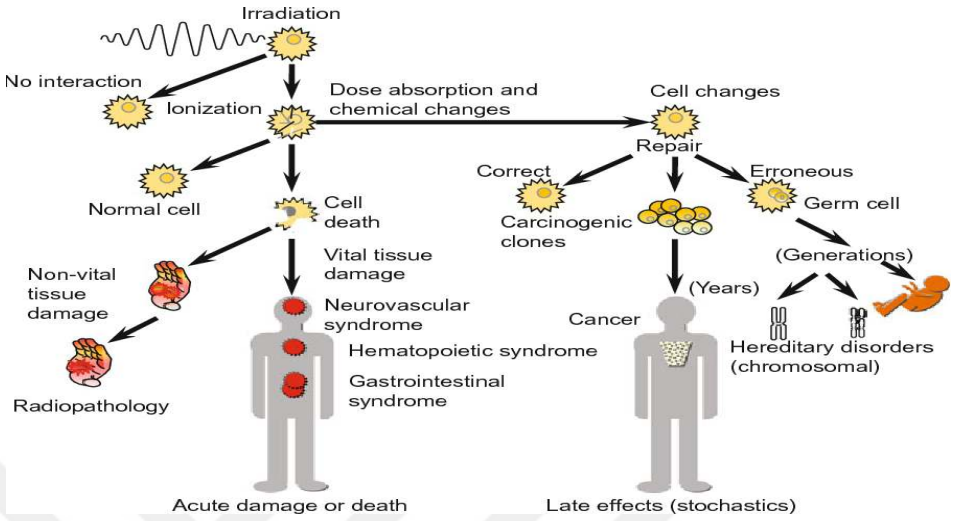

Figure 2.3 From the biological effects of ionizing radiation

Ionising radiation can cause damage cells in one of two ways, either directly or indirectly, when it is absorbed by biological material

2.1.4 Direct effect

Direct effect happens when ions created by alpha, beta, or X-rays physically damage one or both sugar phosphate backbones or split significant DNA base pairs. Weak hydrogen bonds are tying the three major base pairs of adenine, cytosine, and thymine guanine together. Guanine always couples with cytosine, while adenine always pairs with thymine (except in RNA "ribonucleic acid," where uracil replaces thymine). Ionizing radiation's direct impact can also have an impact on the bonding of these primary pairs. In a direct reaction, the radiation affects the cell's vital objective immediately. Through Coulomb reactions, the target's own atoms may be ionized or excited, setting off a chain reaction of physical and chemical events that finally results in biological damage. Direct effect, which settles a significant amount of energy in a little distance like (, n) particles with biological materials, is the main reaction of high

linear energy transition (LET), which means there is a rapid attenuation of the radiation (Al-Mazuri 2000).

2.1.5 Indirect effect

Indirect action occurs when radiation interacts with internal atoms and molecules, primarily water (because water makes up 80% of a cell), to create free roots that can spread within the cell. The direct and indirect effects of radiation on DNA Gene are depicted in (Figure 2.4).

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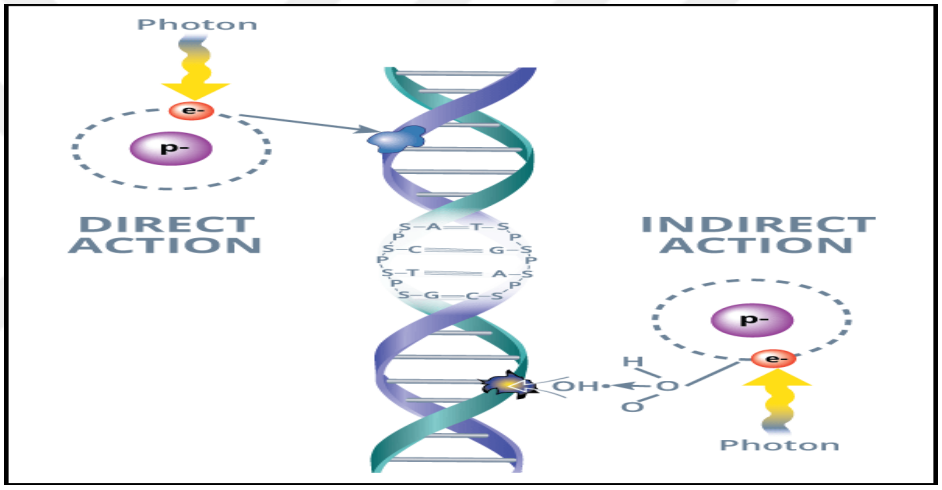

Figure 2.4 Radiation damage to DNA is caused by hydroxyl radicals

Cells contain a lot of water, and each radiation incidence is largely absorbed by water molecules in cells. The water molecule will break due to the height intake energy, releasing (H+ and OH-) ions inside the cell (Equation 1.1). Normally, those ions are low energy and combine quickly to form water; but, with high energies, "hydrogen peroxide" will produce reactions that can be expressed as follows.

$$3H_2\,O + Energy \rightarrow 3H^+ + 3OH^- \rightarrow H_2O_2 + 2H_2O \qquad (1.1)$$

hydroxyl radicals Strongly reactive oxidizing compound H2O2. Being a highly reactive compound, it has the potential to damage other molecules, including DNA (deoxyribonucleic acid) and other vital molecules that organize and regulate key physiological processes. Despite the A cell can sustain significant molecular damage, and too much molecular damage can cause cellular death or mutation. Extremely reactive free radicals like the water radical H2O+ and the hydroxyl radical were created during radiation interactions with water The target damage inside the cell can then be brought on by the free radicals. Although much of the damage caused by heavy charged particles, such as alpha particles, is caused by indirect impacts, they are more likely to directly harm low charged particles, such as X-rays. By generating free radicals, ionizing radiation can potentially indirectly weaken or harm cells. Free radicals are extremely reactive molecules because they have unpaired electrons on the molecule. Free radicals can produce substances like hydrogen peroxide, which can trigger damaging chemical processes inside of the cells. Cells may experience a variety of structural alterations as a result of these chemical changes, which start a change in function or cell death (Ng 2003).

2.2 Cesium - 137

The nuclear fission of uranium-235 and other fissionable isotopes in nuclear reactors and nuclear weapons produces the radioactive isotope cesium-137, also referred to as radiocaesium. One of the more common fission products is it. Another source of tiny quantities is uranium-238 fission that occurs spontaneously. It is one of the most troublesome short- to medium-lifetime fission products. Due to its relatively low boiling point of 671 °C (1,240 °F), caesium-137 is readily volatilized when released quickly at high temperatures, as in the Chernobyl nuclear catastrophe and with atomic explosions. As a result, it may fly quite a distance in the air. The most common chemical forms of caesium, salts, have a high water solubility, which makes it easy for radioactive fallout to move and spread throughout the environment. Caesium-137 was found by Glenn T. Seaborg and Margaret Melhase.

Caesium-137 is valuable in many different contexts. Small amounts of it are used to calibrate radiation-detection equipment. In medicine, radiation treatment makes use of it. flow metres, thickness gauges, moisture-density gauges (for density measurements; moisture reading provided by americium-241/beryllium) and in gamma ray well logging apparatus.

2.3 Previous Studie

Mohammad and Almuhammadi (2011) conducted a study in Iraq to determine some potential risk factors for diabetic nephropathy and evaluated the patients' clinical and hemological conditions. RBC counts, blood Hb and PVC measures, RBC indices, and hormonal research (serum erythropoietin level) are all examples of blood work. According to the study, females with extensive histories of diabetes are more likely to develop diabetic nephropathy. The study's findings regarding hematological parameters revealed a very important drop ($p< 0.01$) in RBC counts., In patients with diabetic nephropathy serum erythropoietin levels, blood Hb, PCV, and RBC indices, and those of the control group were compared. In summary, anemia that is present alongside diabetic nephropathy may be the cause of the elevated and decreased levels of specific hematological markers that are related with the condition (Muhammad and Almuhammadi 2011).

The development of diabetic nephropathy, according to Chung et al. (2005) in Tiwan, was accompanied by an increase monocyte, neutrophil, and peripheral total WBC counts However, the lymphocyte count decreased. The quantity of lymphocytes, monocytes, and neutrophils was separately and significantly linked with diabetic nephropathy when WBC counts were looked at (Chung *et al*. 2005).

The type of RBC. In most cases, substantially larger doses of -radiation were applied to see changes in Hb (Szweda-Lewandowska *et al.* 1989, Oshtrakh *et al.* 1991). Additionally, our research demonstrates that the Hb pool in diabetes RBCs has a higher proportion of MetHb and a smaller proportion of OxyHb. This is in line with the finding

that diabetic RBCs have a higher amount of glycated haemoglobin, which cannot bind oxygen (Adak *et al.* 2008).

According to Multiple enzymatic and chemical processes are probably triggered inside the membranes as a result of modest doses of radiation, as evidenced by the distinctive discontinuities and monotonic hemolysis modifications that we discovered in both healthy and diabetic RBCs.Within minutes, their effects are stabilized. These mechanisms may be crucial for comprehending impacts of "by-stander" behaviour shown in novel radiological techniques that use two distinct radiation doses that are applied at time-separated intervals (Jayashree *et al*. 2001).

by using the blood of diabetic patients and wholesome donors. Chronic hyperglycemia and metabolic disturbance are associated with diabetes, as is poor blood glucose homeostasis (Ha *et al*. 1999, Baynes *et al.* 1999).

There have been reports of changes in RBC inner homeostasis and RBC membrane characteristics in diabetes cases (Ha *et al.* 1999, Nagamatsu *et al*. 1986, Waczulková *et al*. 2000, Adak *et al*. 2008).

When compared to control RBCs, diabetic RBCs exhibit higher levels Among the byproducts of glycooxidation, lipid, and protein peroxidation (Resmi *et al.* 2001).

There is also a glycooxidation hypothesis, which holds that the long-lasting, cumulative oxidative damage to proteins that occurs in aging and diabetes is caused by glycooxidation (Baynes 1991).

A number of enzymatic processes that protect erythrocyte membranes from ROS have also been demonstrated experimentally to be changed in diabetic RBC membranes (Ha *et al.* 1999, Uzel *et al.* 1987, Stevens *et al.* 2000, Murakami *et al.* 1989, Yoshida *et al.* 1995, Thornalley *et al.* 1996, Lang *et al.* 1966, Venerando *et al.* 2002). Consequently,

irradiating both Low-dose -radiation RBCs from diabetic and healthy individuals (0.04 mGy).

2.4 Blood Cells

2.4.1 Red blood cells

Red blood cells that are mature, or erythrocytes, are necessary for effective gaseous exchange and bringing hemoglobin into close contact with tissues. Hemoglobin, a pigment that carries iron, makes up the majority (90–95 percent of its dry weight) is made up of cytoplasm There are hardly many organelles. Lysing the erythrocyte is required for the measurement of hemoglobin, often known as hemoglobin, in whole blood. Haemoglobin levels should be between 12 and 18 g/dL for young female individuals and 14 to 18 g/dL for older male people for young male adults (Hoffbrand *et al.* 2006).

• Form: A biconcave disk is the typical red blood cell's shape, which maximizes the surface area to cytoplasmic volume ratio. An erythrocyte is estimated to have a surface area of 128m.

• Lifespan: The adult erythrocyte has a lifespan in circulation of about 120 days. As red blood cells get older, their surface area shrinks in proportion to their cytoplasmic volume, creating a more rigid sphere shape that eventually gets stuck in splenic cords.

* Purpose: To provide a habitat for the hemoglobin molecule's two alpha and two beta globin chains, which are complexed with the respiratory pigment heme, which contains iron. Hemoglobin's main physiological function is the transfer of oxygen and CO2. Hematocrit (PCV), haemoglobin (Hb), and red cell concentration per unit volume are three numerical measurements that collectively characterise haemoglobin the red blood cell analytical parameter. Additionally, three other indices that describe the typical qualitative traits are obtained from the red cell population. The mean corpuscular

volume (MCV), mean corpuscular haemoglobin (MCH), and mean corpuscular haemoglobin concentration (MCHC) are these three metrics Automated hematology analyzers regularly gather and compute all of these variables (Greer *et al.* 2013). The frequency The amount of RBCs in a unit of whole blood is all that is required to perform an erythrocyte count, often known as an RBC count. Male cells per liter range from 4.5 to 6.5; female cells range from 3.9 to 5.6 (Hoffbrand *et al.* 2006)

• Indexes for red cells Volume Mean of the Corpuscles The average red blood cell volume is a helpful metric for categorizing insights into the pathophysiology of red cell disorders may be provided by anaemias. Red blood cells are referred to as microcytic when the MCV is low and macrocytic when it is high. Blood having a normal MCV is referred to as normocytic. Anisocytosis is aberrant cell volume fluctuation (Gartner and Hiatt 2006).

* Hemoglobin in the MCH, or mean corpuscle To the MCH which is represented in mass unit picograms, stands for the mass of haemoglobin on average within a red blood cell. Hemoglobin mass is reflected by the MCH. Hemoglobin mass per red cell falls in anemias caused by reduced hemoglobin production, such as iron deficiency anemia, decreasing the MCH score as a result (Greer *et al.* 2013).

* Typically, the domain is 27 to 34 pp. The average concentration MCHC, corpuscular haemoglobin The average quantity of haemoglobin found in red blood cells is this. The typical domain is between 31% to 36%. (Hoffbrand et al., 2006). In terms of every deciliter of packed RBCs, there are grammes of haemoglobin, the MCHC is expressed. Normochromic, hyperchromic, and hypochromic, respectively, are terms used to describe normal, high, and low MCHC cells levels. These terms are crucial for categorizing anemia (Gartner and Hiatt 2006).

• The variety of red cell sizes within a sample is reflected by the red cell distribution width (RDW), which measures cellular volume heterogeneity, is a measurement of red cells. RDW has been shown to be helpful in identifying anemia early as it develops (Hoffbrand *et al.* 2006).

2.4.2 White blood cells

Granulocytes White blood cells include lymphocytes, monocytes, and (neutrophils, eosinophils, and basophils). The following are the WBC and other leukocyte normal.

The ranges: (Dace and Lewis 2011).- count of white blood cells 4.0–10.0 x109/l
- distinct white blood cell count
Neutrophils 2.0–7.0 x 109/l (40–80%),
Lymphocytes 1.0–3.0 x 109/l (20–40%),
Monocytes 0.2–1.0 x 109/l (2–10%) ,
Eosinophils 0.02–0.5 x 109/l (1–6%),
Basophils 0.02–0.1 x 109/l (<1–2) .
Different leukocyte cells' functions:

- Neutrophils: prevent infection from bacteria or fungi, and when their amount increases, they are known as neutrophils.

- Eosinophils: They enter exudates linked with play and inflammation a unique role in allergic reactions, parasite defense, and the elimination inflamation-induced production of fibrin (Hoffbrand *et al*. 2006).

- Basophils: Rarely do they appear in healthy peripheral blood. Heparin and histamine are found in the many black cytoplasm granules that cover the nucleus in these cells. They transform into tissues containing mast cells. They produce histamine and have immunoglobulin E (IgE) attachment sites. is correlated with their degranulation (Hoffbrand *et al*. 2006).

- Lymphocytes: Three main lymphocyte populations with distinct antigen recognition mechanisms make up the functional mammalian immune system: natural killer (NK) cells, bursal or marrow-derived (B) cells, and T cells, which are derived from the thymus. Three populations serve as mediators various

immunological effector actions that are intricate and sophisticated. T cells play a crucial role in the body's defense against intracellular germs, as opposed to B cells, which create antibodies that attach to pathogens to support their elimination. Natural killer cells have the ability to eliminate bodily cells that are presenting signs that they need to be eliminated because they have contracted a virus or developed cancer. When lymphocytes grow in number, it is known as lymphocytosis (Lichtman *et al*. 2010).

- Monocytes: They carry out the same phagocytosis, or hoover, function as neutrophils but because they give pieces of pathogens to T cells, they live considerably longer than neutrophils do. When the quantity of monocytes grew, it was known as monocytosis (Young *et al*. 2002).

2.4.3 Blood platelets

Non-nucleated flat, biconvex, round or ovoid discs (2–5 m in diameter), derived from bone marrow megakaryocytes, have pale-blue peripheral hyalomeres, a network of electron-dense tubules, a marginal bundle of 10-15 circumferential microtubules to maintain the disc shape, actin, and myosin, as well as a network of invaginating channels (the open canal) When platelets are activated, the granules are forced into the core of the platelet by the microtubular system, where after which the coagulation system releases them is activated (Gartner and Hiatt 2006). The two distinct states of platelets are active and at rest, with the former characterized by basal metabolic activity and the latter by agonist stimulation (such as a response to thrombin) (Greer *et al*. 2013). When a vascular damage occurs, platelets typically create mechanical plugs as part of the normal haemostatic response. Blood may spontaneously leak from tiny vessels in the absence of platelets (According to Hoffmann *et al*. 2006), the average platelet life span is 7 to 10 days and the average platelet count is 250 x 109/L (range: 150 to 400 x 109/L).

2.4.4 Complete blood count test

The CBC primarily assesses changes in anatomical structures rather than a series of function tests. It provides information of two different kinds, including the cells suspended in the plasma, in number (as well as their morphological characteristics and typical RBC and platelet sizes), and their concentration. Thirdly, the ratio of plasma volume to blood volume, as well as the quantity of cells in one unit of blood, is reflected in the concentration of cells (i.e., the quantity counted). Making clinical judgments that are primarily of a pathophysiological nature Whether suspected or confirmed, while managing a blood condition, is thus challenging when interpreting the CBC. Based on laboratory data that are fundamentally anatomical in nature (e.g., to attempt to determine underlying functional modification) (Beck 2009). A CBC is performed on a haematology cell analyzer by a medical technologist to determine the number of RBCs, Hb, PCV, RBC indices, WBCs, and platelets (Bernadette 1997). The assessment of leukocyte and platelet counts serve to distinguish between pure anaemia and pancytopenia, which signifies a more widespread marrow deficit (caused, for instance, by marrow hypoplasia or infiltration) or general cell death (e.g., hypersplenism). The platelet and neutrophil counts are frequently measured in anemia induced by hemolysis or bleeding. Furthermore, the leukocyte count is frequently elevated in infections and leukemias, and aberrant either neutrophil precursors or leukocytes may be detected (Hoffbrand *et al*. 2006)

2.5 Diabetes Mellitus

A person with diabetes Mellitus causes high blood sugar because the body does not generate enough insulin or the insulin that is produced is not used by the cells. (Lawernce *et al.*2008). High blood sugar affects blood vessels and nerves the likelihood of repercussions including heart disease, stroke, renal disease, blindness, tooth decay, and amputations grows over time. A higher predisposition for other illnesses, aging-related mobility loss, depression, and problems during pregnancy are all potential additional side effects of diabetes (NIH 2014).

2.5.1 Classification of Ddiabetes mellitus

The three primary kinds of diabetes are as follows:

2.5.1.1 Type 1 diabetes (T1DM)

Type 1 diabetes, which is usually characterised by an absolute absence of insulin and is brought on by -cell death (American Diabetes Association 2015). Diabetes, before being called juvenile diabetes, is typically discovered in kids, young adults and teens. because the body's immunological system attacked and destroyed them, the beta cells of the pancreas cease to produce insulin in people with this type of diabetes (NIH 2014). Systemic indicators of an autoimmune process, such as alterations in the circulating B lymphocyte subset and islet cell autoantibodies. Beta cell death often happens during cycle deterioration and remission and takes many months (William and Stephen 1995)

2.5.1.2 Type 2 diabetes (T2DM)

The most common kind of diabetes, commonly referred to as adult-onset diabetes, can range from predominate insulin resistance with a relative insulin shortage to predominate defective secretion with insulin resistance. It frequently has connections to other problems with the so-called metabolic syndrome. Type 2 diabetes can strike anyone at any age, including children, but it's more common in people who are older. Over 90% of instances of diabetes are type 2 diabetes mellitus, which is a serious public health issue. 30-85% of type 2 diabetes cases go untreated as a result of patients delaying seeking treatment due to the disease's sneaky and initially asymptomatic characteristics. 20% of patients will already have illness complications when they are eventually diagnosed (Amod *et al.* 2012). Insulin resistance and relative insulin insufficiency are present in all T2DM patients (William and Stephen 1995).

2.5.1.3 Gestational diabetes

Pregnancy-related hyperglycemia is defined as blood glucose levels that are higher than normal but lower than those that are symptomatic of diabetes. Women with gestational diabetes are more prone to experience complications during pregnancy and delivery. They also have an increased risk of eventually getting type 2 diabetes (WHO 2012).

Specific types of diabetes owing to other reasons, such as monogenic diabetes disorders of the pancreatic exocrine (like cystic fibrosis) syndromes (like newborn diabetes and maturity- Young-onset diabetes (MODY) and chemically or drug-induced diabetes (such as after receiving organ donation or as part of HIV therapy) (American Diabetes Association 2015).

2.5.1.4 Signs and symptoms of diabetes mellitus

Traditionally, polyurea, polydispasia, and polyphagia have been used as indicators of DM. Long-term high blood sugar levels may modify the structure of the eye's lenses, altering vision (Cooke and Plotnick 2008).

2.5.1.5 Diagnosis of diabetes mellitus

Because type 2 diabetes may not exhibit any symptoms in its early stages, blood tests are performed to diagnose the condition. All diabetes blood tests entail taking a sample of blood at the clinic or other commercial location and sending it to a lab for evaluation. Blood must be analyzed in a lab to guarantee that test results are reliable. However, they can be used as a fast indicator of elevated blood sugar levels. In-office glucose testing instruments, such as finger sticks, are not precise enough for diagnosis (NIH 2014). Testing makes it possible for medical professionals to identify diabetes and treat it before complications arise, as well as to identify and treat prediabetes, which can postpone or stop the onset of diabetes type 2. any of the following examinations can used to establish a diagnosis: - The A1C test, commonly known as the HbA1c,

glycohemoglobin, or haemoglobin A1c test, is used to diagnose diabetes or pre-diabetes. Normal ranges are less than 5.7%, 5.7% to 6.4%, and 6.7% or higher. If the fasting plasma glucose (FPG) test results are more than 126 mg/dl, diabetes is diagnosed. Tests for oral glucose tolerance (OGTT). At routine medical checkups, a different Occasionally, a blood test called the random plasma glucose (RPG) test is performed to diagnose diabetesIf the patient also shows indications of diabetes and the RPG is 200 micrograms per deciliter or above, a medical professional may make the diagnosis of diabetes (NIH 2014).

2.5.1.6 Complications of diabetes mellitus

Extremely high blood sugar levels brought on by an inability to produce enough insulin, or a relative lack of it, can result in glucose urea, which causes the body to lose fluid and electrolytes through the urine. It can also prevent the body from storing fat and protein, which leads to ketoacidosis and the release of keton into the blood, which causes the blood to become acidic and is known as DKA (diabetes ketoacidosis) (Nathan *et al*. 2005). excessive doses of insulin or other glucose-lowering drugs can cause low blood sugar, which can result in symptoms of the central nervous system such disorientation, dizziness, and weakness. Diabetes may cause long-term harm to the kidneys, nerves, eyes, heart, blood vessels, and eyes.:

1. Diabetes makes heart disease and stroke risk factors worse.
2. When paired with reduced blood flow, neuropathy (nerve damage) in the feet increases the risk of foot ulcers and infection.
3. The tiny blood vessels of the retina sustain cumulative, long-lasting damage as a result of diabetes, which results An essential factor in diabetic retinopathy cause of blindness.
4. one of the key reasons for renal failure is diabetes (Nathan *et al*. 2005).

Especially in metropolitan areas, diabetes mellitus is rapidly becoming a serious health concern. Diabetes actually affects 3.4% of the population, according to tiny research,

but the true prevalence is unknown. The most frequent reason for hospital admission and non-communicable disease morbidity (7 and 10%, respectively) is diabetes. Some of the issues with diabetes care in Sudan include the lack of efficient diabetes care facilities, the lack of appropriately qualified staff, the high cost of antidiabetic medications, poor adherence to therapy or diet, false information and misperceptions, food and nutritional concerns, and gender-related issues. Implementing nationwide diabetes programs can help reach the objective of effective diabetes care. This program should be in charge of overseeing employee training., Building model care facilities, educating patients, making insulin accessible and affordable, conducting scientific clinical investigation, as well as primary preventative (Ahmed and Ahmed 2001).

2.5.2 Diagnostic categories of diabetic nephropathy

2.5.2.1 Microalbuminuria

- Albumin to creatinine ratio, 2.5 mg/mol for men and 3.0 mg/mol for women
- Twenty milligrammes per litre of urinary albumin
- 30-300 mg/24 hours of urinary albumin excretion, or 20-200 g/min in an overnight samples (Watkins 2003).

2.5.2.2 Proteinuria

- Urinary albumin excretion rate>300mg/24h
- Urinary protein excretion >500mg/24h (albumin creatinine ration>30mg/min; albumin concentration>200mg/l) (Watkins 2003).

*** Investigations in a patient with proteinuria**

protein midstream pee, renal ultrasonography, and erythrocyte sedimentation rate in 24-hour urine, blood count anti-nuclear substance serum augmentation, blood lipids, Renal biopsy only when necessary (Watkins 2003).

2.5.3 Statistical and epidemiology of diabetes mellitus and nephropathy

Diabetes has increased more common worldwide, but especially quickly in underdeveloped nations. By 2010 it is predicted that the number of those affected by the disorder would have nearly doubled, reaching 5 million will have type 1 and 216 million will have type 2 illness out of the world's 221 million people (Warrell *et al* 2003). By 2010, there would be 285 million diabetics worldwide, according to the International Diabetes Federation (IDF). This was a serious underestimation given that 366 million people globally had diabetes in 2011, Amod et al. (2012) use the fifth edition of the IDF Atlas, which states that 183 million of these cases went misdiagnosed. The wide variation in the incidence of incipient and clinical nephropathy that has been described can be partially attributed to the population under study's varied selection. The prevalence rates for early nephropathy range from 5 to 21% for type 1 and from 11 to 42% for type 2 illness when Only cohorts based on population that have reliable patient ascertainment are selected. Type 1 and type 2 diabetes individuals' yearly incidence rates are similar, at roughly 2%. There are currently registries of patients beginning renal replacement therapy in many countries, and they have all showed a sharp rise in the numbers with diabetic kidney disease However, it is unclear whether this represents a real rise in the number of diabetic individuals who develop ESRF or a shift in the acceptance policy. In either case, there will be a steady rise in the number of diabetic patients seeking kidney replacement therapy, especially those who are members of racial or Afro Caribbean and South African ethnic minorities will make up over 50% of these cases in the UK by 2001. Although it has long been believed that people with type 2 disease are less likely to acquire ESRF compared to those with type 1, either as a result of these patients not receiving referrals or because they died of cardiovascular illness prior to establishing renal failure. In the United States, 71% of all diabetic dialysis patients were diagnosed with type 2 disease in 1997 (Warrell *et al*. 2003).

2.6 Nuclear Radiation

Through the many years of radioactivity research, it was discovered that the majority of radioactive cores emit naturally occurring radiation or more (alpha particles, beta-type, neutrons, and gamma rays), where one can distinguish between their ability to penetrate the medium in which they pass as shown in (Figure 2.5 and Table 2.2) and their ionization of atoms and particles of the medium in which they pass as well as their behavior in the electrical and magnetic fields.

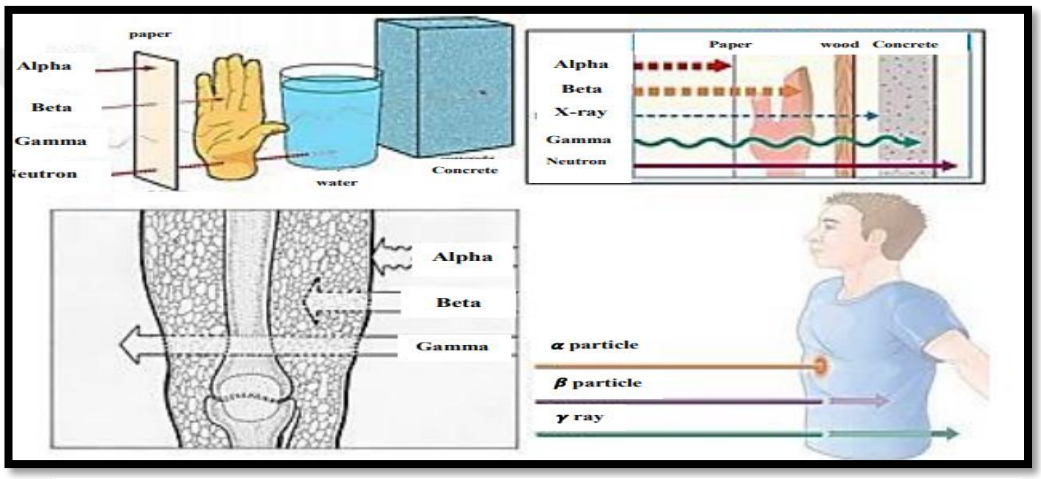

Figure 2.5 Difference between the particles in terms of penetrability

Table 2.2 Radiation characteristics

characteristics	Alpha	Beta	Ncutron	Gammy ray
Symbol	${}^{A}_{z}He$ or σ	β^- or β^+	n^0	γ
Mass (a. m. u)	4	0.00055	1	0
Charge	± 2	± 1	0	0
Speed	Fast	Very Fast	Fast	Speed of light
Lionizing ability	High	Medium	Low or Zero	Low
Penetrating Power	Low	Medium	Very High	High
Radiation type	particulate	particulate	Particulate	Photon
Shielding	Paper/Hand	Aluminum	Concrete/H_2O	Lead

2.6.1 Gamma -ray photons

The electromagnetic radiation known as gamma rays has the shortest wavelength of (0.005 to 0.5) A° and a broad energy range of (0.1 to 10) MeV. Nuclei in excited states release gamma rays as a result of radioactive nuclear collisions. Since space is a major source of high-energy gamma-ray photons, it frequently happens there. Gamma-ray 1s are energy beams known as photons that are typically released along with the emission of beta particles at the same energy level and with energies in the same field (Krane and Halliday 1988) . It is very permeable and mildly ionizes the gas it passes through with gamma rays. insensitive to the magnetic field. They are electromagnetic waves, as evidenced by this. The element does not change as a result of gamma radiation emission because the element's atomic or mass number remain unchanged. (Knoll and Glein 1989) However, it emits when the nucleus is excited, which indicates that it contains more energy than its usual cap (Gupta *et al*. 2012) Any particle has a tendency to have the lowest possible energy level if more energy is provided to excite a nucleus in the form of electromagnetic waves known as gamma rays. As rays of this type are among the most harmful since they have more penetrating energy than alpha and ta particles. Living tissue absorbs gamma rays that can be halted, which may ionize living things and harm them in a way that results in cell death or damage to specific cells (Gupta *et al.* 2012).The following equation illustrates gamma –rays decay Eqution (2.1) .

$$ {}^{A}_{Z}X^{+} \rightarrow {}^{A}_{Z}X + Y \qquad (2.1) $$

(X^{*}) cxcited nuclei

Gamma-ray photons may pierce many materials and travel a great distance in the air, although some materials can absorb gamma-rays, such as Lead Given its wide range in the atmosphere, gamma radiation is one of the most harmful to human health. It can be stopped by a concrete wall (Krane and Halliday 1988).

2.6.2 Gamma-ray interactions with materials

Gamma rays may interact with materials in a variety of ways a variety of ways. matier, these methods can be described using the system developed by (Fano) as follows:

Table 2.3 Types and effects of radiation interactions with the material interaction type

Interaction type	Interaction effect
interaction with matter atoms' electrons	total assimilation
interact with the atom's core	elastic dispersion
interaction with the electrical field surrounding the electron or c-inelastic scattering nucleus	Irregular scattering

Using the above divion gamma radiation reacts to the material by:

1. Photoelcte effect (la)
2. 2.Comon scattering (1b)
3. 3.Rayleigh scattering (1b)
4. 4.Photonobysis of the nucleus or the so-called electronaux phenomenon (2a)
5. Thomson scattering (26)
6. 6.Nuclear resonance scattering (2c)
7. 7.pair production (3a)
8. 8.Delbruck Scattering (3b).

2.6.3 Gamma ray photons

The electromagnetic rays known as gamma rays have the shortest wavelengths, which range from (0.005 to 0.05 Ao). Throughout the electromagnetic spectrum and up to (0.1-10 Me V). Because space is a source of great energy, radioactive nuclear collisions that result in the emission of gamma rays from agitated cores frequently take place there. The bundles of energy known as gamma photons, which produce Gamma rays are

frequently produced along with the emission of beta particles at the same energy level and with energies in the same field. (Knoll 2010) Since the material penetrates deeply when there are more than a few centimeters of lead material, the gamma rays must be electromagnetic waves since they only faintly ionize the gas through which they pass and are unaffected by the existence of a magnetic field. The element does not change as a result of the absence of any accompanying changes in the mass number or atomic number of the gamma-emitting substance. However, because there is a direction for any particle such as when the nucleus is in the case of arousing any energy above the natural limit, it emits. The elevated nucleus contributes surplus energy at the lowest energy level. in the form of gamma rays, electromagnetic waves. Because they have a far higher ability to penetrate things than alpha and beta particles, gamma rays are among the most harmful radiation kinds. As a result, gamma ray photons that can halt (absorb) in live tissues can ionize living things, which can cause death or harm to specific living cells exposed to these rays in the body. Although many materials can be penetrated by gamma x-ray photons (Eqution 2.2), which can travel an unspecified distance in the air, other materials, like lead, can absorb gamma rays. Because of their enormous range in the atmosphere, kama rays are among the most harmful rays to the human body. A concrete barrier could stop it. The following equation serves as an illustration of how gamma rays dissolve (Knoll 2010).

$$\mathbf{{}^{A}_{Z}X^{*} \rightarrow {}^{A}_{Z}X + \gamma} \qquad (2.2)$$

2.7 Gamma Ray Interaction with Matter

In a single collision, the gamma rays' (photons') interaction with the substance will lose all of its energy. The outcome of this collision will be either complete photon absorption, photon import, or photon disappearance, which will change the photon's direction and reduce its energy. As a result, the gamma rays' intensity increased will decrease as they pass through the material, and the following equation describes this phenomenon. (Hassanpour *et al.* 2022).

$$I = I_0 e^{-\mu x} \qquad (2.3)$$

I : The intensity of the gamma rays after their penetration from the material

I_o: the photons' intensity upon impact

μ : The linear absorption coefficient is perpendicular to both the kind of material and the energy of the incoming gamma rays

χ : the material's thickness through which photons will travel Three major mechanisms exist for gamma rays to interact with matter:

2.8 Pair Production

Whenever the incident photon energy exceeds the static electron energy, this event occurs (1.022Mev). A pair (electron-postron) will be produced as a result of the photon yard in the nucleus field when the E energy rays pass through the material and interact with the strong collomics of the nucleus. To achieve the legality of sustaining momentum and energy, a nucleus is required.(Miladjenovic 2012). Where we learn from the energy conservation law that the equation gives the photon energy (Eqution 2.4) (Lwin *et al.* 2008).

$$E_\gamma = 2m_0c^2 + T_e^- + T_e^+ \qquad (2.4)$$

Where: (2moc2) Total electron and positron static.

T_e^-: Kinetic energy for electron

T_e^+: Kinetic energy for positron

Due to the apostate atom's low kinetic energy, it was disregarded. In order to create photons for gamma radiation with energy (0.511Mev), the excess gamma ray capacity of 1.022Mev must first be converted into electron (e-) and positron (e+) energy. As the positron energy decreases, it starts to slow down and unites with the nearby electron, making the two available together. The likelihood of this interaction rises as the material's atomic number square (Z) and incident gamma ray energy both increase.

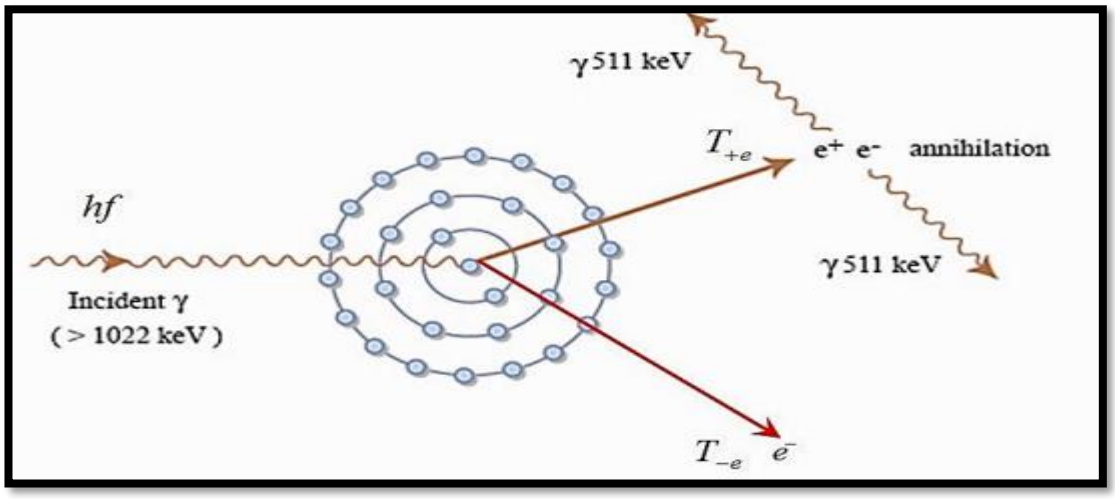

Figure 2.6 Pair Production

2.9 Gamma-Ray Detectors

Gamma rays must contact with the detector's active material in order to be detected, and this interaction must be recorded. Since gamma photons are electromagnetic in nature, there is a good chance that they will interact with electrons in each of the reagents' active ingredients in some manner, depending on the gamma ray photon's energy. Ionization, in which the photon of gamma rays deposits all or part of its energy into the material to raise the electron to a higher level or remove it from the atom, is the primary method by which ray photons are detected. Ionized electrons within the substance smash with other atoms, freeing several additional electrons for good. Through the use of semiconductor reagents or a proportional meter, this beam of emitted electrons is either directly or indirectly collected (as in the case of scintillation detectors). Energy measurement, along with the outcome of a B-pulse whose effort is dictated by the energy that photons have left in the detector's active material, are required to detect the presence of gamma rays.(Schauer and Linton 2009, Lwin *et al.* 2008)

2.10 Scintillation Detector

The flash material, which can be either solid, liquid, or invasive, is the sensitive component of the scintillation detector. It deals with the incident gamma ray photon, which emits light when it enters the flash material and is detected by the PMT photomultiplier tube attached to the flash material. The amygdet can be either organic or inorganic, but inorganic flash matter, like sodium iodide crystals NaI (Tl) and cesium iodide crystals CsI (Tl), is by far the most prevalent. Solid inorganic materials are common. Since the light produced in the flash material emits equally and uniformly in all directions, the flash material is surrounded by light-reflective materials to reduce light losses and focus the light toward the cathode in the optical multiplier tube attached to the material.. (Lwin *et al.* 2008) . During the photoelectric effect process, light photons will liberate electrons when they strike the cathode in the photometric tube. These electrons will then accelerate and multiply as they pass from one dynode to the next until they reach the anode. which, using an effort corresponding to the number of electrons released from the cathode and the energy of the photon falling on the cathode in the optical multiplier tube, is doubled up to 106 times its original value as a pulse (signal). A secondary amplifier can detect the electrical signal and amplify it to a quantity and level up to a super-value of its amount after it exits an optical multiplier and is introduced into a primary amplifier (Preamplifier). Fig. (2-3) and tailored to work with additional electronic systems like multichannel analysts (Ai Deng *et al.* 2022).

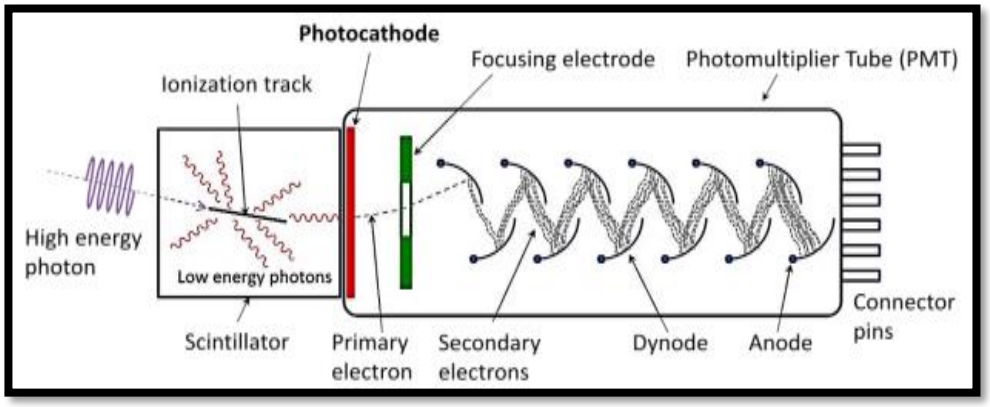

Figure 2.7 Parts of scintillation detector

2.11 Spectroscopic Analysis

One technique for detecting and evaluating radiation readings is spectroscopy, which deals with the measurement and distribution of energy for radioactive particles created by nuclear reactions or released from radioactive sources.

1-Detector Energy Resolution.
2-Detector Efficiency.
3-Nuclear Counting System (Lwin *et al.* 2008).

2.12 Detector Energy Resolution

The peak of the gamma radiation energy has a noticeable width due to statistical processes in the detection system. Different statistical processes are involved in turning the energy of gamma radiation into light in the detector and assembling and converting this light into an electrical pulse. For instance, the total amount of two-gamma radiation absorbed by the detector crystal may not yield exactly the same number of photons that can be collected by the PMT optical multiplier attached to the detector crystal, and photons of equal number and energy do not yield exactly the same number of electrons in the optical multiplier output. Despite having the same gamma-ray energy, these electrical impulses produced by the optical multiplier PMT have distinct elevation levels. These statistical procedures lead to (Schauer and Linton 2009, Lwin *et al.* 2008) A natural or Gaussian distribution, as shown in (Figure 2.8), can be used to describe the gamma ray energy spectrum in the form of a distribution based on the height of the pulse:

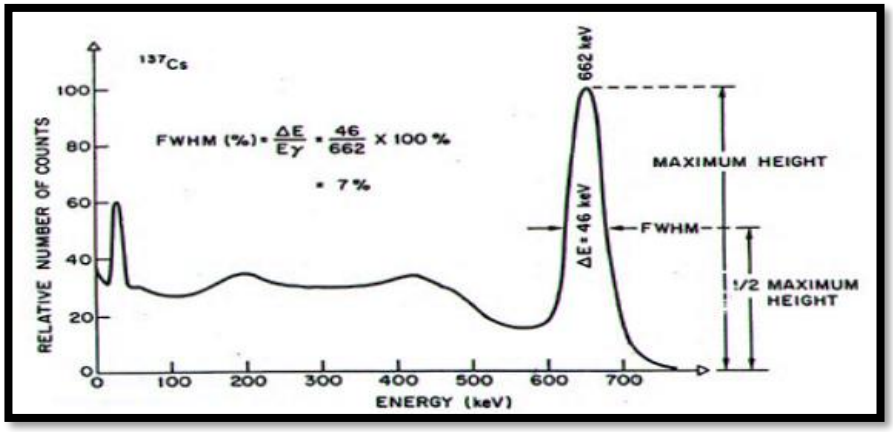

Figure 2.8 The energy spectrum of gamma rays according to the height of the pulse

The breadth of the gamma radiation energy peak at the middle of its height to the value of the center of the power summit, which is given in the following equations, is the detector's energy feature or energy resolution.

$$R = \frac{FWHM}{E_o} \times 100 = \frac{E_2 - E_1}{E_o} \times 100 = \frac{\Delta E}{E_o} \times 100 \qquad \text{in energy (2.5)}$$

$$R = \frac{FWHM}{E_o} \times 100 = \frac{n_2 - n_1}{n_o} \times 100 = \frac{\Delta n}{n_0} \times 100 \qquad \text{in channel (2.6)}$$

The spectrometer's capacity to discriminate between different gamma ray energies, or to separate the peaks of the energies of the gamma ray photons, is a crucial feature. Resolution energy features are the name given to this particular spectrometer characteristic. The most significant of the many elements that affect the energy advantage are:

1. Light coming out of the flash (detector crystal).
2. The size of the flash material collecting light.
3. Moreover (Krane and Halliday 1988).

2.12.1 Detector efficiency

Efficiency of detection is an essential property of nuclear reagents. There are three types of efficiency: absolute, subjective, and relative (El-Tahawy and Hamid 2007).

2.12.1.1 Absolute efficiency (ε_{abs})

The following equation describes the relationship between the total net count of the photogenic peak and the quantity of photons the source has emitted:

$$\varepsilon_{abs} = \frac{N_{PK}}{A.T.F} \quad (2.7)$$

Where:
NPK total net count of photogenic peak.
T count time and measured in second.
F conversion factor the number of photons emitted per 100 decays.
A source effectiveness during the experiment (Lwin *et al.* 2008, Krane and Halliday 1988).

2.12.1.2 Intrinsic efficiency (ε_{in})

the proportion of gamma rays hitting the detector to the overall net count of the photogenic peak. The following equation (2.8) relates absolute and subjective efficiency:

$$\varepsilon_{in} = \frac{\varepsilon_{abs}}{G} \quad (2\text{-}8)$$

G, the geometrical factor, is determined by the following equation (2.9):

$$G = \frac{1}{2}\left[1 - \frac{d}{\sqrt{a^2+d^2}}\right] \quad (2.9)$$

(a) the radius of the detector's face

d the separation between the detector and the radioactive source (Ahmed 2007).

2.12.1.3 Relative Efficiency (ε_{rat})

The ratio of the photogenic peak's relative intensity to its entire net count is known as relative effective. Typically, anonymous sources are employed (El-Tahawy and Hamid 2007).

3. MATERIALS AND METHODS

The tools and materials utilised in this chapter are described this study, as well as the practical measurements that were made to obtain information to achieve the goal for which the study was conducted, the method of preparing samples, choosing the appropriate measurement system, then calibrating the system, calculating experimental efficiency, measurement process procedures.

3.1 Study Area

The study was conducted in Thi Qar Governorate, which is located in the southern part of Iraq between latitudes (29.5 and 31.5) north and between arcs of length (46.4 and 47.65) east, bordered to the north by Wasit Governorate, to the south by Basra Governorate, to the northwest by Qadisiya Governorate, while it is adjacent to the west and southwest by Muthanna Governorate, and bordered on the eastern border by Maysan Governorate.

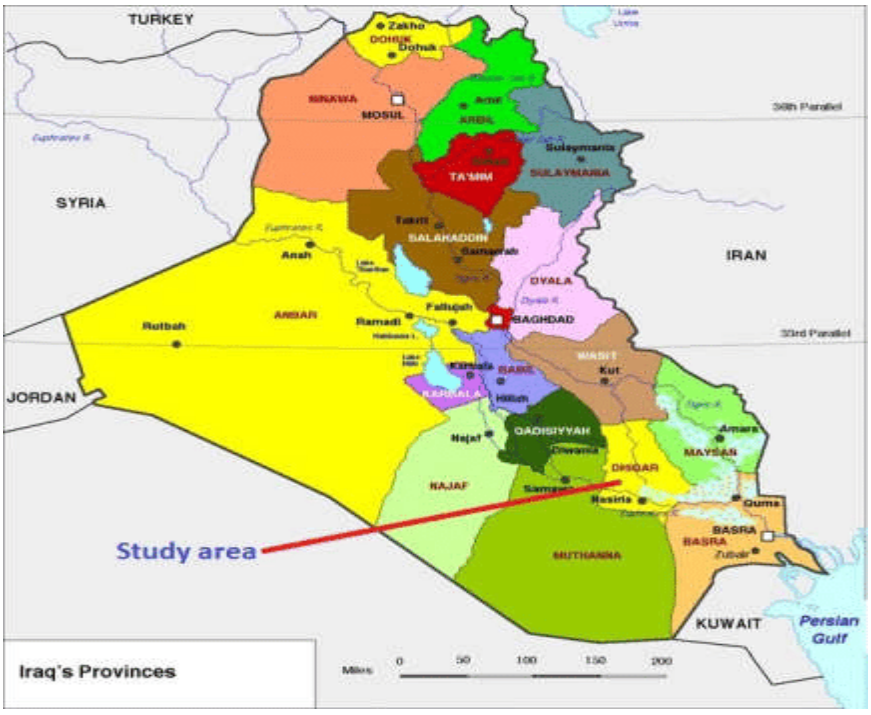

Figure 3.1 Location of Thi Qar Governorate in southern Iraq

3.2 Sampling and Sample Preparation

3.2.1 Study's participants

Participants in the study were split into two groups: a group of patients with type 2 diabetes, the samples from this group were divided into two parts one part serving as a control sample and the second part of the samples exposed to gamma radiation, and the second group of individuals who appeared to be generally healthy also divided in the same manner of the first group.

3.2.2 Exclusion criteria

Patients with serious illnesses like cancer and HIV were eliminated, along with those who had hypertension, liver disorders, anemia, leukemia, or who had just undergone a blood transfusion.

3.2.3 Ethical consideration

After being fully apprised of the study's precise aims, Participants gave informed consent to participate in the study Blood sample collection

3.2.4 blood sample collection

Four ml of venous blood were drawn from the study subject and distributed into an EDTA container for a CBC, a full blood count.

3.2.5 Complete blood count (CBC) procedure

Fully automated multichannel equipment typically measures between 8 and Basic CBC and white blood cell differential with 20 components and simply needs a suitable blood sample to function. While certain diluents are strong conductors of electricity, red cells are not, which is how impedance counting methods work.

3.2.6 Hemoglobin concentration (HGB or Hb)

Non-hazardous substances like Dimethyl lauryl amine oxide, imidazole, sodium dodecyl sulphate, or sodium lauryl sulphate were employed in the automated counter. The concentration of the reagents, as well as the reaction's temperature and pH, can all be modified. To ensure quick cell lysis and to lessen turbidity, a detergent is added. Depending on the final stable hemochromogen, cyan hemoglobin, oxyhemoglobin, methemoglobin, or mono hydroxyferri-porphyrin, For haemoglobin, absorbance measurements are made at several wavelengths. Males with normal hemoglobin concentrations range from 13 to 17 g/L, whereas females range from 12 to 15 g/L. [5].

3.2.7 Red blood cell count (RBC) and platelet count (PLTS)

Aperture impedance-based Red blood cells were counted using various ways and other types of blood cells. The same electrical detection methods that are used to count red blood cells can also be used to count platelets in whole blood. Platelets must be distinguished from red blood cells by a higher threshold, and from debris and electronic noise by a lower threshold. Male RBC range: 4.5-5.5x1012/L; female RBC range: 3.8-4.8x1012/L; and platelet range: 150-410x109/L [5].

3.2.8 Packed cell volume (PCV)

A computerized counting blood cells that has little to do with centrifuging red blood cells to pack them calculated PCV/hematocrit. An electrical pulse that is proportionate to cell volume is produced when a cell enters the impedance counter's opening The RBC can be identified based on the number of pulses produced. For guys, the usual domain is 0.45 to 0.05 L/L and for women is 0.41 to 0.05 L/L.

Twenty Blood samples from volunteers with type 2 diabetes were obtained and the same amount from healthy donors' people in test tubes of 4 ml each. The samples of diabetes patients and healthy donors were divided into four groups [healthy donors (control), healthy donors (irradiation), diabetic donors (control), and diabetic (irradiation)].

The age range of diabetics was (29 to 70 years) and the healthy donors were (17 to 73 years). Each sample taken from the patient is transferred to the measurement laboratory with special blood containers that conform to the specifications in which the heart and blood vessels center works in the governorate. The time period between taking the sample from the patient and irradiating it at the irradiation station prepared for this purpose should not exceed one hour. For each irradiated sample, there is an equal portion that is not irradiated and is used as a control sample.

This includes patients and healthy people. The collected blood samples of type 2 diabetes patients are shown in (Table 3.1) and the collected blood samples of healthy persons are shown in (Table 3.2).

Table 3.1 The collected blood samples of type 2 diabetes patients

Patient number	Patient age	Do you take treatment?	Medical history
1	50 years	Yes	5 years
2	43 years	Yes	Unknow
3	70 years	Yes	9 years
4	43 years	No	1 years
5	61 years	Yes	10 years
6	55 years	Yes	40 years
7	45 years	Yes	4 years
8	39 years	Yes	5 years
9	60 years	Yes	10 years
10	55 years	Yes	10 years
11	43 years	Yes	4 years
12	29 years	No	1 years
13	51 years	Yes	10 years
14	67 years	Yes	12 years
15	53 years	Yes	10 years
16	42 years	Yes	12 years
17	48 years	Yes	2 years
18	58 years	Yes	1 years
19	48 years	No	Unknow
20	42 years	No	3 years

Table 3.2 The collected blood samples of healthy doners

number	Sample ID	Age (years)
1	HP1	22
2	HP2	44
3	HP3	73
4	HP4	23
5	HP5	53
6	HP6	33
7	HP7	30
8	HP8	32
9	HP9	17
10	HP10	32
11	HP11	42
12	HP12	37
13	HP13	48
14	HP14	42
15	HP15	48
16	HP16	18
17	HP17	25
18	HP18	28
19	HP19	24
20	HP20	55

3.3 Irradiation and Measurements

3.3.1 Irradiation station

A container of lead, copper and aluminum was designed in the form of a box with a thickness of 2 cm. It consists of the body of the box, the cover, the holder of the radioactive source used, and the limiter of the beam of photons falling on the sample. It also contains a hole for the detector used to measure the dose delivered to the sample instantly. (Figure 3.2) shows the most important parts of the irradiation system. The samples were irradiated for 4 hours, and at the same time the dose received from the sample was measured and To keep an eye on, the sample's photons' energy spectrum was gathered the radiation distribution received from the sample. Three basic doses were adopted in the irradiation process, which are (1.989, 4.891, and 18.863 mGy).

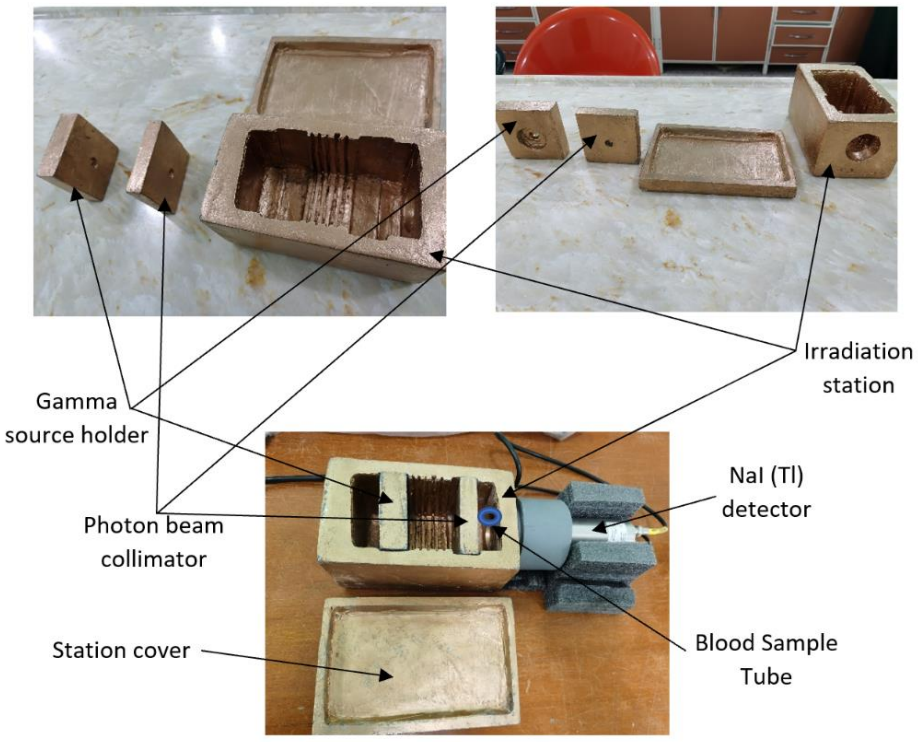

Figure 3.2 Experimental setup of irradiation station

3.3.2 Gamma-ray standard source

Caesium-137 (Cs-137) is a radioactive form of cesium that is created when uranium-235 splits into two pieces and plutonium-239 in nuclear reactors. This isotope releases gamma radiation of 662 KeV which can be detected and monitored with a suitable device. The activity of Cs-137 can range from a few millicuries up to curies and is measured in units of Becquerel (Bq). With a half-life period of about 30 years, Cs-137 is considered to be significantly more radioactive than many other materials. According to the World Nuclear Association, "the worldwide average concentration of Cs-137 in the environment is about 90 becquerels per kilogram of the soil". Therefore, Cs-137 is a high-level radioactive source that must be handled with utmost care. In Table 3.3, contain the fact sheet of the used gamma ray source and the (Figure 3.3) represents the decay mode.

Table 3.3 Cs-137 data sheet

<table>
<tr><td colspan="2">Radionuclide Safety Data Sheet</td></tr>
<tr><td>Radionuclide: cs-137</td><td>Forms: soluble</td></tr>
<tr><td colspan="2">Physical characteristics
Half-life: 30.17 years
Decay emissions
<table>
<tr><td colspan="2"></td><td colspan="2">Betas / positrons (+) / electrons*</td><td colspan="2">Alphas</td></tr>
<tr><td>E (kev)</td><td>%</td><td>E (kev, ave)</td><td>%</td><td>E (kev)</td><td>%</td></tr>
<tr><td>662
32</td><td>85
6</td><td>174
624*
426
656*</td><td>94
8
6
1</td><td></td><td></td></tr>
</table>
- only 4 most probable emissions per decay type included. Emissions below 10 kev or 1% excluded.

Stanford hazard category
C – level (low hazard): ≤ 2 mci
B – level (moderate hazard): > 2 mci , ≤ 100 mci
A – level (high hazard): > 100 mci</td></tr>
<tr><td>External radiation hazards
Gamma dose rate, point source at 1 ft, 1 mci:
3.1 mrem/h

Beta dose rate to skin, point source at 1 ft, 1 mci:
788 mrem/h

Contamination skin dose, uniform
deposit of 1 µci per cm2:
5800 mrem/h
Shielding
Gammas/x-rays:
2.2 cm of lead will reduce the gamma dose rate by 90%.

Betas/electrons:
4 mm of plastic will absorb all emissions. Bremsstrahlung may be created and require additional shielding.</td><td>Internal radiation hazards
Annual limit on intake: 200 µci (ingestion)
200 µci (inhalation)

The values above indicate the activity taken into the body that would result in either 5 rem to the whole body (cede) or 50 rem to an organ or tissue (cde).
Dosimetry and bioassay reqs
Whole-body and finger-ring dosimeters are required for handling 5 mci or more, or 1 mci amounts weekly. Urine assays may be required after large spills or contaminations.</td></tr>
</table>

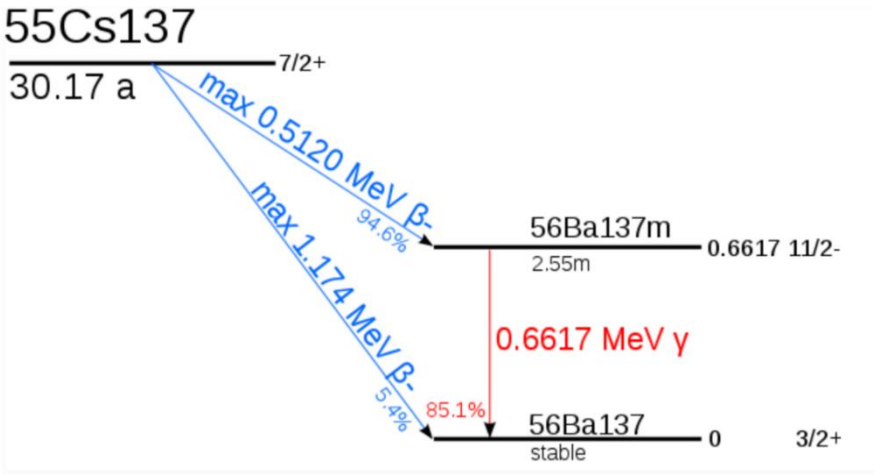

Figure 3.3 Cs-137 source decay mode

The source was used in the present study to irradiate samples for 4 hour's period in varying dosage rates throughout time. The utilised activity in the current study of Cs137 is 0.5 mCi with three dose rates obtained according to equation below,

$$D_r = A(mCi)\ x\ \Gamma\ x\ r^{-2} \text{ ---------- (3.1)}$$

Where D_r is the dose rate, A is the source activiy(mCi), Γ is the gamma factor, and r is the distance from the sample. The gamma factor Γ for Cs137 radioactive Source given by the formula,

$$\Gamma = 3.82 \frac{Rad.cm^2}{mCi.hr}$$

Table 3.4 The contain the dose rates obtained the empirical formula

Distance from the sample(cm)	Dose rate (rad/hr.)	Dose rate (mGy/hr.)
1	1.9134	19.134
2	0.4775	4.775
3	0.2122	2.122

Table 3.5 Dose rates of Cs-137 source obtained from the empirical formula eq

Distance from the sample(cm)	Dose rate (rad/hr.)	Dose rate (mGy/hr.)
1	1.8863	18.863
2	0.4891	4.891
3	0.1989	1.989

The calculated in present study as a function of distance from the sample (3.1).

Using hematology and biochemistry equipment, we investigated the the impact of modest gamma radiation doses on the stability of human blood components from diabetes patients and healthy donors.

3.3.3 Measurement system

Measurement system consist of two type of detectors the first is UCS30 gamma spectrometer system includes 2”x2” NaI (Tl) detector and the electronic devices attached to it as shown in a diagram in (Figure 3.2). Second is Handheld Digital Radiation Alert Detector, Inspector EXP as a dosimeter. The two measurements systems are calibrated Using a common gamma ray source (Co-60, Ba-133, Cs-137, Mn-54, Na-22) to determine the experimental efficiency and the accuracy of the two detectors. The dosimeter used to measure the dose rate per hour of (0.5 mCi) Cs-137 source at different distances (1, 2, 3 cm) from the sample and compared with the dose rates obtained from the Equation (3.1). The measures' outcomes are

depicted in (Table 3.4 and Table 3.5). There is a little deference comparing the actual and estimated dosage rates, therefore, we take the measured dose rates to irradiate the samples. There is a little deference between dosage rates that were estimated and measured, therefore, we take the measured dose rates to irradiate the samples.

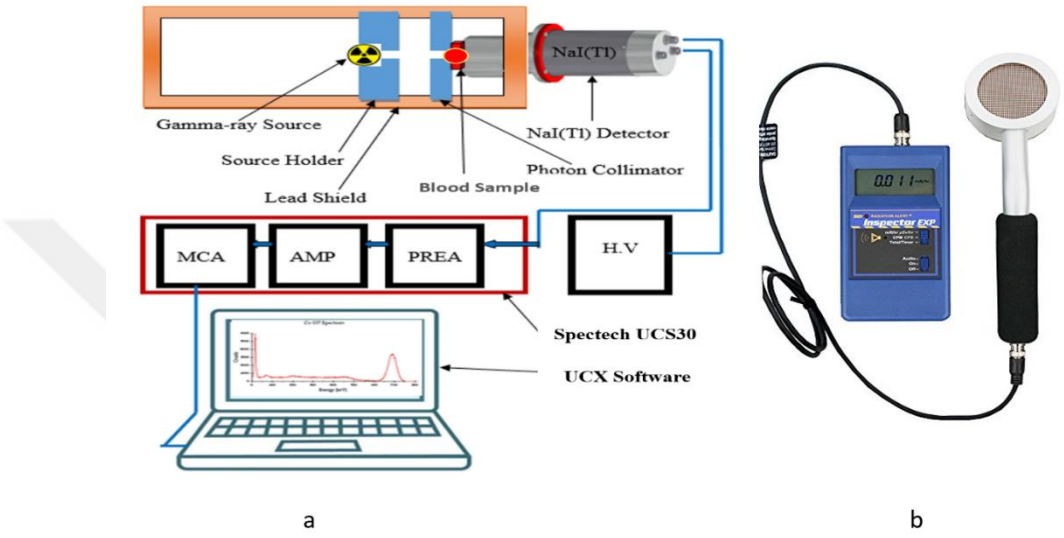

Figure 3.4 [a] A diagram of the spectroscopy system used in present study. [b] Handheld Digital Radiation Alert Detector, Inspector EXP

3.3.4 Hematology (Complete Blood Count CBC)

In order to generate a change in resistance proportionate to the volume of the particle passing the orifice, the automated hematology analyzer pulls particles through an orifice while applying an electric current. The automated hematological analyzer works by counting the different sized cells that make up whole blood.

Hematological tests are crucial for identifying and diagnosing blood-related diseases as well as supporting medical procedures. The three major blood components that are checked during a full blood count (FBC), also known as a complete blood cell count (CBC), are white blood cells (WBCs), red blood cells (RBCs), and platelets. In present study GENEX COUNT 60 hematology analyzer

was used to measure the CBC of the collected samples as shown in figure (3-5). The Specifications of the analyzer used in present study are [4]:

1. Impedance technique for measuring WBC, RBC, and PLT. HGB spectrophotometer.
2. High voltage pulse on the aperture and high pressure back flush to remove the clot.
3. Sample sizes are 10µl for whole blood and 20µl for predilution.
4. WBC has a 100 µm aperture, while RBC and PLT have a 70 µm aperture.
5. Parameter: WBC Lymph# Mid# Neut# Lymph% Mid% Neut% RBC HGB HCT MCV, MCH, MCHC, RDW-SD, RDW-CV PLT MPV PDW PCT P-LCR.

Figure 3.5 GENEX COUNT 60 hematology analyzer used in current study

4. RESULTS AND DISCUSSION

This chapter includes the most important results obtained from this practical field study, as well as analyzing and discussing these results in comparison with the global production in this field.

4.1 Results and Discussion

The results of irradiated blood samples of diabetes patients show a significant decrease in many hematological and biochemical parameters as a function of gamma-ray dose rate compared with control samples of the same category as shown in (Tables 4.1, Table4.2, Table 4.3, Figures 4.1, Figure 4.2, Figure 4.3). The maximum decrease in all parameters happened at a dose rate of 18.863 mGy/hr. In fact, the blood damage increases with increasing the dose rate for diabetics and for healthy but with lower effect.

Table 4.1 The measured hematological and biochemical parameters of blood samples from healthy Donors and diabetics after irradiation with a gamma-ray dose rate of 1.989 mGy/hr

Group / Parameters	Healthy Donors (Control)	Healthy Donors (Irradiation)	Diabetic Donors (control)	Diabetic Donors (Irradiated)
RBC (x10^6/ uL)	4.47	4.02	4.32	3.89
Hb (g/dL)	13.43	12	13.7	12.5
Hct (%)	40.8	40.4	42.16	38.5
Mcv (fL)	91.4	81.7	86.72	88.4
McH (pg)	30	26.2	28.17	25.6
McHc (g/dL)	32.7	31.6	32.27	31.37
RDW-CV (%)	44.7	14.3	13.31	14.63
RDW-SD (fL)	12.8	42.7	43.3	42.55
WBC (x10^3/ uL)	8.8	7.97	7.38	6.79
Lym (x10^3 /uL)	2.1	2.13	2.38	2.1
Neu (x10^3 /uL)	6.2	5.11	4.24	3.98
PLT (x10^3 /uL)	241	219	236	202
MPV (fL)	9.95	10.27	10.06	10.8
PDW (fL)	12.5	13.11	12.82	13.6
P-LCR (%)	25.1	31.68	26.22	32.5
PCT (%)	0.23	0.23	0.24	0.215

Table 4.2 The measured hematological and biochemical parameters of blood samples from healthy Donors and diabetics after irradiation with a gamma-ray dose rate of 4.8919 mGy/hr.

Group / Parameters	Healthy Donors (Control)	Healthy Donors (Irradiation)	Diabetic Donors (control)	Diabetic Donors (Irradiated)
RBC (x10^6/ uL)	4.47	3.57	4.32	3.16
Hb (g/dl)	13.43	10.6	13.7	10.3
Hct (%)	40.8	37.8	42.16	29.7
Mcv (fL)	91.4	63.4	86.72	72.8
McH (pg)	30	20.8	28.17	23.4
McHc (g/dL)	32.7	25.3	32.27	21.35
RDW-CV (%)	44.7	13.9	13.31	10.81
RDW-SD (fL)	12.8	46.7	43.3	36.44
WBC (x10^3/ uL)	8.8	5.69	7.38	5.25
Lym (x10^3 /uL)	2.1	1.82	2.38	1.66
Neu (x10^3/ uL)	6.2	4.07	4.24	2.96
PLT (x10^3 /uL)	241	197	236	188
MPV (fL)	9.95	8.37	10.06	9.37
PDW (fL)	12.5	16.11	12.82	12.4
P-LCR (%)	25.1	42.68	26.22	28.12
PCT (%)	0.23	0.2	0.24	0.185

Table 4.3 The measured hematological and biochemical parameters of blood samples from healthy Donors and diabetics after irradiation with a gamma-ray dose rate of 18.863 mGy/hr.

Group / Parameters	Healthy Donors (Control)	Healthy Donors (Irradiation)	Diabetic Donors (control)	Diabetic Donors (Irradiated)
RBC (x10^6/ uL)	4.47	1.82	4.32	1.05
Hb (g/dl)	13.43	8.91	13.7	6.55
Hct (%)	40.8	28.24	42.16	21.13
Mcv (fL)	91.4	43.4	86.72	41.47
McH (pg)	30	10.14	28.17	16.72
McHc (g/dL)	32.7	16.3	32.27	9.15
RDW-CV (%)	44.7	11.53	13.31	4.89
RDW-SD (fL)	12.8	28.64	43.3	36.44
WBC (x10^3/ uL)	8.8	3.53	7.38	2.07
Lym (x10^3 /uL)	2.1	0.764	2.38	0.45
Neu (x10^3/ uL)	6.2	2.97	4.24	1.17
PLT (x10^3 /uL)	241	103	236	98
MPV (fL)	9.95	5.37	10.06	3.97
PDW (fL)	12.5	11.08	12.82	6.18
P-LCR (%)	25.1	31.43	26.22	19.23
PCT (%)	0.23	0.106	0.24	0.065

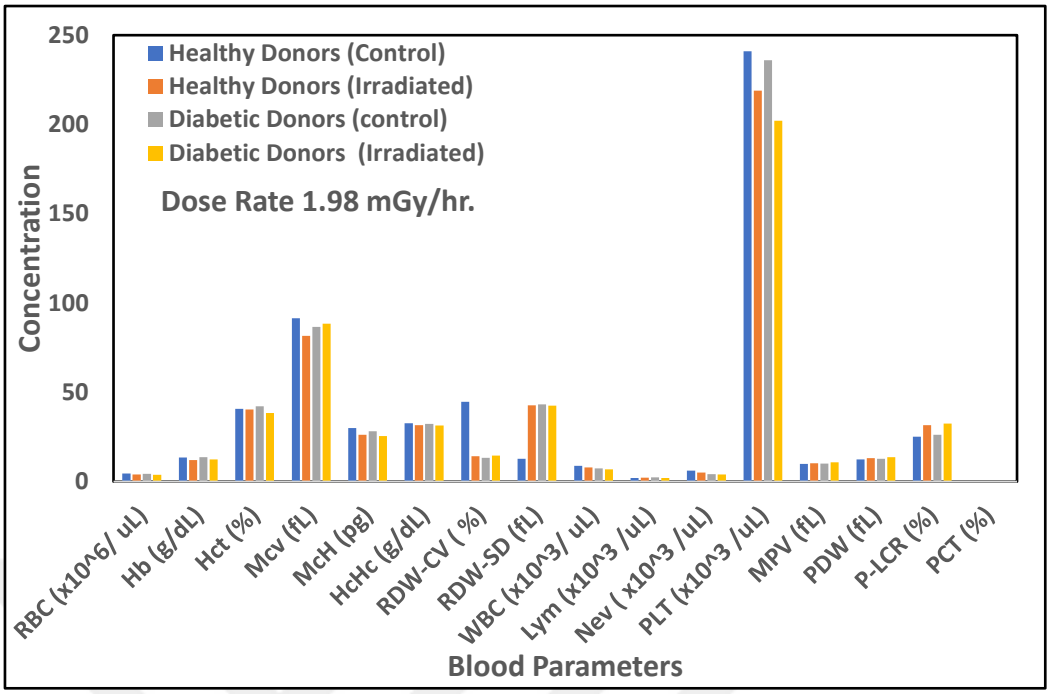

Figure 4.1 The variation of parameters between samples according to groups at a dose rate of 1.989 mGy/hr

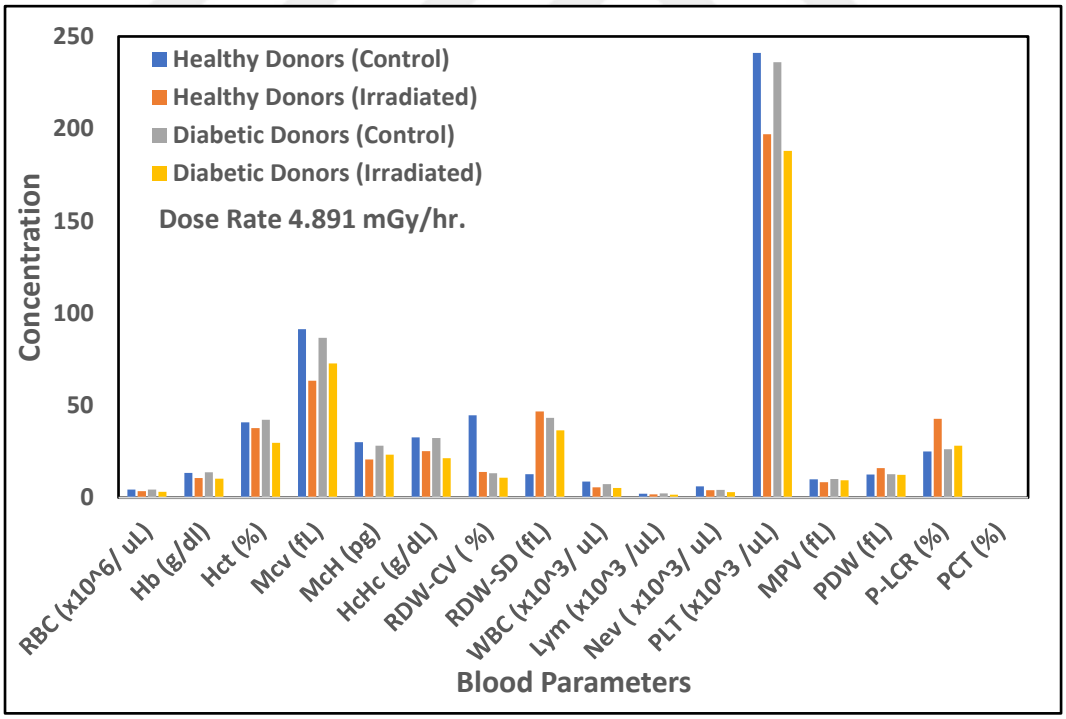

Figure 4.2 The variation of parameters between samples according to groups at a dose rate of 4.891 mGy/hr

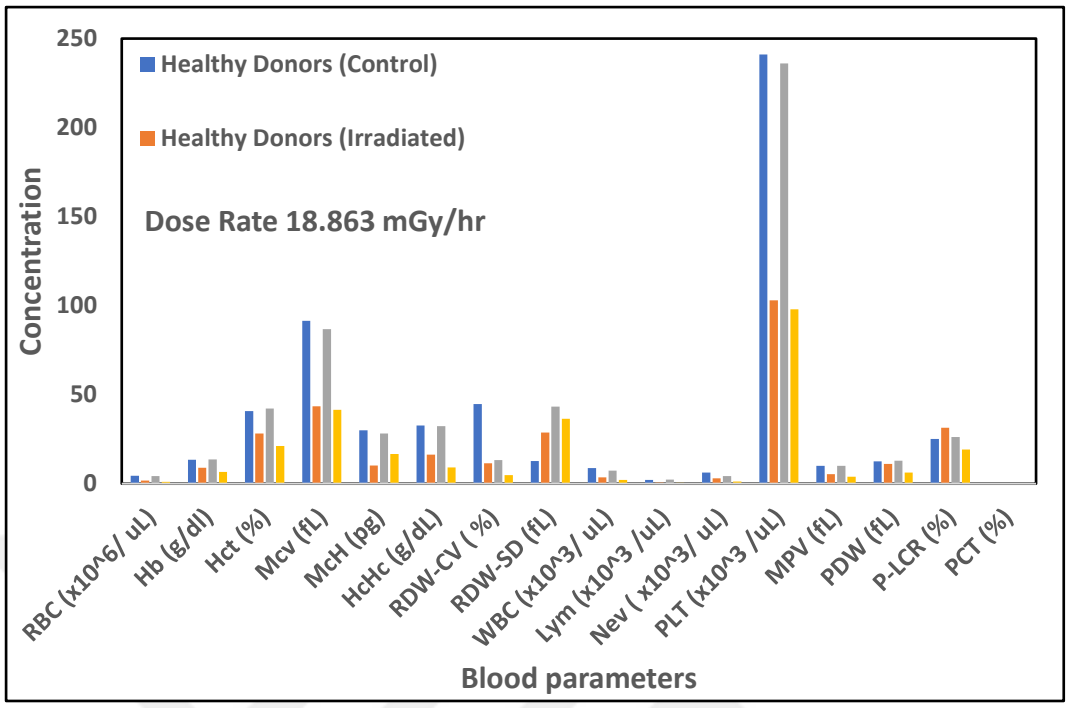

Figure 4.3 The variation of parameters between samples according to groups at a dose rate of 18.863 mGy/hr

One would anticipate that ionizing radiation would have different effects on the stability of blood components in diabetes and healthy people because diabetic RBCs have changed enzymatic pathways that significantly modify the lipid and protein membrane cells. Based on the unique discontinuities and monotonic hemolysis changes identified in healthy and diabetic RBCs, it appears that several enzymatic and chemical processes are triggered in these membranes by radiation.

According to measurements, at a substantial gamma radiation dosage, the hemoglobin was found to modify in both types of RBCs. The results of the investigations suggest that diabetic blood components may be more susceptible to damage from low doses of radiation than healthy.

The results of the spectroscopy investigations suggest that diabetic blood components may be more susceptible to damage from low doses of radiation than healthy. The variation in the main blood parameters for irradiated samples, which

are Red blood cells RBC, platelets PLT, and white blood cells WBC, is clearly seen in (Figures 4.4, Figure 4.5 and Figure 4.6) accordingly ,This rapid decrease applies to other parameters such as Hb, Hct, Mcv, McH, and HcHc, where we notice a clear deterioration in the values of these parameters with the increase in the applied dose as shown in (Figure 4.7).

Where we note that the blood samples of diabetic patients were clearly affected by gamma rays, especially in doses greater than 5 mGy/hr compared to healthy blood samples, and this means that diabetic patients in general suffer from a weakness in autoimmunity.

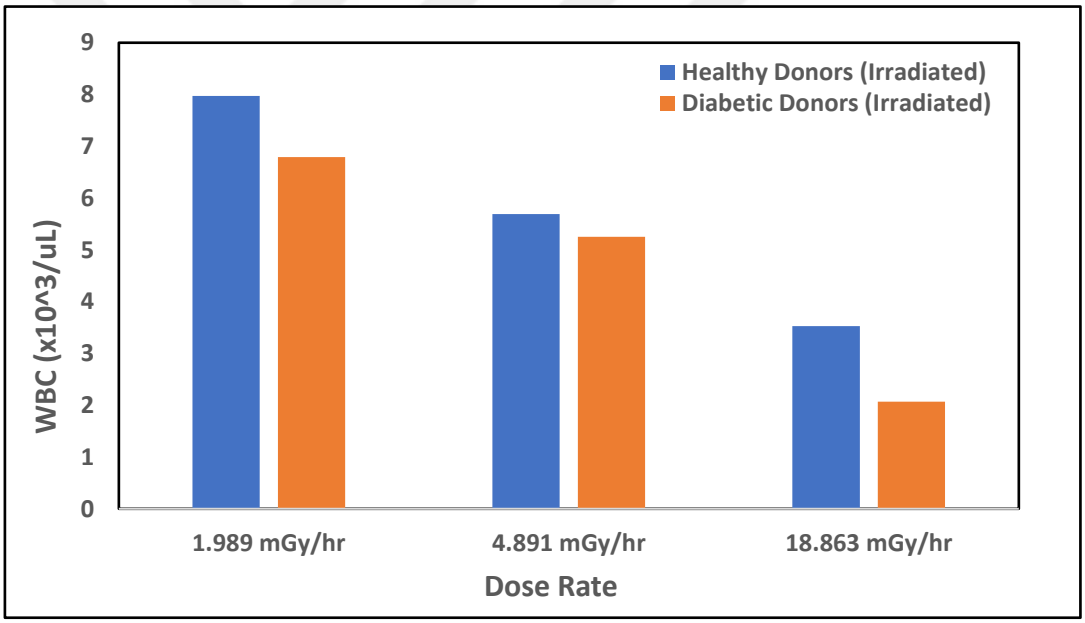

Figure 4.4 The variation of WBC between irradiated samples of healthy and diabetic donors at different dose rate

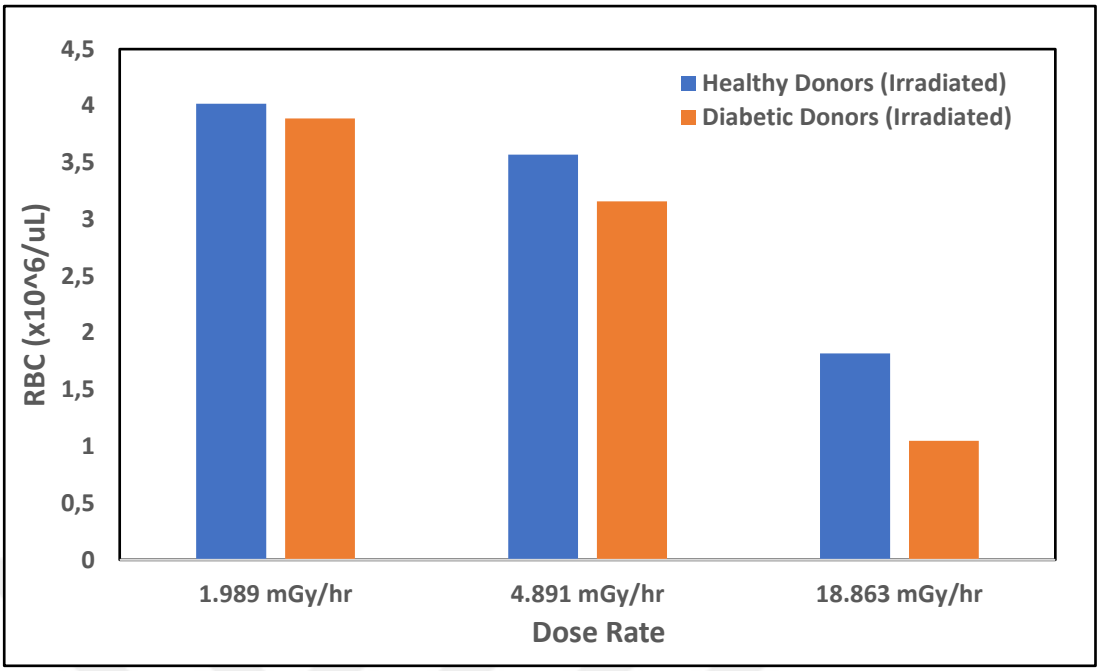

Figure 4.5 The variation of RBC between irradiated samples of healthy and diabetic donors at different dose rate

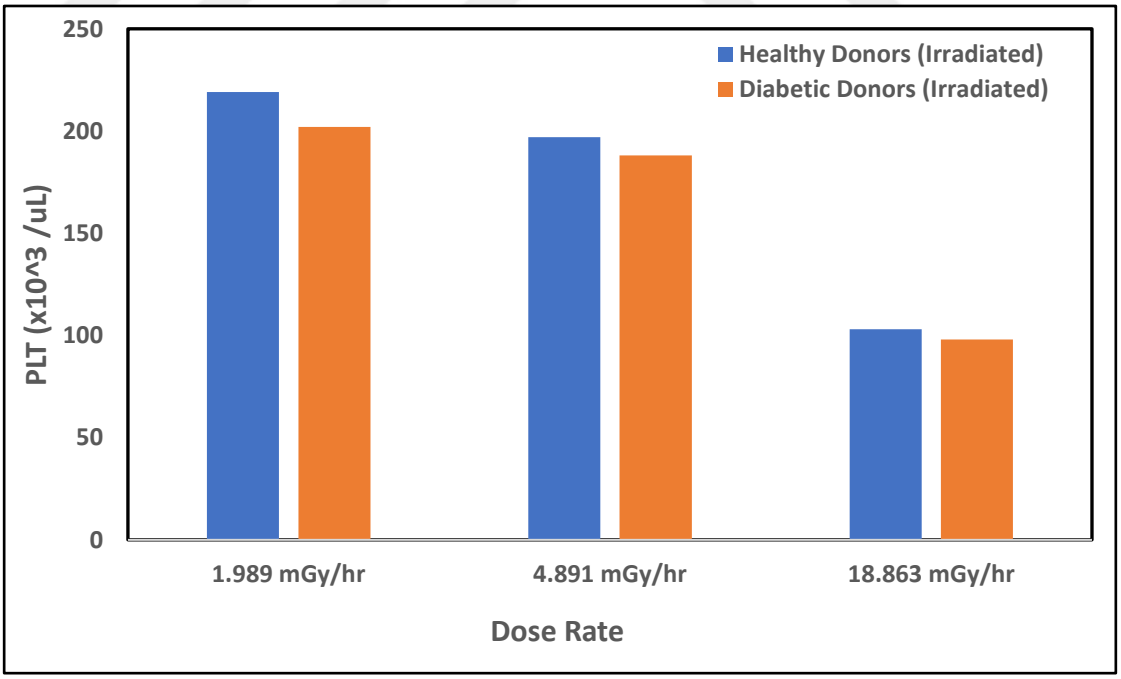

Figure 4.6 The variation of PLT between irradiated samples of healthy and diabetic donors at different dose rate

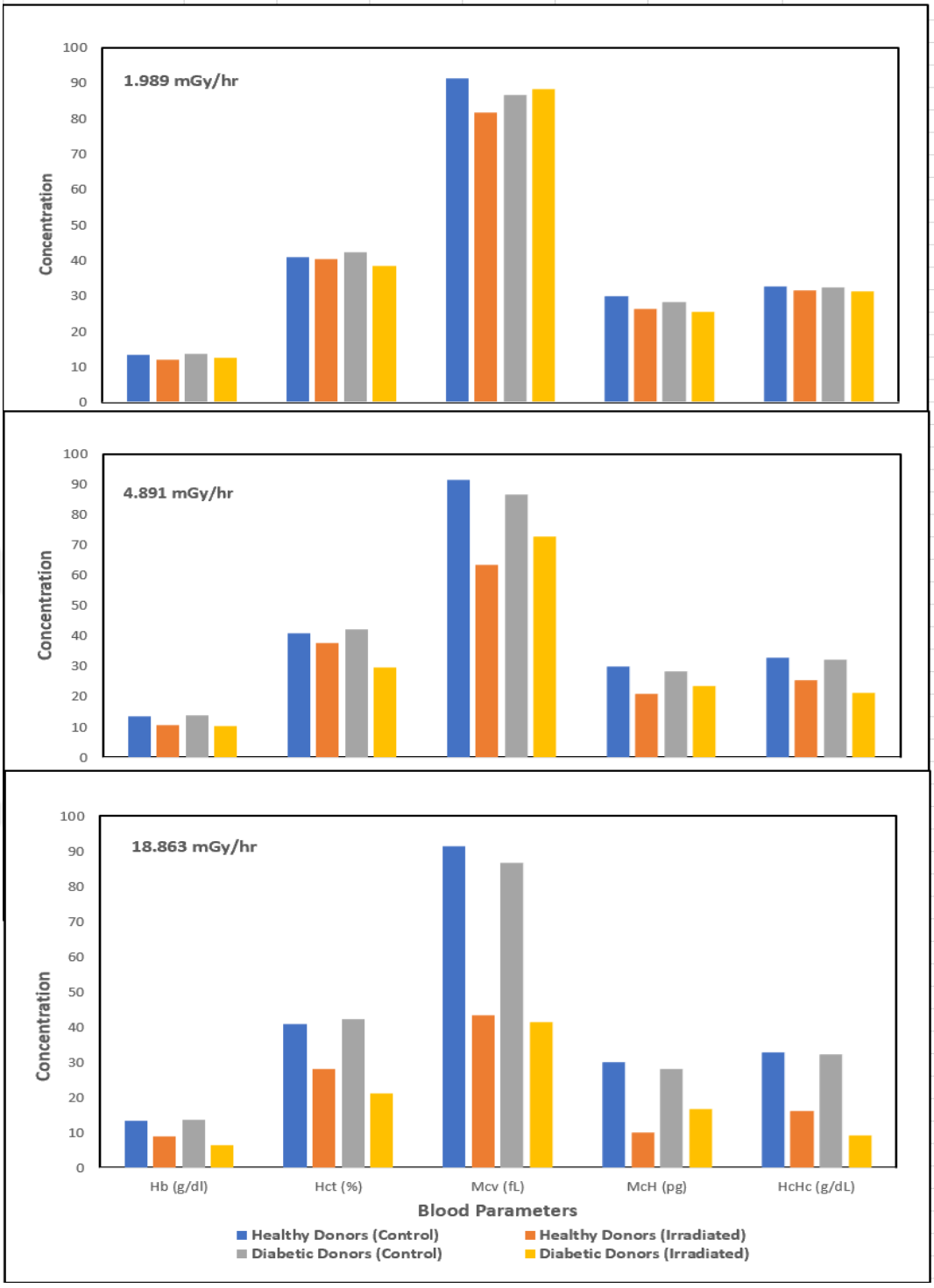

Figure 4.7 Variation of Hb, Hct, Mcv, McH, and HcHc between irradiated and control samples of healthy and diabetic donors as a function of applied dose rates

5. CONCLUSIONS, RECOMMENDATIONS, AND FUTURE WORKS

5.1 Conclusions

In Iraq, Diabetes mellitus is regarded as a major issue as well in cities or rural areas. Nowadays, diabetes affects all ages, but the elderly were the most affected. There is a lot of research and studies supporting this conclusion. Also, the disease used to affect men more than women by a ratio of 3:2. Now women are more susceptible to this disease, especially pregnant women. From the present investigation, we may draw the following conclusions:

1. As expected, people with diabetes were more affected by radiation, especially gamma rays, and their immunity decreased as a result of being exposed to high radiation dosage levels.
2. Low radiation doses are effective on blood components despite being low, because the radiation effect is cumulative, and the longer the time, the greater the effect.
3. The effect of the radiation dose on any blood factor is irreversible except after exposure is gone, as there is a possibility that this factor will regain its effectiveness or can be replaced, such as red and white blood cells, provided that the person's autoimmunity is good.
4. It was found that red and white blood cells are the most affected because of being exposed to these high of radiation doses.
5. Despite this change in the main and secondary blood parameters because of being exposed to these high of radiation doses, they are not significant changes that lead to serious complications for people, especially if these doses are instantaneous and not repeated, as they are approximately equivalent to the radiation doses that a person is exposed to in imaging X-rays, in which the exposure time does not exceed a few seconds.

5.2 Recommendations

Among the most important recommendations of the current study are:

1. Diabetic patients should stay away from radiation sources as much as possible, especially patients who take certain chemotherapy treatments, because exposure to radiation for long periods, even if it is a low dose, can affect the patient anytime, and here the treatment can work as a catalyst for the deterioration of his health or complications.
2. A diabetic patient should not repeat x-rays for close periods of one or two days, except in the case of extreme necessity, because x-rays are electromagnetic radiations that are completely similar to gamma rays, except that gamma rays are of high energy and higher penetration.

5.3 Future Works

Through the data of the current study, we can suggest the following future work:

1- Studying the effect of different low doses of gamma rays and X-rays on the blood of type 1 diabetic patients.
2- Studying the effect of different low doses of alpha and beta particles on the blood of patients with type 1 and type 2 diabetes.
3- Studying the effect of low doses of gamma rays and neutrons on the blood and urine of type 1 and type 2 diabetics who are taking certain therapies.

REFERENCES

Ademola, A. K., Bello, A. K. and Adejumobi, A. C. 2014. Determination of natural radioactivity and hazard in soil samples in and around gold mining area in Itagunmodi, south-western, Nigeria. Journal of Radiation Research and Applied Sciences, 7(3): 249-255.

Adziz, M. A. and Khoo, K. S. 2018. An assessment of absorbed dose and radiation hazard index from soil around repository facility at Bukit Kledang, Perak, Malaysia. In IOP Conference Series: Materials Science and Engineering, 298 (1): 012001).

Ahmed M. A. and Ahmed H. N. 2001. Diabetes mellitus in Sudan: the size of the problem and the possibilities of efficient care. Journal Practical Diabetes, vol (18): 324–327.

Ahmed, S. N. 2007. Physics and engineering of radiation detection. Academic Press.

Ahmed, S. N. 2007. Physics and engineering of radiation detection. Academic Press.

Ai, P., Deng, Z., Wang, Y. and Shen, C. 2022. Universal uncertainty estimation for nuclear detector signals with neural networks and ensemble learning. Journal of Instrumentation, 17(02): P02032.

Al-Alawy, I. T., Mhana, W. J. and Ebraheem, R. M. 2020. Radiation hazards and transfer factors of radionuclides from soil to plant and cancer risk at Al-Taji city-Iraq. In IOP Conference Series: Materials Science and Engineering, (7): 072139).

Al-Ali, S., Hannina, S., Soltan, B., Vartanian, K. and Rukyes, K. 2022. Natural Radioactivity and its Hazards of Infracambrian Rocks at Jabal Sanam Structure, Southern Iraq. Iraqi Journal of Science, 5386-5401.

Al-Attiyah, K. H. and Kadhim, I. H. 2013. Measurement and study of radioactive radon gas concentrations in the selected samples of river Hilla/Iraq. Measurement, 3(14).

Al-Jundi, J., Al-Bataina, B. A., Abu-Rukah, Y. and Shehadeh, H. M. 2003. Natural radioactivity concentrations in soil samples along the Amman Aqaba Highway, Jordan. Radiation Measurements, 36(1-6): 555-560.

Al-Mazuri, N. S. M. 2000. Environmental Radiological Pollution and it, s Sources in Nineveh Governorate (Doctoral dissertation, M. Sc. Thesis, Coll. of Engineering, Univ. of Baghdad).

American diabetes Association. 2004. Diagnosis and classification of DM. Diabetes Care, (27):55-510.

American Diabetes Association. 2010. Standards of Medical Care in Diabetes. Diabetes Care, vol (33): 11-61.

American diabetes Association. 2015. Classification and Diagnosis of Diabetes.Diabetes Care, (38): 8-16.

Amod A., Ascott E., Bergd G., Blom D and Brown S. 2012. The 2012 SEMDSA Guideline for the Management of Type 2 Diabetes. Journal JEMDSA., (17): 1-95.

Arogunjo, A. M., Farai, I. P., and Fuwape, I. A. 2004. Dose rate assessment of terrestrial gamma radiation in the Delta region of Nigeria. Radiation Protection Dosimetry, 108(1): 73-77.

Bain, B. J., Bates, I. and Laffan, M. A. 2016. Dacie and lewis practical haematology e-book. Elsevier Health Sciences.

Beck N. 2009. Diagnostic hematology 1st edition, Springer. London, 22-23.

Berger, M. J. 1971. Distribution of absorbed dose around point sources of electrons and beta particles in water and other media. National Bureau of Standards, Washington, DC.

Bernadette F. R. 1997. Diagnostic hematology 2ndedition.W.B. Saunders

Bird, J. R., Allen, B. J., Bergqvist, I. and Biggerstaff, J. A. 1973. Compilation of keV-neutron-capture gamma-ray spectra. Atomic Data and Nuclear Data Tables, 11(6): 433-529.

Bosman D. R., Winkler, A. S., Marsden, J. T., Macdougall, I. C. and Watkins P. J. 2001. Anemia with erythropoietin deficiency occurs early in diabetic nephropathy. Diabetes Care, (24):495–499.

Bou-Rabee, F. and Bem, H. 1996. Natural radioactivity in building materials utilized in the state of Kuwait. Journal of radioanalytical and nuclear chemistry, 213(2): 143-149.

Cember, H. and Johnson, T. E. 2009. Introduction to health physics. NNRA Library.

Chowdhury, M., Alam, M. and Ahmed, A. 1998. Concentration of radionuclides in building and ceramic materials of Bangladesh and evaluation of radiation

Chung F., Tsai J. and Chang D. 2005. Peripheral total and differential leukocyte count in diabetic nephropathy: the relationship of plasma leptin to leukocytosis. Journal Diabetes Care, (7):171-177.

Company. Illinois. 180.

Cooke D. W. and Plotnick L. 2008. Type 1 diabetes mellitus in pediatrics, Pediatr Rev. (29):374- 385.

Dacie J. V. and Lewis M. 2011. Practical Hematology11th edition Elsevier

Das, I. J., Ding, G. X. and Ahnesjö, A. 2008. Small fields: nonequilibrium radiation dosimetry. Medical physics, 35(1): 206-215.

El-Tahawy, M. S. and Higgy, R. H. 1995. Natural radioactivity in different types of bricks fabricated and used in the Cairo region. Applied Radiation and Isotopes, 46(12): 1401-1406.

Gartner L. P. and Hiatt L. L. 2006. Color Text book of histology 3thedition,

Gazineu, M. H. P. and Hazin, C. A. 2008. Radium and potassium-40 in solid wastes from the oil industry. Applied Radiation and Isotopes, 66(1): 90-94.

Greer J. P., Arber D. A., Glader B., List A. F., Means R. T., Paraskevas F. R. and George M. 2013. Wintrobe's Clinical Hematology 13th Edition, Wolter Kluwer. London. 13-16.

Gupta, M., Mahur, A. K. and Verma, K. D. 2012. Indoor radon levels in some dwellings surrounding the National Thermal Power Corporations (NTPCs), India. Advances in Applied cience Research, 3(3): 1262-1265.

H Kareem, K., O Abdullah, K. and M Hussein, A. 2010. Determination of Natural Isotope and Radionuclide of Out Door High Dose Rate in Garmik Area-kurdistan Region NE-Iraq. Kirkuk University Journal-Scientific Studies, 5(2): 88-105.

Hamad, H. T., Karim, M. S. and Kadhim, N. F. 2021. Assessment of 222Rn gas concentrations in Educational laboratories of Department Physics in the College of Sciences, Al-Mustansiriya University. In Journal of Physics: Conference Series, 1879(3): 032067).

Harb, S. R. M. (2004). On the human radiation exposure as derived from the analysis of natural and man-made radionuclides in soils.

Hasan, A. K., Hatif, K. H. and Hameed, R. A. 2018. Study of the Natural Radioactivity of selected models of the land of some schools of Qasem city using the Gama ray spectroscopy. Journal of Kufa-Physics, 10(1).

Hassan, N., Ishikawa, T., Hosoda, M., Sorimachi, A., Tokonami, S., Fukushi, M. and Sahoo, S. 2010. Assessment of the natural radioactivity using two techniques for the measurement of radionuclide concentration in building materials used in Japan. Journal of Radioanalytical and Nuclear Chemistry, 283(1): 15-21.

Hassanpour, M., Dehghanipour, P., Rezaie, M., Hassanpour, M., Faruque, M. R. I. And Khandaker, M. U. 2022. Study of alpha spectrometry for detection of radon and progeny using gas micro-strip detector. Applied Radiation and Isotopes, (187): 110344.

Hewamanna, R., Sumithrarachchi, C. S., Mahawatte, P., Nanayakkara, H. L. C. and Ratnayake, H. C. 2001. Natural radioactivity and gamma dose from Sri Lankan clay bricks used in building construction. Applied Radiation and Isotopes, 54(2): 365-369.

Hoffbrand A. V., Moss P. A. H. and Pettit J. E. 2006. Essential Hematology 5th edition, Blackwell.London.1-27.

Hussain, H., Hussain, R., Yousef, R. and Shamkhi, Q. 2010. Natural radioactivity of some local building materials in the middle Euphrates of Iraq. Journal of Radioanalytical and Nuclear hemistry, 284(1): 43-47.

Hussein, Z. A., Salih, N. F. and Sedeeq, S. Z. 2021. Assessment the natural radioactivity of radionuclides (226Ra, 232Th, 40K, and 137Cs) in wheat grain. ARO-The Scientific Journal of Koya University, 9(1): 95-102.

Kiss, J. J., De Jong, E. and Bettany, J. R. 1988. The distribution of natural radionuclides in native soils of southern Saskatchewan, Canada, 17(3): 437-445).

Knoll, G. F. 2010. Radiation detection and measurement. John Wiley and Sons.

Knoll, G. F. and Glein, F. 1989. Radiation detection and measurement, Wiley. New York.

Krane, K. S. 1991. Introductory nuclear physics. John Wiley and Sons.

Krane, K. S. and Halliday, D. 1988. Introductory Nuclear Physics, John Wiley&Sons. Inc., Kanada.

Lichtman A. M., Beutler E., Seligsohn U., Kaushansky K. and Kipps O. T. 2010. William, s hematology 7th edition. McGraw-Hill Education / Medical.76 Limited.London. 1- 14.

Lwin, M. T. M., Kassim, H. A. and Amin, Y. M. 2008. Determination of dose from the disposal of radioactive waste related with TENORM using residual radioactivity (RESRAD) Monte Carlo Code. In AIP Conference Proceedings, 1017 (1): 199-204).

Mandal A. 2013. Diabetes nephropathy symptoms. www.newsmedical. net/health/Diabetic-Nephropathy-Treatment.aspx.

Mauer S. M., Steffes M. W. and Brown D. M. 1981. The kidney in diabetes. Am J Med (70): 603– 612. 35

Mehdi U. and Toto D. R. 2009. Anemia, Diabetes, and Chronic Kidney Disease. Diabetes Care, (32): 1320-1326.

Mettler Jr, F. A., Bhargavan, M., Faulkner, K., Gilley, D. B., Gray, J. E., Ibbott, G. S. and Yoshizumi, T. T. 2009. Radiologic and nuclear medicine studies in the United States and worldwide: frequency, radiation dose, and comparison with other radiation sources—1950–2007. Radiology, 253(2): 520-531.

Miladjenovic, M. 2012. Radioisotope and Radiation Physics: An Introduction. Elsevier.

Muhammad O. and AlMuhammadi S. M. A. 2011. A Study of Some Haemato-Physiological Changes in Patients with Diabetic Nephropathy. Medical Journal of Babylon, (8):461-475.

Najem, H., BAKR, H. and JM ALKHALIFA, I. 2012. Determination of radon concentration in soil of Basrah governorate by using solid state nuclear track detectors. Basrah journal of Science, 30(1): 38-48.

Nathan C., Leary P. and Back lund J. 2005. Intensive Diabetes treatment and Cardiovascular Diseases in Patient with type 1 Diabetes. New England Journal of Medicince, (353):2643-2653.

Ng, K. H. 2003. Non-ionizing radiations–sources, biological effects, emissions and exposures. In Proceedings of the international conference on non-ionizing radiation at UNITEN (pp. 1-16).

Ngachin, M., Garavaglia, M., Giovani, C., Njock, M. K. and Nourreddine, A. 2007. Assessment of natural radioactivity and associated radiation hazards in some Cameroonian building materials. Radiation Measurements, 42(1): 61-67.

NIH. National Institutes Healthy. 2014. Diagnosis of Diabetes and Prediabetes, NIH Publication., 14–4642.

Ogura, K., Hosoda, M., Tamakuma, Y., Suzuki, T., Yamada, R., Negami, R. and Tokonami, S. 2021. Discriminative measurement of absorbed dose rates in air from natural and artificial radionuclides in Namie Town, Fukushima Prefecture. International Journal of Environmental Research and Public Health, 18(3): 978.

Omeje, M., Adewoyin, O. O., Joel, E. S., Ehi-Eromosele, C. O., Emenike, P. C., Usikalu, M. R. and Saeed, M. A. 2018. Natural radioactivity concentrations of 226Ra, 232Th, and 40K in commercial building materials and their lifetime cancer risk assessment in Dwellers. Human and Ecological Risk Assessment: An International Journal.

Paleari, C. I., Mekhaldi, F., Adolphi, F., Christl, M., Vockenhuber, C., Gautschi, P. and Muscheler, R. 2022. Cosmogenic radionuclides reveal an extreme solar particle storm near a solar minimum 9125 years BP. Nature Communications, 13(1): 214.

Pantelica, A., I. Georgescu, I., D. Murariu-Magureanu, M., Margaritescu, I. and Cincu, E. 2001. Thorium determination in intercomparison samples and in some Romanian building materials by gamma ray spectrometry. Radiation Protection Dosimetry, 97(2): 187-191.

Raghu, Y., Ravisankar, R., Chandrasekaran, A., Vijayagopal, P. and Venkatraman, B. 2016. Assessment of natural radioactivity and radiological hazards in brick samples used in Tiruvannamalali district, Tamilnadu, India, with a statistical approach. Health Physics, 111(3): 265-280.

Rahman, S., Matiullah, Malik, F., Rafique, M., Anwar, J., Ziafat, M. and Jabbar, A. 2011. Measurement of naturally occurring/fallout radioactive elements and assessment of annual effective dose in soil samples collected from four districts of the Punjab Province, Pakistan. Journal of Radioanalytical and Nuclear Chemistry, 287(2): 647-655.

Regulla, D. F. 1986. Importance of exposure to beta particles in practical radiation protection. Radiation Protection Dosimetry, 14(2): 95-100.

Robinson, B. L. 1964. Precision Determination of the Energy of the Gamma Ray of Potassium-40. Physical Review, 134(3B): B506.

Saunders. 233-237.

Schauer, D. A. and Linton, O. W. 2009. National Council on Radiation Protection and Measurements report shows substantial medical exposure increase. Radiology, 253(2): 293-296.

Shultis, J. K. and Faw, R. E. 2016. Fundamentals of Nuclear Science and Engineering Third Edition. CRC press.

Sinclair S. H., Delvecchio C. and Levin A. 2003. Treatment of anemia in the diabetic patient with retinopathy and kidney disease. Am J Ophthalmol., (135):740–743.

Singh, N. P., Burleigh, D. P., Ruth, H. M. and Wrenn, M. E. 1990. Daily U intake in Utah residents from food and drinking water. Health Physics, 59(3): 333-337.

Śleziak, M., Petryka, L. and Zych, M. 2010. Natural radioactivity of soil and sediment samples collected from postindustrial area. Polish J. of Envir. Studies, 19(5): 1095-99.

Sterner G., Carlson J. and Ekberg G. 1998. Raised platelet levels in diabetes mellitus complicated with nephropathy. Journal of Internal Medicine, (244): 437–441.36

Talwar G. P and Srivastava L. M. 2006. Biochemistry and Human Biology 3theditionPhi Learning.New Delhi. 3-12.

Tkachuck D. C. and Hirschmann J. 2007. Wintrobes atlas of clinical hematology1stedition, Wolter Kluwer.1-2

Trevisi, R., Risica, S., D'alessandro, M., Paradiso, D. and Nuccetelli, C. 2012. Natural radioactivity in building materials in the European Union: a database and an estimate of radiological significance. Journal of Environmental Radioactivity, (105): 11-20.

Tufail, M. and Hamid, T. 2007. Natural radioactivity hazards of building bricks fabricated from saline soil of two districts of Pakistan. Journal of Radiological Protection, 27(4): 481.

Tzortzis, M., Svoukis, E. and Tsertos, H. 2004. A comprehensive study of natural gamma radioactivity levels and associated dose rates from surface soils in Cyprus. Radiation pProtection osimetry, 109(3): 217-224.

Warrell A. D., Cox M. T., Firth D. J., Edward J. and Benz M. D. (2003). Textbook of Medicine.4thedition. Sir David Weatherdl. Chapter 12:11:1.

Watkins J. P. 2003. ABC OF DIABETES5th edition, Wiley-Blackwell.London. 65-70.

Whicker, F. W., Eisenbud, M. and Gesell, T. 1997. Environmental radioactivity from natural, industrial, and military sources. Radiation Research, 148(4): 402.

WHO. World Health Organization 2012. Diabetes. Fact sheet, No 312.

William J. M. and Stephen K. B. 1995.Clinical Biochemistry Metabolic and Clinical Asoecte1st edition. Chorchill living ston Elsever, 257-277.

Young B. A., Maynard C. and Boyko E. J. (2003). Racial Differences in diabetic nephropathy, cardiovascular disease, and mortality in a national population of veterans. Diabetes Care, (26): 2392–2399.

Young B., Steven A., Lowe S. J. and. 2006. Wheater, s functional histology 5thed.Churchill Livingston Elsevier. London. 2-31.

Zarkooshi, A. A. H. 2015. Measuring the concentrations of natural radioactive isotopes and radiation dose rates for Missan Province. Iraqi Journal of Physics, 13(27): 63-69.