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The impact of low doses of gamma rays on Chemical and hematological parameters for healthy people and diabetes in Thi Qar province.

Assel M. Radhi
Department of Physics/ Faculty of Science / University of ÇANKIRI KARATEKİN
Turkey
asselmurad77@gmail.com

Jabbar M. Rashid
Department of Physics/ College of Science/ University of Thi-Qar
Thi-Qar/ Iraq
Drjabbar.ph@sci.utq.edu.iq

İLYAS İNCİ
Department of Physics/ Faculty of Science / University of ÇANKIRI KARATEKİN
Turkey
ilyasinci@karatekin.edu.tr

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***Abstract*—The objective of this study is to explore the effect of gamma irradiation on the hematological and biochemical parameters of complete blood counts for diabetic and healthy people. A total of 20 blood samples were collected from people with diabetes, and 20 samples were collected from healthy people of different ages. The samples were analyzed before and after exposing to 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 and after exposing to irradiation. The results showed a significant change in the number of Red Blood Cells at 18.863 mGy/hr. compared with the control sample in healthy and unhealthy people from $4.47x10^{6}$ µL to $1.82x10^{6}$ µL and from $4.32x10^{6}$ µL to $1.05x10^{6}$ µL, respectively. The results also showed a significant change in all hematological and biochemical parameters such as WBC, PLT, Hb, Hct, Mcv, McH, and HcHc after exposing to irradiation, especially at a high dose rate of more than 5 mGy/hr. The obtained results are in a good agreement with the data that were recommended by recognized international organizations and agencies such as the EPA, IAEA, WHO, UNSCEAR, and ICRP.**

***Keywords*—** Blood, Hematology, Diabetes Mellitus, Gamma Irradiation, Dosimetry.

I. INTRODUCTION

The majority of diseases, regardless of their effects on the body organ, cause alterations in the blood at some point or over time [1]. Type 2 diabetes mellitus (DM), one of the most prevalent of these illnesses, can lead to End-Stage Renal Disease (ESRD)[2]. For example, diabetes cause unique alterations in kidney structure x, and hyaline arteriosclerosis, diffusive mesangial sclerosis, and increasing in glomerular basement membrane width [3]. Diabetic nephropathy, one of the most serious complications of diabetes mellitus. It affects African Americans, Asians, and Native Americans more frequently than Caucasians [4-6]. Most patients with renal disease have normocytic, normochromic anemia, which is primarily caused by decreasing in the renal erythropoietin production. Practically speaking About 90% of an individual's erythropoietin production occurs in the kidney, Anemia happens if the patient has one or more of the following m decreasing in Hb, hematocrit, or RBC, [7] Prior to the onset of advanced renal failure (serum creatinine 1.8 mg/dl), anemia has been linked to erythropoietin insufficiency in patients with diabetic nephropathy [7]. Target Hb levels for diabetic individuals should be 12–13 g/dl, and the chance that erythropoietin treatment could cause blood pressure [8]. Patients with CKD who have diabetes may experience anemia due to some reasons like iron and erythropoietin deficiency, and hypo responsiveness to erythropoietin's effects. Chronic renal illness is typically the source of these people's lack of erythropoietin; as a result, you will have anemia and fewer red blood cells [9]. When Hb is less than 11 g/dl in patients who have diabetic and renal disease, doctors’ advice patients to think about treating anemia [10]. In order to accurately assess hematological function and diagnose associated diseases, careful blood analysis is frequently required [11]. Many hematological problems are also identified by certain blood tests. The analysis of blood smears and hematological parameters provides crucial diagnostic data on cellular morphology, quantification of the blood cellular components, and evaluation of cellular size and shape that enables the formation of broad differential diagnostic impressions and guides further testing. The International Diabetes Federation (IDF) reported that there would be 2,011,400 adult cases of diabetes in Iraq in 2021, or a mean 9.4% prevalence of the disease among the 21,391,100 adults in the country [12]. This study set out to investigate how gamma irradiation affected the biochemical and hematological aspects of complete blood counts in both healthy and diabetic individuals.

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II. MATERIAL AND METHODS

A. 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.

B. Sampling and Sample Preparation

a) study's participants

The study's participants were divided into two groups: unhealthy group, a group of type 2 diabetic patients. The samples from this group were divided into two parts: one part was as a control sample and the second part of the samples exposed to gamma radiation. The second group of individuals who were healthy, and also were divided in the same manner of the first group.

b) 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.

c) Ethical consideration

After being fully apprised of the study's precise aims, participants in the study gave their informed consent.

d) Blood sample collection

Twenty blood samples were collected from donors' people with type 2 diabetes 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 was taken from the patient was transferred to the measurement laboratory with special standard blood containers. The time period between taking the sample from the patient and exposing them to irradiation for one hour. For each irradiated sample, there was an equal portion that was not irradiated and was used as a control sample. This includes patients and healthy people.

C. Irradiation and measurements

a) 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 (1) shows the most important parts of the irradiation system. The samples were irradiated for 4 hours. At the same time, the received dose from the sample was measured. The energy spectrum of the photons transmitted from the sample was collected to monitor the radiation distribution from the sample. Three basic doses were adopted in the irradiation process, which are (1.989, 4.891, and 18.863 mGy).

a) Gamma-ray Standard source

Caesium-137 (Cs-137) is a radioactive isotope of cesium that is produced by the fission of uranium-235 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 source was used in the present study to irradiate samples for 4 hour's period of time in different dose rates. In present study, the used activity of Cs137 is 0.5 mCi with three dose rates obtained according to equation below [13],

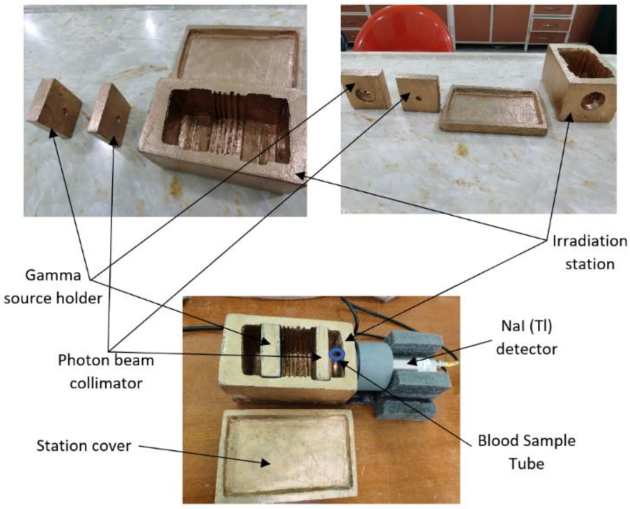

Fig. (1): Experimental setup of irradiation station.

$$D_r = A(mCi)\ x\ \Gamma\ x\ r^{-2} \quad (1)$$

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 [14],

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

Table (1) contain the dose rates obtained the empirical formula.

TABLE (1): DOSE RATES OF CS-137 SOURCE OBTAINED FROM THE EMPIRICAL FORMULA EQ. (1), CALCULATED IN PRESENT STUDY AS A FUNCTION OF DISTANCE FROM THE SAMPLE.

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

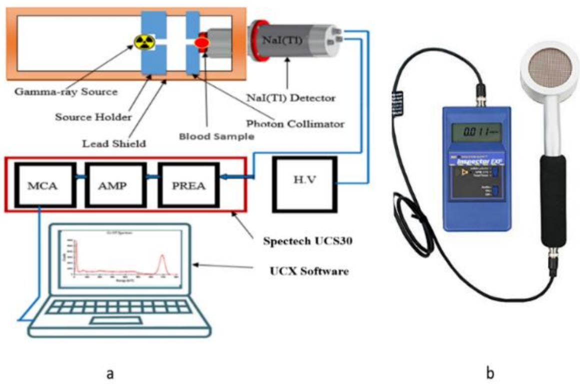

Fig. (2): (a) A diagram of the spectroscopy system used in present study. (b) Handheld Digital Radiation Alert Detector, Inspector EXP

Using hematology and biochemistry equipment, we investigated the effects of low doses of gamma radiation on the stability of human blood components from healthy donors and diabetic patients.

C. Measurement systems

a) Dose measurement

The measurement system consists of two type of detectors. The first detector is UCS30 gamma spectrometer system which includes 2”x2” NaI (Tl) detector and the electronic devices attached to it as shown in a diagram in figure (2). Second detector is Handheld Digital Radiation Alert Detector, Inspector EXP as a dosimeter. The two measurements systems are calibrated using a standard 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 was 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 equation (1). The results of the measurements are shown in table (2). There is a little deference between the calculated and measured dose rates, therefore, we took the measured dose rates to irradiate the samples. There is a little deference between the calculated and measured dose rates, therefore, we took the measured dose rates to irradiate the samples.

TABLE (2): THE DOSE RATES MEASURED USING INSPECTOR DOSIMETER IN PRESENT STUDY.

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

b) Hematology measurement

Samples were analyzed using the GENEX COUNT 60 hematological analyzer along with auxiliary calibrators, control materials, and reagents. All of the reagents were still within their validity period, and the analyzer was successfully calibrated and closely observed by daily quality control.

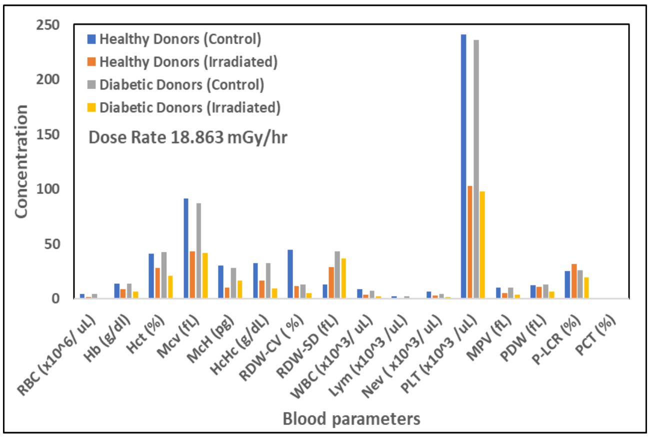

Fig. (3): The variation of Chemical and hemato- logical parameters between samples according to groups at a dose rate of 1.989 mGy/hr.

III. RESULTS AND DISCUSSION

The results of irradiated blood samples of diabetes patients showed 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 figures (3), (4), and (5). The maximum decrease in all parameters happened at a dose rate of 18.863 mGy/hr. In fact, blood damage rises when dosage rates rise for both healthy people and diabetics, but the effect is less pronounced for healthy people.

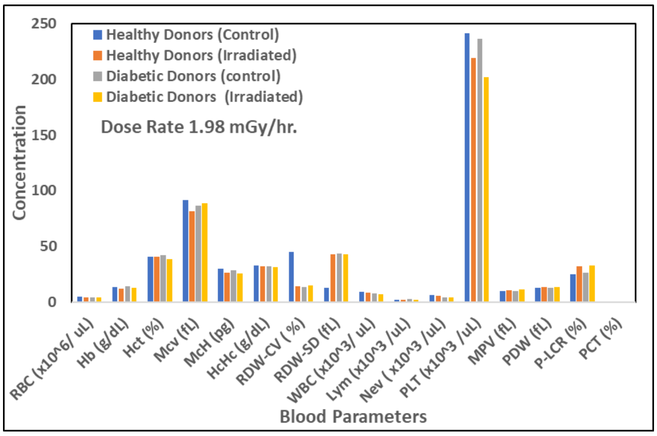

Fig. (4): The variation of Chemical and hemato- logical parameters between samples according to groups at a dose rate of 4.891 mGy/hr.

One would anticipate that ionizing radiation would have different effects on the stability of healthy and diabetic blood components because many enzymatic pathways in diabetic RBCs are altered, leading to a strong modification of the lipid and protein membrane cells.

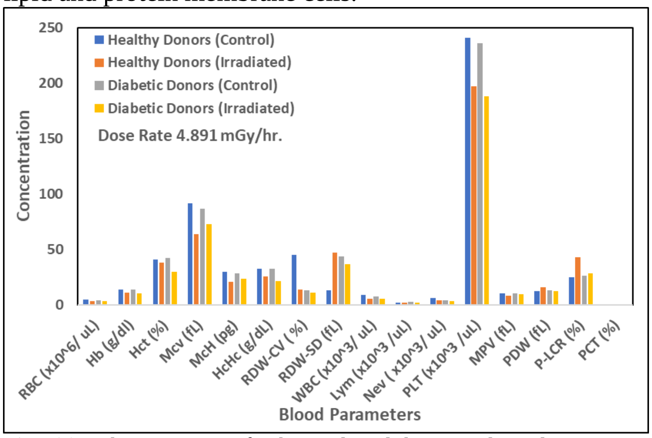

Fig. (5): The variation of Chemical and hemato- logical parameters between samples according to groups at a dose rate of 18.863 mGy/hr.

In fact, it appears that different enzymatic and chemical processes are activated in these membranes by radiation based on the distinct discontinuities and monotonic hemolysis changes found in healthy and diabetic RBCs. According to our measurements, at a high applied dose of gamma radiation, the hemoglobin was found to modify in both types of RBCs. The results of the investigations suggested that diabetic blood components may be more susceptible to damage from low doses of radiation than healthy.

The results of the spectroscopy investigations suggested 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 white blood cells WBC, red blood cells RBC, and platelets PLT, is clearly seen in figures (6), (7), and (8) respectively. 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 (9). We notice 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. This means that diabetic patients in general suffered from a weakness in autoimmunity.

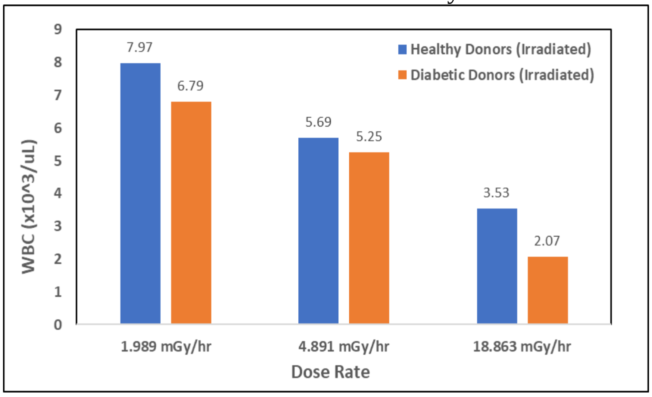

Fig. (6): The variation of WBC between irradiated samples of healthy and diabetic donors at different dose rate.

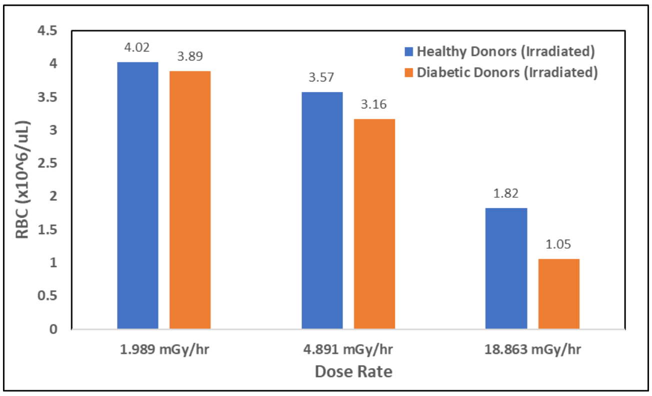

Fig. (7): The variation of RBC between irradiated samples of healthy and diabetic donors at different dose rate.

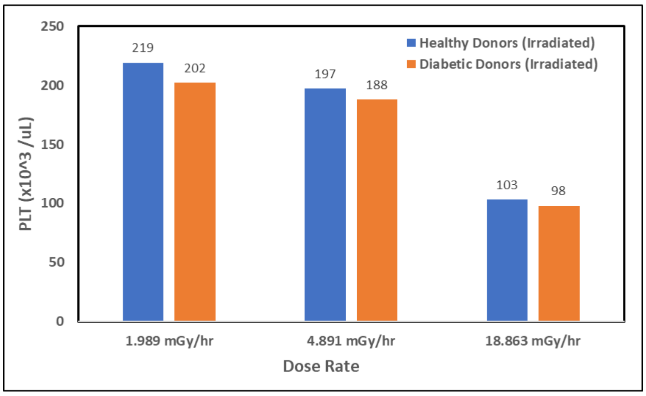

Fig. (8): The variation of PLT between irradiated samples of healthy and diabetic donors at different dose rate.

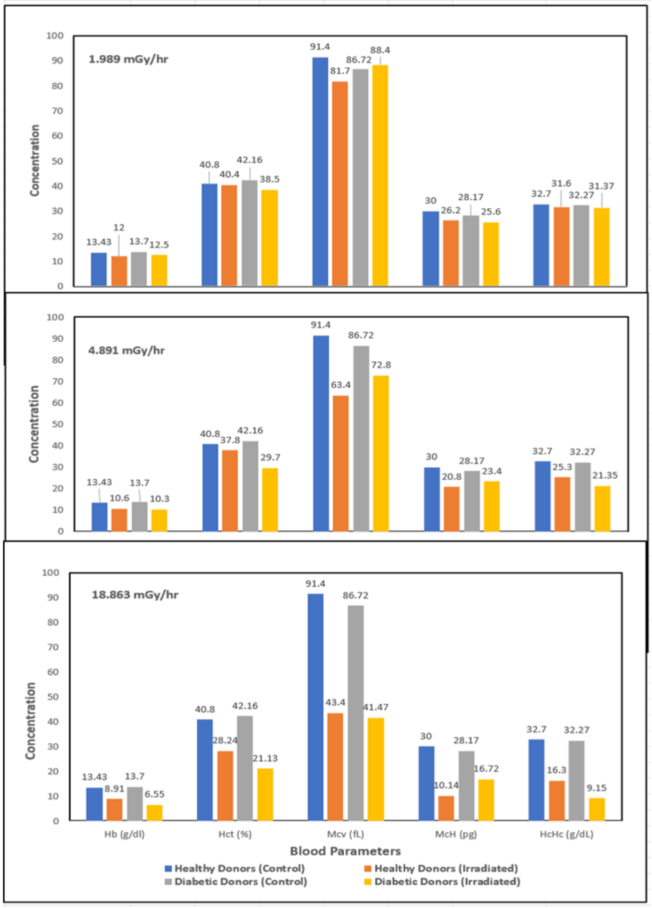

Fig. (9): Variation of Hb, Hct, Mcv, McH, and HcHc between irradiated and control samples of healthy and diabetic donors as a function of applied dose rates.

IV. Conclusions

In Iraq, diabetes mellitus is considered a serious problem either in cities or rural areas. Nowadays, diabetes affects all ages, but the elderly were the most affected [5, 6]. There is a lot of research and studies supporting this conclusion. Also, the disease usually affects men more than women by a ratio of 3:2. Now women are more susceptible to this disease, especially pregnant women [15]. From the current study, we can conclude the following:

1- As expected, people with diabetes were more affected by radiation, especially gamma rays, and their immunity decreased as a result of exposure to these levels of radiation doses as shown in the present study results.

2- Low radiation doses are effective on blood components despite being low. The radiation effect is cumulative, and as the exposing time was longer, the effect was greater.

3- The effect of the radiation dose on any blood factor is irreversible except after exposure was stopped. There is a possibility this factor will regain its effectiveness or can be replaced, such as red and white blood cells, for people with good autoimmunity system.

4 - It was found that red and white blood cells are the most affected as a result of exposure to these levels of radiation doses.

5 - Despite this change in the main and secondary blood parameters as a result of exposure to these levels of radiation doses, they are not significant changes that lead to serious complications for people, especially if these doses

are instantaneous and not repeated. 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.

V. Acknowledgment

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Conflict of interest

Authors declare that they have no conflict of interest.

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