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Research Article

A comparison between the effective and annual dose of radon for human blood and serum samples

Haura Mohammed Abas

Department of Physics, College of Science, University of Kerbala, 56001 Kerbala, Iraq

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Abstract

Recently, serum, whole blood, and other body fluids or components were utilized as "biomarkers" to assess the levels of radioactive elements, including radon. When exposed to radioactivity, human cells' structure, function, or both, are impacted. That way, various factors are considered when analyzing radioactivity's risk and safe rates.

The research project attempted to determine hazards for radon concentration in the human body, evaluate them between blood and serum samples, and link them to high blood pressure.

To determine the levels of radon, 40 human samples were taken. The total volunteers are 20, where it is ten healthy and others hypertension. Solid nuclear track detector CR-39 was utilized to record the radioactive values, while SPSS v 23 was used in statistical comparisons.

The findings demonstrated that blood samples from hypertension individuals had the greatest levels of radon concentrations, activity, and yearly effective dose with 12.19 Bq/m^3, 0.117Bq and 2.94 mSv/y respectively, compared to the rest of the samples. In contrast to the other samples, the healthy serum group had the greatest value of the work safety factor with ($11.45*10^{-4}$).

Although the radon values of the samples in the air and the annual activity did not exceed the permissible global percentages, they constituted an indicator of the occurrence of diseases, and this has been proven through research that patients have the highest values. The differences in the recorded values are due to different environmental and human factors, it can be inferred from the results that blood samples were more effective in detecting radiation compared to serum.

Corresponding Author E-mail : haura.m@uokerbala.edu.iq

Introduction

The biomarkers were used recently to determine the concentrations of radioactive elements, including radon gas, and their effects on human health, which included serum, whole blood, and other body fluids or parts. These biomarkers in the human body are impacted both directly and indirectly by exposure to radioactivity that is present around a person through food, drink, inhalation, etc., as this exposure results in a change in the shape, function, or both of the living cell, which inevitably results in various diseases (1,2). if it is considered that half of this radioactive exposure is caused by the noble radon gas that results from the breakdown of radioactive chains of uranium (3). Several variables influence the risk of exposure, including the annual effective dose, which can be referred to as the annual dosage from inhaling and ingesting radioactive elements during a year, is the most significant of these. The estimated average annual effective dosage from all-natural radiation sources is about 2.4 mSv, of which about 1 mSv is brought on by breathing in indoor radon (4,5) the equivalent dosage and the safe dose in common settings are frequently utilized. Considering that some particulate matter and gases are included at the top of this list of pollutants, the World Health Organization has acknowledged that air pollution is one of the largest environmental health threats. Multiple investigations have also connected high pollution levels to a variety of diseases, including cancer and high blood pressure(6,7).

The research aimed to compare indicators of risk factors for radon concentration in the human body and compare them between blood and serum samples and link them to high blood pressure.

Experimental Part

a- Samples collection:

40 human blood and serum samples were utilized to measure radon concentrations from 20 volunteers. 20 samples of blood and the same number of samples for serum (10 males and 10 females) 10 of the volunteers are healthy other 10 with high blood pressure aged from 20 to 50 years for both groups. A questionnaire was filled out by all those whose humans were accompanied by their consent to use and share the results of the study for scientific purposes only. It also included information such as age, sex, area of residence (all of them were from Karbala province), type of disease, type of treatment, and smoking. To prepare the sample, 5 to 6 ml of blood were drawn from the veins of humans, for the blood samples 2.5 ml were placed in tubes containing an anti-coagulant substance until they reach the laboratory and empty them into Petri dishes. Then they are placed in an oven equipped with a fan at room temperature for drying. Dry blood is manually ground and then purified homogeneously through a sieve with dimensions of half ml and then half a gram is taken from it. It is stored in a plastic container five cm high and three and a half cm wide. The detector CR-39 SSNTTD (which has a surface area of one square cm) is installed on its inner cover. To prepare serum samples, 3 ml were placed in the container designated for storage and kept at a temperature below 70 degrees Celsius. After sixty days, a brine solution was prepared from distilled water and sodium hydroxide salt, and a water bath at a temperature of seventy degrees and eight hours was used for the purpose of chemical scraping and showing the hidden effects in tracks (8) high-sensitivity microscope connected to a programmed computer was used to read the traces after the chemical scraping process .The statistical program SPSS(Statistical Package for the Social Sciences v.23) was used to make comparisons using the mean values for the samples during the presentation and discussion of the results.

b- Calculation

To determine the intensity of the track, the number of radiation-induced tracks is divided by the area of the detector, the required values are then determined using the following equations (6,9–11).

$C_{Rn} = \rho / Kt$.........1

Radon concentrations, the density of the alpha-track, and the moment of exposure time are represented by C_{Rn}, ρ and t respectively. The diffusion coefficient K is equal to 0.0412 (Track.m^3.day/Bq.cm^2) and is computed as

$K = 0.25\, r\, (2\cos \theta_c - r/r_a)$ 2

when r and the r_a container radius and alpha particle range in the atmosphere which equal to (4.15 cm). while θ_c : detector's critical angle equal =35^0 . C^s_{Rn} refers to the amount of radon in the container

$C^s_{Rn} = C_{Rn} \lambda_{Rn}\, h\, t\, / l$ 3

λ_{Rn}, h and l are radon's gas's decay rate constant, the separation between the sample surface and the detector, and represents the sample's thickness respectively.

Equation 4 provided the radon concentrations inner samples

$C^{s,ac}_{Rn} = C^s_{Rn}\, A^s\, l / M_s$........... 4

where the sample's mass and surface area are denoted by A^s and M_s

Equation 5 is used to calculate the radon activity of the samples, commonly abbreviated as

$A^s_{Rn} = C^s_{Rn} V^s$............... 5

V^s : volume of sample .

According to equation 6, the annual effective dose is

$E = A^s_{Rn} \times F \times O \times DCF$ 6

O: the typical amount of time spent inside per person per year (7000 hours); F: factor of equilibrium equal to 0.4; DCF the dosage conversion factor = 9.0 nSv h^{-1}(Bq. m^{-3}.h^{-1}).

Equation7 was used to calculate the equivalent dose according to the United Nations Scientific Committee on the Effects of Atomic Radiation is

$$H = 8 * 10^{-10} * C_{Rn} \quad ....7$$

The term *PAEC* work level has been created as a reference for measuring the danger resulting from radon gas for workers and the general public due to the high rate of dosage caused by radon gas. It requires measuring the alpha energy concentration or work level in order to be calculated by equation(8)

$$PAEC(WL) = \frac{F * C_{Rn}}{3700} \quad ....8$$

Results

Tables 1 and 2 present radon concentrations (C_{Rn}, $C^{s,ac}_{Rn}$) safety indicators pace work ($PAEC(WL)$) and risk (efficacy A^s_{Rn}, equivalent dose H and annual dose E) in serum and blood samples for the first group, which included donors who do not have high blood pressure, and the second group, which included donors who do have high blood pressure respectively.

Table 1 radon concentrations, hazards and security indicators in samples (without high blood pressure)

Measurements	Means		P- Values
	Blood	Serum	
C_{Rn} (Bq/m^3)	12.19	10.60	NS
$C^{s,ac}_{Rn}$ (Bq/kg)	70.14	61.35	
A^s_{Rn} (Bq)	0.088	0.077	
E (mSv/y)	2.23	1.95	
H(nSv/y)	97.03*10^{-10}	84.86*10^{-10}	
PAEC(WL)	13.09*10^{-4}	11.45*10^{-4}	

NS: not significant at 0.005

Table 2 radon concentrations, hazards and security indicators in samples (under high blood pressure)

Measurements	Means		P- Values
	Blood	Serum	
C_{Rn} (Bq/m^3)	15.99	11.35	NS
$C_{Rn}^{s,ac}$ (Bq/kg)	92.47	65.64	
A_{Rn}^{s} (Bq)	0.117	0.071	
E (mSv/y)	2.94	2.09	
H(nSv/y)	$127.92*10^{-10}$	$90.80*10^{-10}$	
PAEC(WL)	$17.26*10^{-4}$	$12.53*10^{-4}$	

NS: not significant at 0.005

It was evident from the results that radon concentrations were lower in the blood and serum of the first group (those without high blood pressure) than in the second group (those with high blood pressure), with the blood of hypertensive patients having the highest values with (12.19 Bq/m^3), as indicated in figure one. Also the second graph demonstrated how the radon's effectiveness, measured in Becquerel, represented the quantity of decay occurring in a second. The blood of hypertension individuals contained higher levels of it with (0.117 Bq).When the values of the annual doses received and accumulated in the human body were compared, it was evident from what was shown in tables 1 and 2 as well as figures 1 to 6 that the values of the annual dose were higher in the serum of the second group, or those who had blood pressure with (1.95 mSv/y), compared to the serum of healthy subjects (2.09 mSv/y), as shown in figure 3 while in the fourth figure demonstrated a comparable outcome, with the annual dose greater at that point in blood samples (2.94 mSv/y) compared to healthy participants (2.23 mSv/y). Moreover, figures 5 and 6 show that the yearly dosage values for blood and serum were greater in samples from people with high blood pressure compared to healthy subjects, the dosage was consistently higher for blood samples with(2.94 mSv/y). Referring to the findings of tables one and two for the safe dose in the workplace, the smallest dosages were discovered in serum samples from healthy people with ($11.45*10^{-4}$), while the greatest amounts were observed in blood samples from hypertension patients with ($17.26*10^{-4}$).

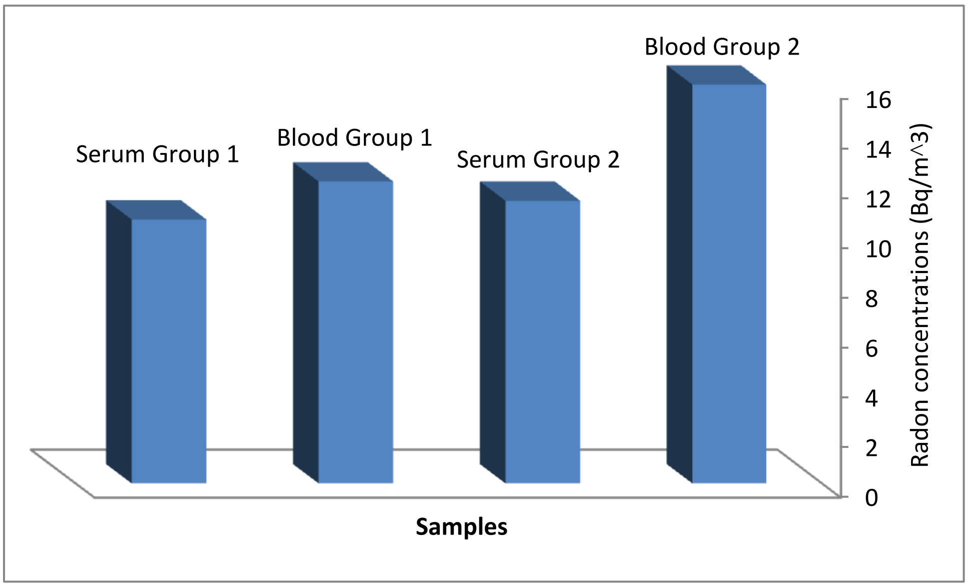

Fig1. The radon concentration with blood and serum samples for the two groups

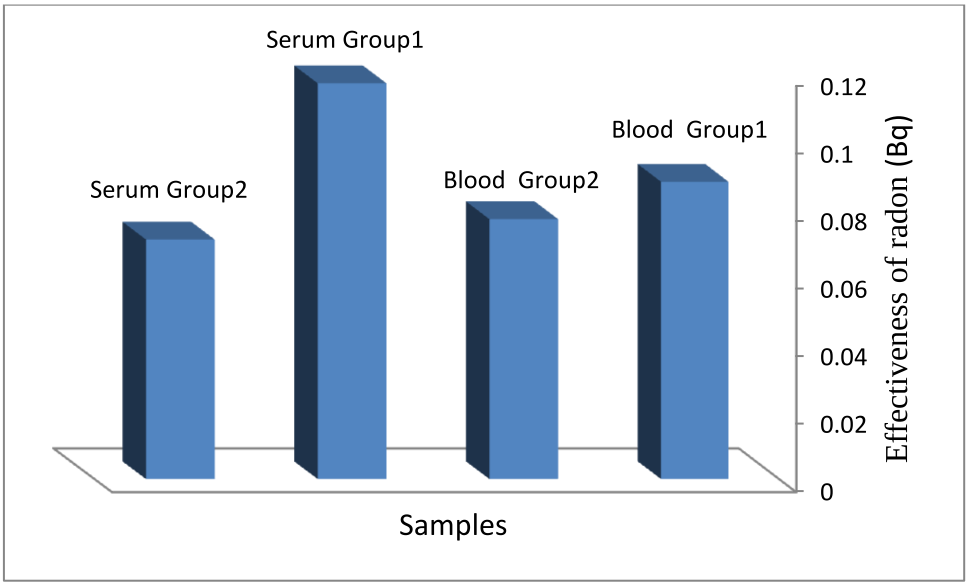

Fig2. The effectiveness of radon with blood and serum samples for the two groups

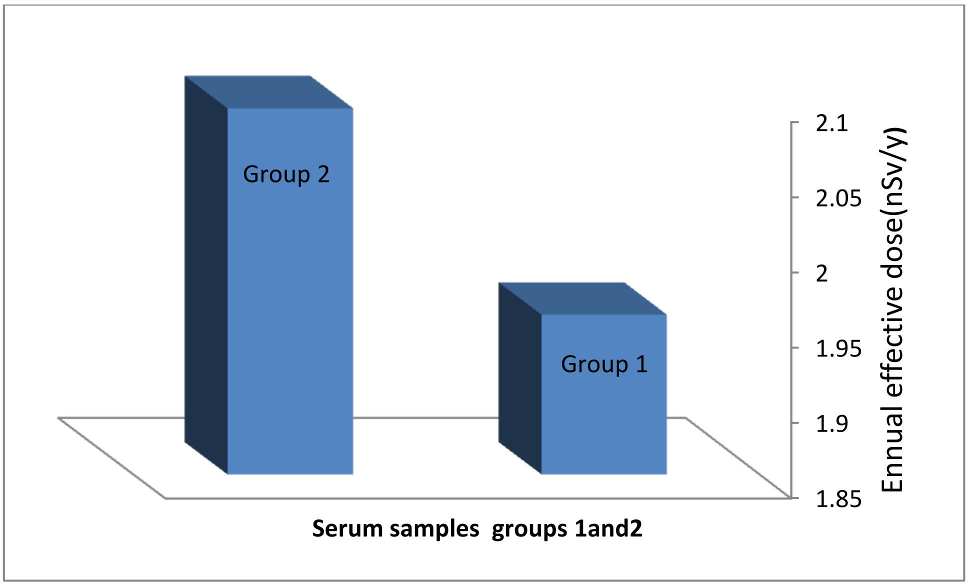

Fig3. The annual effective dose for serum samples for the two groups

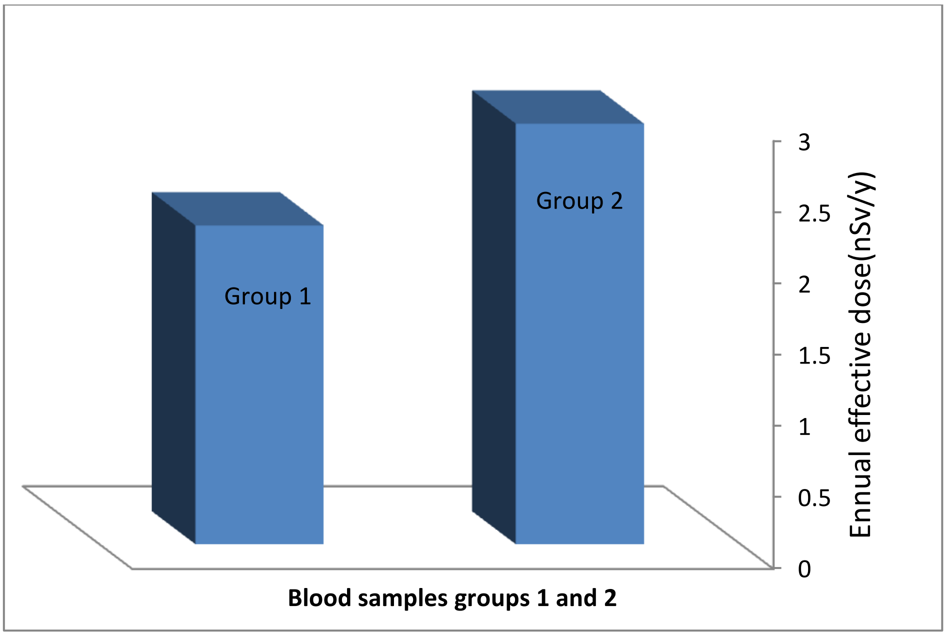

Fig4. The annual effective dose for blood samples for the two groups

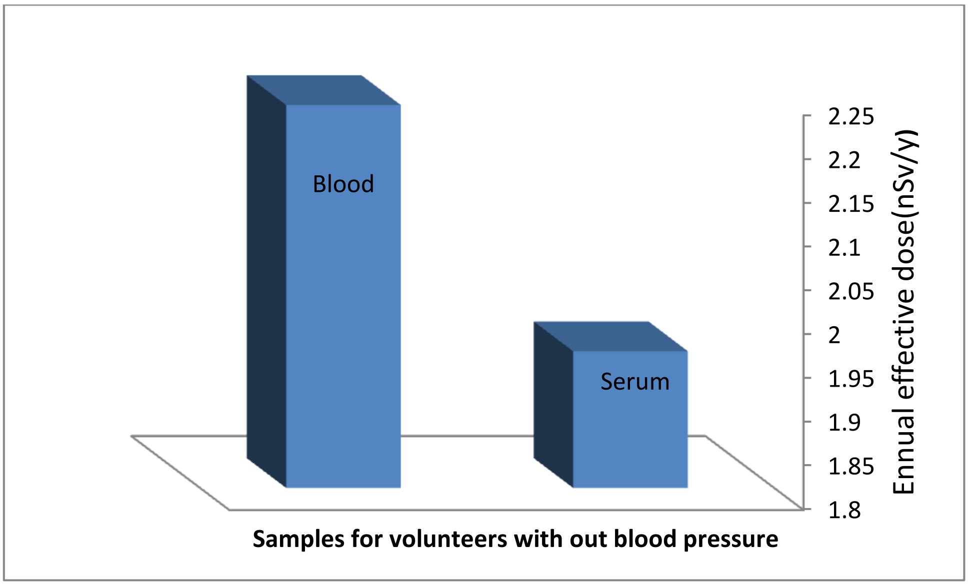

Fig5. Compartion of annual effective dose for serum and blood samples (without blood pressure)

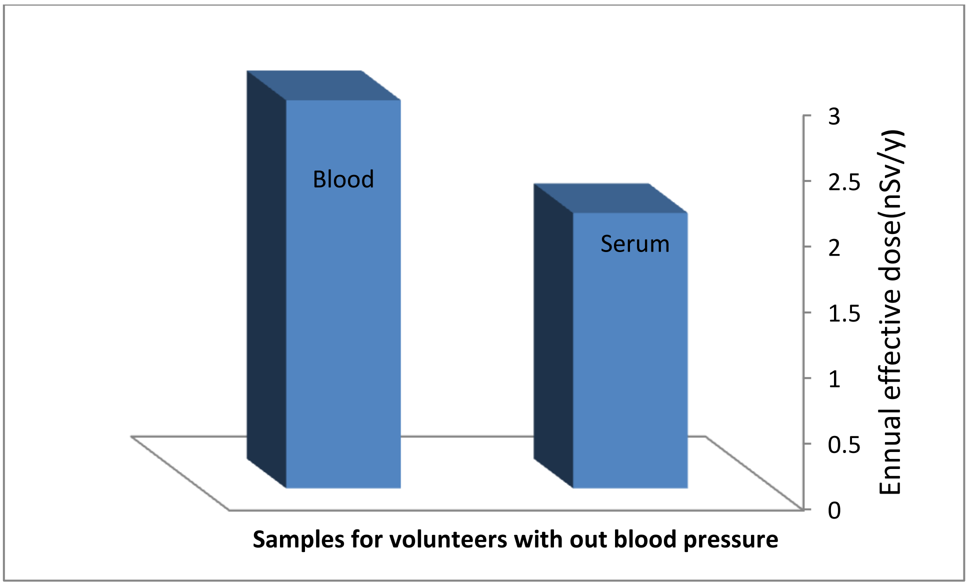

Fig6. Compartion of annual effective dose for serum and blood samples (with blood pressure)

Discussions

Although radon concentrations were not statistically significant between the two groups, all the values were lower in earlier investigations of the governorates of Karbala, Babylon and Najaf, (8,12,13) and other Iraqi regions (14), also did not exceed the permitted level by the International Organization for Radiation Protection for radon concentration(in air) which were 200 (Bq/m^3)(15). The effectiveness of radon, Individuals with hypertension had higher levels of it in their blood, which is also less than (16). The yearly dose values for blood and serum were higher in samples from people with high blood pressure than in samples from people with normal blood pressure. Moreover all these values are below the 4 mSv/y at the workplace and 14 mSv/y for the inhabitant are the allowed and recommended values by the International Atomic Energy Agency (ICRP) (5).

The danger of radiation posed by uranium and its offspring on the body is caused by the fact that every milligram of this element produces roughly one million alpha particles, each of which produces the equivalent of 4 million electron volts. This radiation is also dangerous because it has the power to kill six adjacent cells, which can result in cell disease due to a defect in form and function(16). According to the World Health Organization, concentration values rise with years of age (3). Additionally, as stated by Nuclear Information and Resource Services Data NIRS, when both genders are exposed to radiation, men are at a risk that is fifty percent greater than women, but women's bodies retain radiation and its cumulative form for longer periods of time because radiation accumulates in the soft tissues that make up their bodies(4). Additionally, smoking and pollution constitute two of the most significant contributors to the body's excessive radiation concentrations, which are associated with serious diseases involving cancer and hypertension(7)(17). Another of the major variables which influence the buildup of radioactive materials and the occurrence of diseases is the housing factor. Housing in rural areas may expose residents to the dangers of fertilizers and agricultural pesticides, and vice versa; cities, on the other hand, may contain dust from factory waste, as well as some areas where housing poses a danger because their lands are made up to an enormous degree of phosphate rocks, which naturally emit radiation(18)(19). All of these factors interact with the radiation that is ingested through food and drink and contribute to an increase in the body's radiation accumulation(20), which was more obvious when utilizing blood samples rather than serum samples. This is due to the fact that blood samples contain white blood cells, which are renewed in less than a day, and platelets, which are renewed every six days, whereas red blood cells, which are renewed roughly every 120 days (21), are responsible for the survival of substances and their transport in the body in comparison to serum, which does not contain it.

Conclusion

Although the radon levels in the air samples and the annual activity did not exceed the allowable worldwide percentages, they were an indicator of disease prevalence, as evidenced by research showing that patients with high blood pressure had the greatest levels. In comparison to healthy subjects, the results also demonstrate that blood samples were more effective in detecting radiation than serum, due to the different blood components that retain radiation compared to serum, even though statistical analyses did not provide significant statistical indicators. The differences in the recorded values of each of the radon concentrations, as well as the comparison of annual doses and the effectiveness of radon, are due to environmental factors represented by inhalation, food and drink, place of residence and work, and human factors represented by genders, all or some of which performed to change the results.

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