

Research Article

Evaluation of lead ion and radon into blood samples

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Abstract

The current study's objective is to develop and produce a biosensor that can identify lead and radon in the blood of cancer patients and healthy individuals at the Cancer Oncology Center in Najaf, Iraq. Both healthy individuals and various cancer patients provided the samples. A biosensor made of TRIS-HAC, Malachite green, acetic acid, and Aptamer was used to measure lead and radon, which were subsequently analyzed using a fluorescence spectrophotometer. The biosensor's radon gas concentration was determined to be 20.552 Bqm⁻³. 4.376 Bqm⁻³ was the lowest radon gas concentration. The highest concentration of the isotope lead was found (0.0571ppm) and the lowest concentration of the isotope of lead was (0.0111ppm). It was concluded from this current study that the concentration of radon for males was higher than for females, and this study also concluded that the concentration of the isotope of lead for males was higher than for females, where the concentration of radon and lead was found. Smokers have a higher concentration than non-smokers. Also, I have noticed that the concentration of radon and lead isotope in smokers is more than in non-smokers. The results of this investigation showed that lead ions and radon gas levels into the samples of blood were within the World Health Organization's allowed limits.

1. Introduction

Biosensors have revolutionized analytical chemistry by enabling the detection and quantification of many analytes in complex matrices [1, 2]. Biosensors are extremely helpful in a variety of applications, such as food safety, environmental monitoring, and medical diagnostics, due to their capacity to detect certain analytes with great sensitivity and selectivity [3, 4]. However, because they are radioactive and possibly dangerous, some analytes, like radon, can be difficult to detect. Given this, the creation of biosensors for radon detection is crucial for both public safety and health [5, 6]. This paper will examine the difficulties involved in creating biosensors for measuring blood radon levels and talk about potential solutions [7, 8]. Because of its unique properties, the creation of a biosensor over the blood direct measurement of radon is challenging. However, the measurement of its decay products can be used to indirectly determine blood radon levels. Pollonium is one such decay product that can be quantified by liquid scintillation counting or alpha spectrometry. With gamma spectroscopy, one can measure lead-210, another decay product. similar techniques are not unique to radon because similar decay products can be produced by other radiation sources as well, but they can nonetheless serve as a sign of radon exposure [9, 10]. Given that excessive radon exposure was connected to a risk increase in of lung cancer, so, a serious public health concern is the radon exposure. Public health would thus greatly benefit from the development of a trustworthy and precise biosensor for the direct monitoring of radon levels in blood. It is significant to remember that the possible health effects of exposure to ionizing radiation, such as radon, are still being studied and debated. The hazards of

low-level radiation exposure are less well understood, while high-level radiation exposure is known to raise the risk of cancer and other health issues. While some studies have not identified a clear association, others have proposed that exposure may increase the risk of cancer even at low levels [11]. Researchers and medical experts should keep looking into the probable health impacts of radon and other radiation sources, and people should try to reduce their exposure as much as possible. It is crucial to remember that the possible connection between Iraqi cancer and the use of nuclear bombs is a complicated and contentious issue. Although some research has indicated a potential connection between nuclear weapons radiation exposure and higher cancer rates in particular regions, other variables including pollution, inadequate healthcare facilities, and lifestyle choices might also be involved. The intricate connection between environmental exposures, such as radiation exposure, and cancer rates requires further study [12]. The study's objectives are to create and evaluate a biosensor for radon and lead ion detection in blood samples and compare its findings with those of an Airthings Canary, a device also utilized for radon detection. Along with assessing the possible impact of variables like age, gender, location, occupation, and smoking habits on radon exposure. Additionally, the purpose of the study is to look at the connection between radon levels and lead isotopes in biological samples. Additionally, the usage of a respirator is mentioned, indicating that the study may investigate the efficacy of methods for preventing radon exposure. In order to more accurately evaluate and reduce the related health hazards, the study seems to be primarily concerned with comprehending and measuring human exposure to radon and other dangerous compounds. In addition to homes and buildings, drinking water contains radon, a radioactive gas that can expose people internally. Radon is created when uranium and radium break down in soil, rock, and water. Blood radon levels cannot be measured directly, but internal exposure can be estimated indirectly using biosensors and other techniques. To develop a biosensor for monitoring radon levels in blood, researchers must develop a device that can accurately detect radon and generate a measurable signal proportional to the radon concentration. To protect patients and laboratory personnel from potential health and safety hazards related to the use of radioactive materials, the development of a biosensor is a complicated process that calls for a great deal of research and testing in addition to stringent safety procedures [13, 14]. The release of energy via space or a solid medium as energetic waves or particles is known as radiation. Our bodies naturally contain radioactive materials like ^{14}C and ^{40}K , and it is created by processes including nuclear cleavage, radioactive decay, and chemical interactions. Gamma rays and beta and alpha particles are the most prevalent types of radiation. There are three isotopes of uranium, a naturally occurring radioactive material, and two series of radioactive decay may be traced back to ^{238}U and ^{235}U . Because they are naturally occurring, gamma rays are helpful as intrinsic uranium indicators. A biological element, such as a protein or enzyme, is used by a biosensor to identify the existence of radon and give a detectable signal. When consumed in large quantities, radon is a hazardous gas. However, the difficulties in identifying gases in biological fluids and the absence of knowledge about the radon binding affinity of proteins make it difficult to create a radon biosensor [15]. Although there is potential for research into creating a biosensor to measure blood radon levels, practical implementations would necessitate substantial scientific investigation and technological advancement. The main sources of radiation in the human body are naturally occurring radioactive elements, specifically carbon and potassium, which are the source of internal radiation. The alpha decay products of the radioactive uranium and thorium series, such as ^{222}Rn and ^{220}Rn , also contribute to the radioactivity of the human body. The effects of radiation from both natural and artificial sources are comparable. The main causes of radiation exposure are man-made processes including radiotherapy, nuclear medicine, and diagnostic X-rays. Consumer goods including televisions, construction materials, luminous (tritium) watches, and airport x-ray machines can also expose people to radiation. There are two types of synthetic radionuclides: those made in nuclear power plants and other nuclear processes, and those made especially for different uses in human endeavors [16]. Small amounts of the latter kind are made in nuclear research labs. The most important isotope in the ^{238}U series is ^{222}Rn , a colorless gas that occurs naturally. It has three isotopes (^{238}U , ^{232}Th , and ^{235}U) matching all the three chains of naturally occurring radioactive decay. Radon (^{222}Rn) emits alpha particles, whereas Actinon (^{219}Rn) and Thoron (^{220}Rn) release gamma particles having half-lives of 3.92 and 55.6 seconds respectively. The radioactive disintegration of radium ^{226}Ra produces Radon with 9.73 g/L density at 0°C and penetration ability through soil and rocks. It is more than 100 times heavier than hydrogen and 7.5 times heavier than air, with detection levels of 10 to 20 atoms per million atoms. At -61.8°C , the gas liquefies, and at -71°C , it freezes. One of the most hazardous metal contaminants, Pb^{2+} ions have a detrimental impact on human health and the biological environment [17]. The silver-coloured metal lead (Pb) is found in the Earth's crust in different amounts. It is rarely found in nature in its pure form, but it is frequently found in combination with other elements (PbS , PbSO_4 , and PbSO_3) [18, 19]. Inhaling lead-contaminated dust particles, as well as consuming tainted food or water, is the main way that humans are exposed to lead [20]. Paints, polluted soil, industrial emissions, and domestic dust materials are the main sources of lead compounds. In both children and adults, disorders affecting the neurological system and gastrointestinal tract exhibit an accumulation of increased lead values [21]. The neurological system, kidneys, liver, and other soft tissues absorb the most lead in the human body, and lead poisoning is a very dangerous condition that can have permanent negative health repercussions [22]. Recent industrialization and natural sources, such as the earth's crust, which contains heavy metals that are transferred to water and air through erosion, have increased human exposure to these elements. Heavy metal exposure is further increased by other human activities such mining, oil extraction, industries, hospitals, leaded fuel combustion, and the disposal of untreated industrial waste. These substances build up within the human body and are difficult to break down, posing numerous health hazards [23]. During the Gulf Wars (1991–2003), human activity and military operations had a significant impact on Iraq's environment, leading to a surge in hazardous materials that endanger the environment and have a detrimental effect on Iraqis' health [24]. Any type of biological material, such as peptides, proteins, antibodies, cells, tissues, bacteria, and viruses, can serve as the biological identification component of a biosensor. It is vital to remember that choosing an efficient sensing component for biological recognition depends on a number of engineering considerations, the most important of which are hardware durability and ease of manufacture, in addition to the information to be detected. For example, because they are easily cultivated *in vitro* and *in vivo*, certain microorganisms can substitute both proteins and antibodies. The goal of current research is to create highly selective microbial biosensors by altering and activating particular metabolic pathways on the target compounds' substrate. It has also been suggested to modify the sensitivity and selectivity of microbial sensors at the DNA level using Genetically Engineered Microorganisms (GEMs). Two major categories can be used to classify bio-based sensors. (a) sensors that measure a biological reaction to instantly determine a target material and (b) sensors that use secondary components to identify a chemical, often in combination with a catalyst such as fluorescent tags or enzymes. There are several ways to detect the contact between the recognition element and the target material, and choosing the appropriate one is often challenging [25].

2. Materials and Procedures

2.1. Study Area

The city of Najaf is situated on the edge of the plateau, or the eastern edge of the Western Desert, which divides Iraq from the boundaries of the Kingdom of Saudi Arabia. It is bordered to the west by the Western Plateau and the Najaf Sea, to the south by Kasbah al-Hira and Abu Sakhir, to the north by the Najaf plateau, and to the east by the city of Kufa. Because of its natural geographic location, it occupies the transitional zone between the western plateau and the sedimentary plain, which create the types of surface in its south and center. The Najaf Sea serves as a boundary between the two areas. In the southwest, in the Bahr al-Najaf region, can find a territory capable of agricultural development; to the east, there is an agricultural region surrounding Kufa and the middle Euphrates. In contrast, its western borders constitute a region that hinders the emergence of settlement. The Najaf Governorate is situated 70 meters above sea level at latitude 31059 north and longitude 44019 east, roughly 160 kilometers southwest of Baghdad [26].

2.2. Materials and Methods

This study deals with the practical part by collecting samples consisting of blood and different tissues and preparing them for testing and estimating radon and lead isotopes using two different methods, which are biosensors that mainly rely on aptamers, in addition to measuring radon concentration by air devices. In the current study, human blood samples were collected from male and female volunteers from different governorates of Iraq. Blood samples were taken from different types of cancer. As well as from healthy individuals. Cancer patient's groups were collected from the Oncology Hospital in Najaf Governorate. Healthy individuals were also collected from different places of the governorate. Each sample was stored in refrigerated boxes at a temperature of (4°C), with the sample code until the time of analysis. The study members had no previous history of occupational exposure to radon and heavy metals.

The present study has used the Mega 2100 UV-Vis spectrophotometer double beam to determine the wavelength at which the highest absorbency is achieved so that it can be relied upon when installing the lens to be used to measure fluorescence. The results shown that the greatest absorbance of the primer was at the wavelength 240nm, at which the greatest absorbency was achieved. Whereas when measuring the lead isotope, it was found to have the highest absorbance at the wavelength of 611nm.

Making a biosensor based on the fluorescence optical property and preparing a biosensor cell were the following steps in the project. The aptamer powder was acquired from Bioneer (South Korea) and had a minimum purity of 99.9%. After mixing 1 milliliter of deionized water with the aptamer powder, the mixture was centrifuged for 15 minutes at 1000 rpm to create the aptamer solution. The resulting primer sequences (5'-AGGGTTAGGGTTAGGGTTAGGG-3') formed the foundation of the biosensor (BIOS) and were stored in a refrigerator at 4°C until they were needed. In this investigation, ^{222}Rn and ^{210}Pb were captured using a diluted acetic acid (CH_3COOH) solution. The diluted acetic acid was made out of 1000 milliliters of deionized water and 0.2 milliliters of 99.9% pure acetic acid (Solvochem, UK). Lead isotopes and radon gas are captured by the acid solution. It is crucial to remember that using a strong acid will damage the dye and cause the aptamer to hydrolyze. G-quadruplex production is also known to be induced by a few typical basic solutions that contain potassium and sodium ions. A tube containing 10 mL of 0.2% acetic acid is partially inserted into a 5 mL tube containing the sample to form the biosensor cell. To stop other impurities from getting into the acid and reacting with it and escaping, a cellulose acetate film (Sartorius Stedim Biotech, Germany) is placed over the tube. The cellulose acetate membrane has pores that are around 45 μm in size. A vacuum pump fitted with a pressure gauge to detect the pressure is linked to a vacuum chamber containing the biosensor cell. To extract a significant amount of radon gas from the sample, the cell (acid and blood) is kept in a vacuum for four days at a pressure of 40 bar. To get rid of any unattached molecules, the biosensor was rinsed with Tris-HAC buffer after the incubation. A fluorescence spectrophotometer (Cary Eclipse, Agilent Technologies, USA) was used to measure the biosensor's fluorescence intensity at 620 nm excitation and 530 nm emission wavelengths. The concentration of lead ions in the sample was directly correlated with the biosensor's fluorescence intensity. To ascertain the biosensor's sensitivity and limit of detection, calibration curves were created using known lead ion concentrations. With a limit of detection of 0.5 μM , the biosensor responded linearly to lead ion concentrations in the 0–10 μM range. The selectivity of the biosensor was also evaluated, and it was discovered to have little interference from other metal ions. These findings show that the biosensor has the ability to detect lead ions in human blood samples with high sensitivity and accuracy. The aptamer's conformational shift, which produces G-quadruplex, enables precise identification of highly fluorescent lead and radon isotopes. The sample is moved to a fluorescent device to detect the lead and radon isotopes once the biosensor is ready. Using a gadget like Canary or Airthing, the radioactive survey detector is calibrated to measure the amount of radon gas present. The detector is calibrated using a preset system that includes radon emission sources at varying concentrations throughout time. The amount of radon accumulated in the calibration system room is directly correlated with the time period in a linear fashion. It yields a high correlation coefficient of $r=0.98$ as shown in Figure 1.

Six concentrations of a standard lead solution (Sigma-Aldrich, USA) at 100, 200, 300, 400, 500, and 600 nM were used to generate a lead calibration curve. A fluorescence spectrophotometer was used to assess the concentrations, and Figure 2 illustrates the high positive connection that was found with a correlation coefficient of 0.968.

A portable digital canary device that detects radon gas was used to quantify the quantities of radon gas in blood samples from cancer patients and healthy individuals during a 4-day period. The device weighs 0.3 lbs (with batteries) and measures 4.7 in $\times$ 2.7 in $\times$ 1 in. Its technical features include a 3AAA alkaline battery power supply. Temperatures between 39 and 104 degrees Fahrenheit can be used to operate it, and its measurement range has a lower detection limit of 0 pCi/L and an upper display limit of 500 pCi/L. The device's precision and accuracy fall within reasonable bounds. Using a measuring equipment, the experiment's variables were temperature, relative humidity, and pressure (T, RH%, P). ANOVA and one-way classification were among the statistical techniques used to evaluate the data.

3. Results and Discussion

^{222}Rn and ^{210}Pb concentrations vary around the world due to the varying radioactive amounts found in blood samples. Both cancer patients' and healthy people's blood samples had their concentrations of these two components analyzed. A biosensor that can identify radon gas in blood samples is one of the two techniques used to measure radon gas concentrations. The biosensor detected radon values ranging from

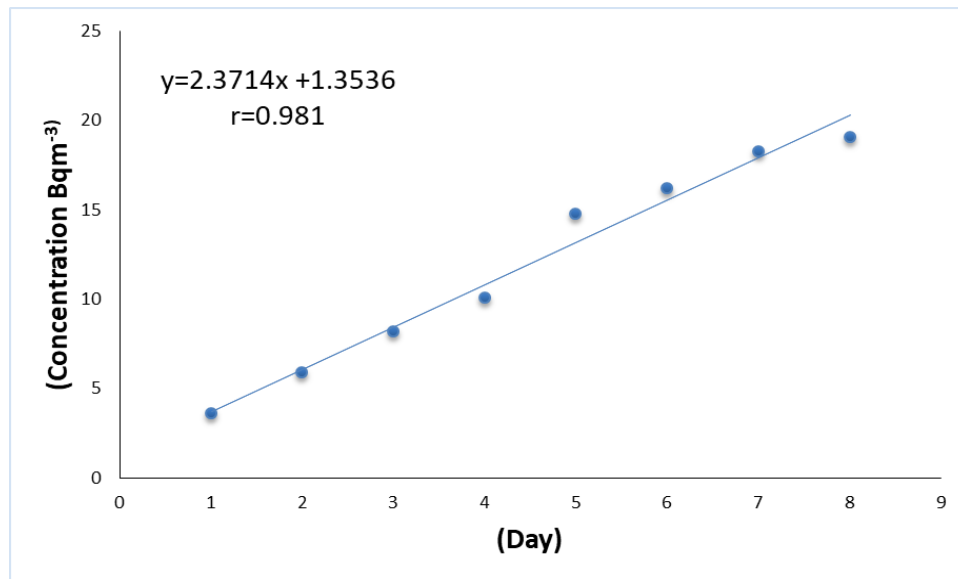


Figure 1: Radon Gas Calibration Curve

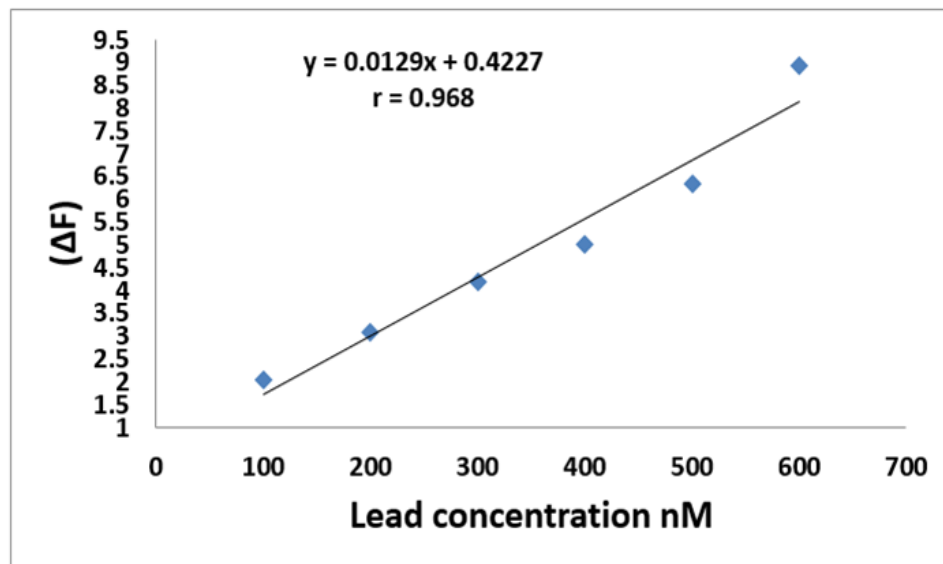


Figure 2: Lead Ion Calibration Curve

4.276 to 20.552 Bqm⁻³ in all blood samples. Throughout the experiment, the temperature ranged from 20.00°C to 29.75°C, with an average of 22.13°C ± 0.80, and the humidity levels fluctuated, averaging 85.44% ± 3.53 Table 1.

Interestingly, the blood sample of a male (B₆) who might have been exposed to radon gas at work and in his home vicinity had the greatest concentration of ²²²Rn. He added that the 2003 American bombing of his neighbourhood may have increased the radon levels in the area. However, the blood sample of a healthy, non-smoking woman (B₉) had the lowest concentration of ²²²Rn, indicating that smoking and other lifestyle choices may also be linked to elevated blood radon levels. These findings highlight the need of monitoring radon exposure and taking the necessary precautions to reduce exposure to this harmful gas. Males have a greater mean radon gas concentration than females in both the sick and healthy groups, as seen in Figure 3. This is because of the nature of what they do and the pollution they encounter in the environment. Men are more likely than women to work in environments where radioactive materials may be used, such as factories, construction sites, and hospitals, where they may be exposed to radiation for prolonged periods of time. High concentrations of radon gas have been discovered in building materials in particular, which increases the exposure of those employed in the construction sector. In order to reduce the hazards associated with extended exposure to radon gas and other radiation sources, these findings highlight the necessity of greater knowledge and safety precautions for those working in such conditions.

Figure 4 makes it evident that smoking is linked to increased blood radon gas concentrations. It was discovered that smokers have a wider range of radon concentrations than non-smokers. This could be explained by the fact that tobacco smoke contains polonium-210 and other radioactive chemicals that can raise radon levels in the body. A healthy man smoker had the lowest radon concentration (B₄), while a male patient who smokes had the highest concentration (B₆). However, it was discovered that non-smokers had a lower range of radon concentrations than smokers. A healthy female (B₉) had the lowest radon concentration, while a female patient (B₁₂) had the highest concentration. These findings emphasize how smoking should be avoided since it raises the body's radon gas levels, which are linked to an increased risk of cancer.

Table 1: Radon gas concentration by biosensor

SC	^{222}Rn (Bqm $^{-3}$)	T _{in} (C°)	T _{out} (C°)	RH%
B ₁	17.775	21.82	20.75	80.50
B ₂	13.389	32.00	29.75	79.50
B ₃	9.195	30.25	26.00	78.50
B ₄	4.729	21.67	25.00	81.25
B ₅	4.963	22.30	20.00	82.00
B ₆	20.552	21.22	20.75	87.75
B ₇	15.73	21.97	20.25	88.00
B ₈	18.591	21.10	21.00	88.25
B ₉	4.376	21.42	20.00	86.00
B ₁₀	12.731	21.25	20.25	88.25
B ₁₁	5.633	22.22	20.25	89.25
B ₁₂	11.845	22.75	20.75	89.50
B ₁₃	6.237	23.05	21.50	89.00
B ₁₄	5.090	23.50	22.25	88.50
Avg±SE.	10.766 ±0.23	23.32±0.83	22.13±0.80	85.44±3.53
Max	20.552	32.00	29.75	89.50
Min	4.376	21.10	20.00	78.50

SC: Sample Code RH: Relative Humidity T: Temperature

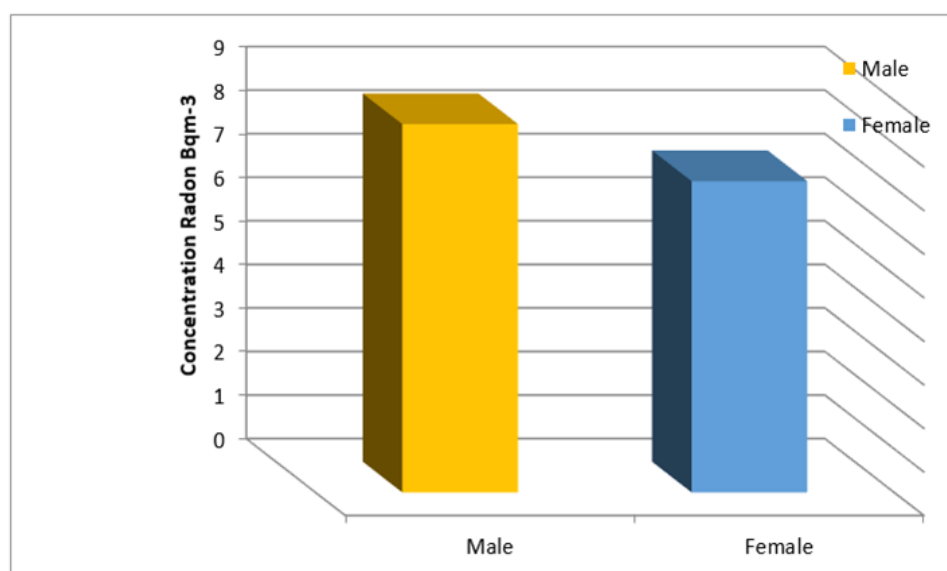
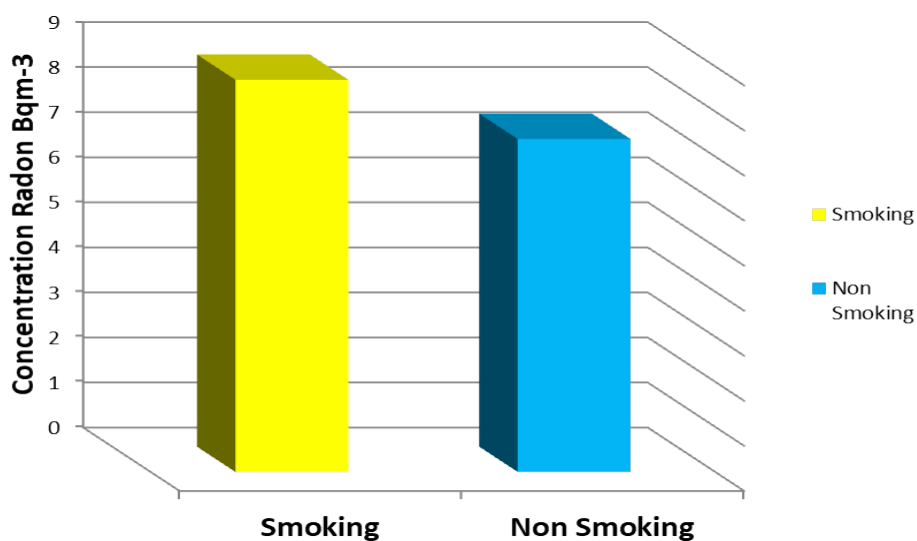
**Figure 3:** Comparison between the average concentration of radon between male and female**Figure 4:** Comparison of smokers' and non-smokers' average radon gas concentrations

Table 2 compares the radon levels in blood samples from cancer patients and healthy individuals with other research conducted in various parts of Iraq and other nations. The research of cancer patients revealed that the average radon concentration was 6.770Bqm^{-3} . Babylon, Iraq, had higher concentrations, whereas Karbala, Najaf, and Palau Penang, Malaysia, had lower amounts. However, it was discovered that the healthy sample's average radon gas concentration was 5.080Bqm^{-3} . Concentrations are lower than those in Iraq, Najaf, and higher than those in Iraqi Babylon and Karbala.

Table 2: Comparison of the current study's blood samples' radon (Bqm^{-3}) levels with those from prior studies conducted both inside and outside of Iraq.

Country	Healthy	Patients	References
Babylon, Iraq	4.98		[27]
Karbala, Iraq		64.3	[28]
Najaf, Iraq	7.6	14.5	[29]
Najaf, Iraq	10.96	11.87	[30]
Babylon, Iraq	4.32	7.79	[31]
Babylon, Iraq	1.789	5.89	[32]
Palau Penang, Malaysia		570.25	[33]
Najaf, Iraq	5.08	6.677	This study

The lead ion concentration using a biosensor. The biosensor detects a lead value between 0.0111 ppm and 0.0571 ppm. The young, healthy, nonsmoking female (age 32) had the lowest lead ion concentration of 0.0254 ppm. The highest concentration of lead ions is 0.0515 ppm. A 45-year-old man with cancer smokes. Humidity levels varied during the trial, varying from 78.5% to 89.5%, having an average of $85.44\% \pm 3.53$. Table 3 displays temperature values ranging from 20.00°C to 29.75°C , with an average of $22.13^\circ\text{C} \pm 0.80$.

Table 3: Lead ion concentration (ppm) by the biosensor

SC	Pb^{+2}	T_{in}	T_{out}	RH%
B ₁	0.0386	21.82	20.75	80.50
B ₂	0.0399	32.00	29.75	79.50
B ₃	0.0369	30.25	26.00	78.50
B ₄	0.0341	21.67	25.00	81.25
B ₅	0.0511	22.30	20.00	82.00
B ₆	0.0375	21.22	20.75	87.75
B ₇	0.0394	21.97	20.25	88.00
B ₈	0.0359	21.10	21.00	88.25
B ₉	0.0406	21.42	20.00	86.00
B ₁₀	0.0571	21.25	20.25	88.25
B ₁₁	0.0111	22.22	20.25	89.25
B ₁₂	0.0407	22.75	20.75	89.50
B ₁₃	0.0512	23.05	21.50	89.00
B ₁₄	0.0245	23.50	22.25	88.50
Avg.	0.0385	23.32	22.13	85.44
Max	0.0571	32.00	29.75	89.50
Min	0.0111	21.10	20.00	78.50

Notably, lead is a poisonous element that may build up in the body over time and has been linked to a number of health issues, such as issues with the nervous system and development. There may have been occupational and environmental exposure to lead in this study population, as evidenced by the fact that the male employee with the highest lead content was a hospital worker who had been exposed to bombing. However, a healthy, nonsmoking woman had the lowest lead concentration, underscoring the significance of lifestyle factors in lead exposure. A visual comparison of the lead amounts in the study samples is shown in Figure 5, where sample B₁₀ has the highest concentration and sample B₁₁ has the lowest.

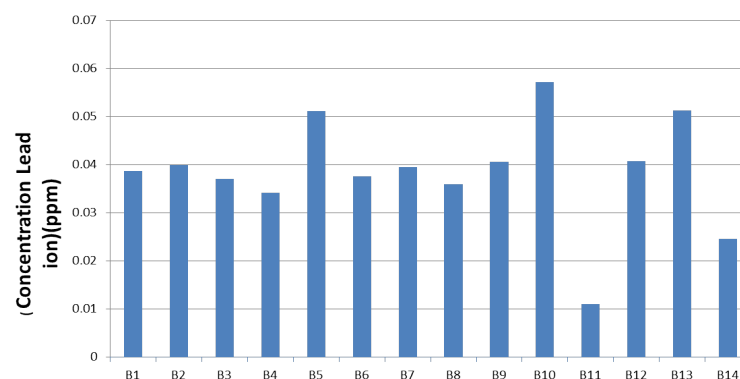


Figure 5: Concentration of lead in research samples

One of the biggest health hazards that can cause death, even if it develops gradually, is smoking. The World Health Organization (WHO) estimates that smoking causes the deaths of about four million people year, and by 2030, that number might increase to about ten million [34]. Furthermore, secondhand smoke exposure, commonly referred to as passive smoking, poses a health risk. This happens when people are exposed to both the smoke breathed by smokers and the smoke from the end of a burning cigarette or other tobacco product. According to the World Health Organization, this combination contains compounds that are hazardous or carcinogenic Figure 6.

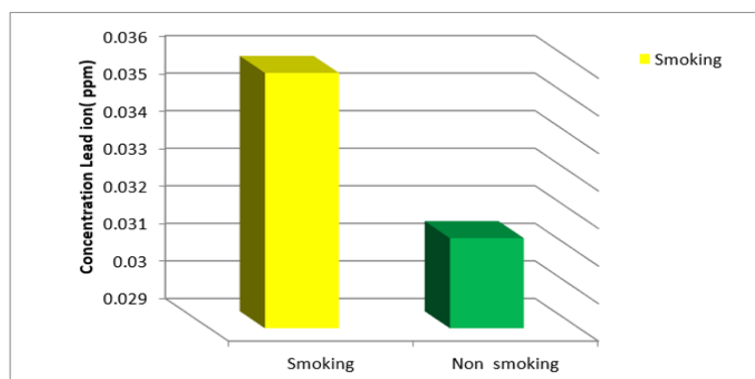


Figure 6: Comparing Lead ion between Smokers and Non-Smoker

Table 4: Radon Gas Concentration by airthing Bqm^{-3}

SC	^{222}Rn (Bqm^{-3})	T_{in} ($^{\circ}\text{C}$)	T_{out} ($^{\circ}\text{C}$)	RH%
B ₁	8.88	21.82	20.75	80.50
B ₂	5.92	32.00	29.75	79.50
B ₃	3.7	30.25	26.00	78.50
B ₄	5.92	21.67	25.00	81.25
B ₅	5.18	22.30	20.00	82.00
B ₆	9.99	21.22	20.75	87.75
B ₇	5.92	21.97	20.25	88.00
B ₈	1.85	21.10	21.00	88.25
B ₉	6.66	21.42	20.00	86.00
B ₁₀	2.22	21.25	20.25	88.25
B ₁₁	4.81	22.22	20.25	89.25
B ₁₂	8.88	22.75	20.75	89.50
B ₁₃	4.81	23.05	21.50	89.00
B ₁₄	4.81	23.50	22.25	88.50
Avg $\pm$ SE.	5.68 ± 0.18	23.32 ± 0.83	22.13 ± 0.80	85.44 ± 3.53
Max	9.99	32	29.75	89.5
Min	1.85	21.1	20	78.5

Over the course of four days, a portable digital radon detector was used to test the levels of radon in blood samples from cancer patients and a select group of healthy people. The range of radon levels was 1.870 Bq/m^3 to 3.880 Bq/m^3 . The mean radon level for males ranged from $2.76 - 3.74 \text{ Bq/m}^3$ with a mean of 3.07 Bq/m^3 , while for females it ranged from $1.98 - 3.32 \text{ Bq/m}^3$ with a mean of 2.64 Bq/m^3 .

4. Conclusions

The results indicated that the highest percentage of radon was (20.552 Bqm^{-3}) and the lowest percentage of radon was (4.376 Bqm^{-3}) in healthy people. Also, the results indicated that the highest percentage of lead was (0.0571 ppm) and the lowest percentage of lead was (0.0111 ppm) in healthy people. Radon concentration in females is less than in males because males work in the field of industry, radiation, construction and other works. The radon concentration level in all samples of blood is in the allowable limits WHO. The average concentration of radon in smokers is more than in Non-smokers. The level of concentration of lead isotopes in males more than females due to medical professions and construction sites. The average concentration of lead isotopes in smokers is more than in Non-smokers. All samples of blood were within the permitted limit according to WHO. There is no connection between all biosensors and humidity. This study concluded that biosensors for the detection of radon and lead gas can be manufactured based on aptamer rich in guanine bases. The biosensor is more sensitive. There is no correlation between all biosensors and temperature.

Article Information

Ethical Approval: The study was approved by the Directorate of Education / Iraqi Ministry of Education.

Informed Consent: Written informed consent was obtained from all participants before their inclusion in the study.

Data Availability: All data generated or analyzed during this study are included in this published article.

Conflict of Interest: The authors declare that they have no conflict of interest.

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Author Contributions: A.S.Y. - Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Resources, Writing – Review & Editing, Supervision, Project Administration; A.A.A. - Methodology, Formal Analysis, Supervision, Project Administration; S.K.A. - Conceptualization, Writing – Original Draft, Supervision, Project Administration; N.H. - Investigation, Writing – Original Draft, Supervision; T.N.J. - Conceptualization, Investigation, Data Curation, Resources, Writing – Original Draft, Writing – Review & Editing.

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