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# Novel method to assessing and the impact of alpha emitter's concentration of the uterus on women fertility in Iraqi Kurdistan region

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**Abstract** In the present work, 30 uterine tissue samples were collected from women with uterine problems from Iraqi Kurdistan. Tissue samples were analyzed and examined to measure levels of concentrated α-particle emitters and their short-lived decay products using a plastic track detector (CR-39) and the PVC long-tube technique with standard source radium ($^{226}$Ra). A new method and apparatus for the passive sampling of α-particles were also introduced. The maximum 0.0691 ppm and minimum 0.0180 ppm concentrations of particles were found in Sedakan and in Dukan, respectively; the average value was 0.0330 ppm, when compared the result with the result (0.12 ppm) in Asumadu-Sakyi et al. (Res J Environ Earth Sci 3(1):24–31, 2011) is lower than it and is agree with the result in Rubyie (Radioactive detection on the blood samples of cancer patients diseases by using CR-39 detector and its effect on cytogenetic. MSc. thesis, Al-Nahrain University, 2007). Also the results of fresh uterus are Significant ($p < 0.001$) when used non-parametric tests. The concentration of $^{222}$Rn gas varied from one woman to another depending on her age, the allergic reaction of her uterus to the radiation, and the geological formation of the area under study. The hazardous effects of α-particles are caused by increasing levels of ionizing radiation in the environment.

**Keywords** Uterus · Iraqi Kurdistan · CR-39NTD · Alpha particle radiation · In vitro study

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## Introduction

Radon is an inert, radioactive gas that produces α-particles that emit progeny when they decay, such as $^{218}$Po, $^{214}$Pb, $^{214}$Bi, $^{214}$Po, $^{210}$Pb, $^{210}$Bi, $^{210}$Po, and $^{206}$Pb. These elements are of great importance to the environment. The energy carried by α-particles can cause permanent damage to DNA because α-particles have higher linear energy transfers (LETs) than gamma radiation, which do not penetrate deeply into tissues [1]. Radon particles and their progeny may be breathed or swallowed. Radon has low penetrating power. In human tissues, the distance of $^{222}$Rn is approximately 20 μm. Radon can be carried by the blood to reach the most remote parts of the human body and then diffuse into intracellular fluids, fat cells, and uterine tissues [2].

Exposure to radiation is known to reduce fertility in women, causing them to become unable to conceive. The density of ionization in ova causes special problems because the damage (protein breakage) is concentrated within a few cells. Every exposure to ionizing radiation can kill or permanently change cells [3]. Radon progeny is soluble in tissues with higher fat contents. A fetus in the uterus can take up material from the mother's bloodstream. These findings have been published by the International Commission on Radiological Protection (ICRP) [4]. Radiation can cause considerable damage by reducing the potential fertility (i.e., the ability to produce offspring) of a normally fertile woman [5]. Radiation in the environment can affect human and animal fertility, a condition that has been confirmed by numerous studies conducted in laboratories around the world. Significant health risks, including infertility, have been associated with high levels of exposure to contaminants. However, low levels of chronic radiation exposure appear to have no measurable effect on female fertility.

Many factors affect reproductive health, including age, genetics, nutrition, life style, history of reproductive tract infection, stress level, and pharmaceutical use. As reported by scientists in recent years, pollutants in the environment certainly play an important role, contributing in some cases to the underlying causes of fertility problems [6].

Several in vitro studies using alpha have been conducted to understand early changes induced at the cellular and molecular levels in the tissue. Such studies are important in understanding the response of cells to environmental radon, where only a small fraction of the cell population interacts with α-particles. The risk per unit dose for α-radiation anywhere is estimated to be between 2.5 and 20 times higher than that for high and acute doses of low-LET radiation [7].

Fertility issues are becoming increasingly prominent, which is why it is important to understand infertility, as well as its causes and risk factors.

The fertility of women in Iraqi Kurdistan is relatively low [8]. Therefore, examination of the effect of external exposure to α-particle radiation is crucial. Exposure to ionizing radiation may exert harmful biological effects to women. Medical tests can uncover infertility resulting from physical defects, but infertility caused by environmental factors may be more difficult to determine. A factor that can aggravate infertility is radiation from radon gas, which damages both male and female reproductive systems. Radon in human tissues is not detectable by routine medical testing [9] but by the use of α-particle detectors. The α-particle detector CR-39 NTDs can be used in two modes: passive (long term) and irradiation (short term) [10]. In 1958, the science of solid-state nuclear track detectors was born when D. A. Young first discovered tracks in a crystal of LiF. When a particle interacts with a detector, etch pits along its trail are affected, which results in the formation of “tracks” [11]. The mechanism of solid state nuclear track detectors basically involves the movement of heavily ionizing particles, thereby creating narrow path of severe damage Because the operation of the CR-39 SSNTD’s relies on the fact that a heavy charged particle will result in extensive ionization of the material in its track as it ionizes roughly all molecules in its path [12] shows in Fig. 1.

The energy of α-particles depends on the time exposure and distance between the tissue sample and the standard source, $^{226}$Ra. If either of these parameters is changed, the energy of the α-particles, as well as its range, also changes. The stopping and range of ions in matter (SRIM) program has been used to evaluate and analyze this relation. Many types of equipment have been used to evaluate women’s fertility, such as CR-39 plastic detectors and the long-tube (PVC) technique. In this study, uterine tissue samples were collected from women who had temporary or permanent sterility and cancer in different locations of Iraqi Kurdistan.

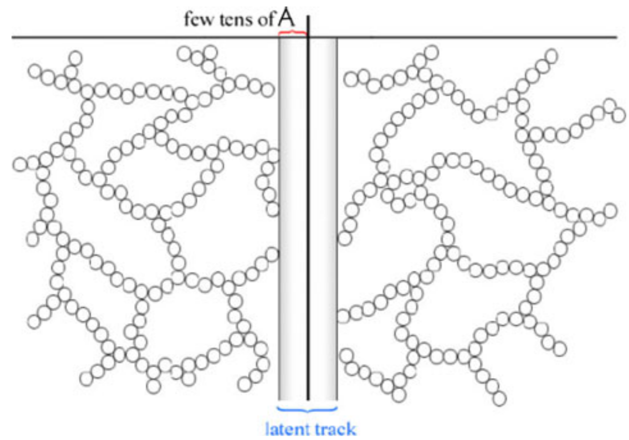


**Fig. 1** Track development produce materials damage along their path due to the excitation and ionization of atoms with which they interact

These samples were prepared in a suitable manner under the supervision of medical authorities and institutions to gauge radon hazards and α-particles concentrations in the uterus. This research focuses on the effects of contaminants in the womb that can lead to important breakthroughs in medical physics and biophysics in the future [6].

## Materials and methodology

### Long-tube PVC technique

This technique is well known and used by many researchers to evaluate radon gases and α-particle emitters. Methods for long-term monitoring of radon gases have been well established [13]. In this technique, a PVC plastic cylinder 2 mm thick, 2.1 cm in diameter, and 10.5 cm long [14] was used.

### CR-39 NTDs

CR-39 is a clear, colorless, rigid piece of plastic with a density of 1.30 g cm$^{-3}$ and a chemical formula $C_{12}H_{18}O_7$. The material is made of polyallyl diglycol carbonate resin [15]. The detectors used in the present study had an area of (1.0 × 1.5) cm$^2$ and a thickness of 700 μm [16, 17] and were produced by Intercast Europe SRL (43100 Parma, Italy) [18]. The polymer was further sensitive to α-particles and had a low background, as shown in Fig. 2.

### Methodology

#### *Sample collection and preparation*

Biological samples of uterine tissues were collected from female cancer patients and women with fertility problems;

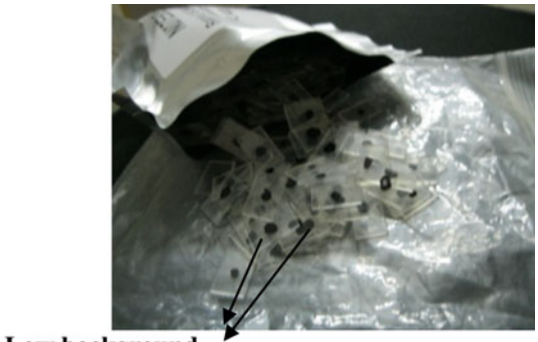


**Fig. 2** CR-39 NTD produced by Intercast Europe SRL (43100 Parma, Italy)

other data, including sex, age, and housing conditions, were also obtained. Samples and data were obtained from the histopathology departments of private laboratories, as well as from surgery units and specialist maternity hospitals. In this work, 30 uterine samples were collected. The women from whom samples were collected were from different parts of Iraqi Kurdistan. Samples were prepared in a suitable manner for practical work under the supervision of medical authorities and institutions. Each sample was separated in a plastic can containing 70 % liquid formalin. Measurement of α-particles was carried out using the passive method (natural method and new method) with the detector directly exposed to the uterine tissue and The CR-39 registered the tracks of α-particles during exposure in the PVC tube.

0.5 g of each uterine sample was placed in a rectangular sandwich-like manner between two detectors and then fixed with a long adhesive strip. The detectors were immersed and stored in sufficient quantities of 70 % formalin in a PVC tube at 4 °C in a hospital refrigerator. Each container hung vertically, with the end of the adhesive strip fixed to the top of the PVC tube cover. Another CR-39 detector was held in the formalin liquid in another PVC container to measure the concentration of α-emitters in the formalin liquid. The tubes were left at 4 °C in the hospital refrigerator for 2 months, as shown in Figs. 3 and 4 [20].

During this time, particles from the decay of radon and their daughters bombarded the CR-39 NTD. The tracks were registered by two detectors, one of which recorded the α-particle emitters from Rn decays and the progeny from uterine samples and formalin, while the other detector (i.e., the detector in the PVC tube) containing formalin recorded α-particle emitters from Rn decays and the progeny from formalin. When α-particles penetrate the detector, they cause damage along their path; this damage can be made visible by chemical etching. The etching produced a hole in the detector along the path of the particle, which can be easily observed using a light transmission microscope with moderate magnification. Track visualization using etching generally consists of four steps: etching, washing, drying, and observation under an optical microscope [21]. After exposure, the detectors were etched chemically with 6.25 N NaOH solution at 70 °C for 8 h [18]. The tracks were counted using an optical microscope, as shown in Fig. 5.

## Statistical analysis

All statistical calculations were performed using SPSS for Windows, Standard version 20.0. The data of the research were saved in Microsoft Excel Spread sheet and analyzed on the computer using Microsoft Excel program.

### *Etching process and scanning*

After an exposure time of 60 days, the detectors were collected and etched chemically in an energy laboratory using a water bath (Gotecg test in G Machines Inc., Model

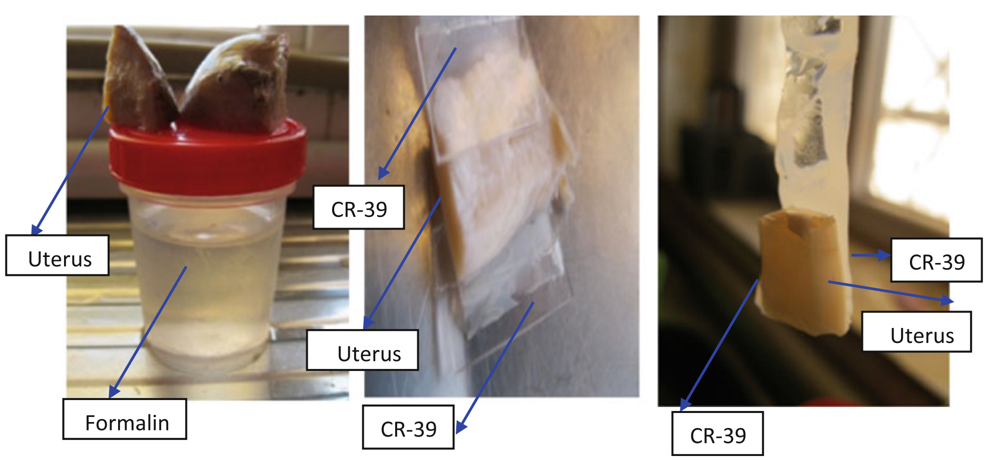


**Fig. 3** The stage of preparation sample uterus with the formalin

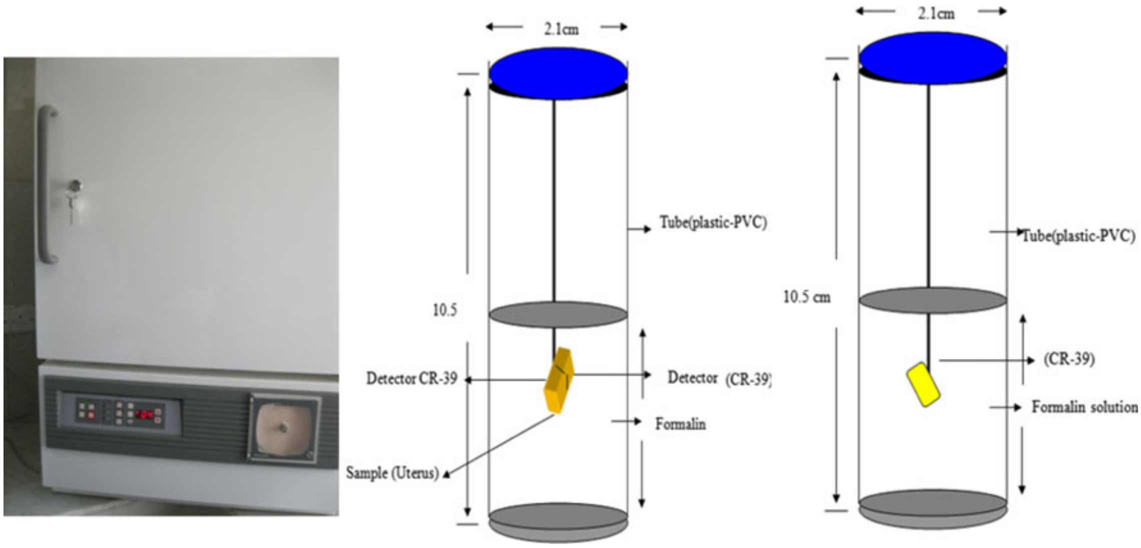


**Fig. 4** The tube PVC after preparation with uterus, formalin and fridge at the hospital

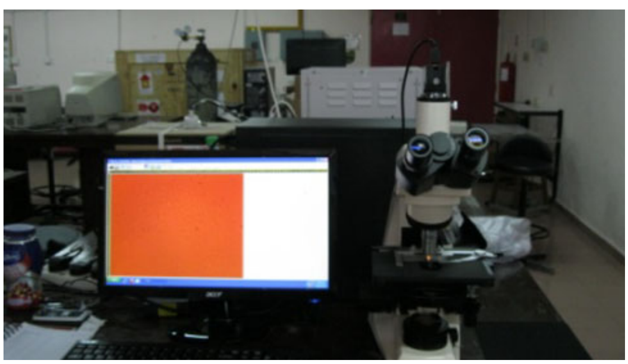

**Fig. 5** Scanning and counting tracks with the camera to image a track

GT-7039-M, 220V, 50 Hz) to display and enlarge latent α-tracks due to Radon decay [20]. The detectors were then washed with distilled water. To determine the track density per square centimeter, an optical microscope at 400× magnification and 70 fields were used to scan each detector. The range of α-particles between uterus samples and CR-39 NTDs was calculated using the SRIM program, the results of which are shown in Table 1.

*Risk of α-particles determination*

An in vitro study was conducted to determine the track density of alpha emitters in fresh uterus and for women. Each detector was scanned using an optical microscope, and were calculated in relation to Sen et al. [22]. The alpha emitter concentrations in the fresh uterus samples were calculated using the formula in Sen et al. [22] and Karim et al. [23] with used a uranium standard obtained from the *International Atomic Energy Agency*. The concentration of α-particle emitters from radon gas to the population of the Kurdistan region area due to exposure to radon decay products depending on α-particles concentration. The concentrations of alpha emitters (uranium) in fresh uterus samples for women suffer the tumor in the gonads were calculated used the relation in the uterus samples were measured by making comparisons between track densities recorded by the detectors of the uterus samples and that of standard uranium concentrations by used the calibration curve was prepared [8] to calibrate the samples using the standard of different uranium concentrations adopted from the IAEA (International Atomic Energy Agency), as shown in Fig. 6 and used the formula [23–25], and the results of which are shown in Table 2

$$C_X(\text{sample})/\rho_X(\text{sample}) = C_S(\text{standard})/\rho_S(\text{standard})$$
$$C_X = C_S.(\rho_X/\rho_S)$$

where, $C_x$: Uranium concentration in unknown sample (ppm); $C_s$: Uranium concentration in standard sample (ppm); $\rho_x$: track density of unknown sample (tracks/mm$^2$); $\rho_s$: track density of standard sample (tracks/mm$^2$).

*Demographic characteristics* There were 30 participant were enrolled in current study, and their mean (±SD) age was 36.33 ± 5.701, as shown in Table 3.

*Correlations between participants' age and their laboratory data* Participants' age and their laboratory data were analyzed using non-parametric tests. Significant strong positive correlations found between participants' age and their laboratory data, as shown in Table 4.

**Table 1** Range of alpha particles in CR-39 and uterus samples from women in Iraqi Kurdistan region with energy loss for them in different energy

| Energy MeV | Range α particles in CR-39 (Å) | $\frac{dE}{dx}$ in CR-39 | Range α particles in Uterus (Å) | $\frac{dE}{dx}$ in Uterus |
|---|---|---|---|---|
| 1 | 170 | 1.973E | 192 | 2.217E |
| 2 | 306 | 1.683E | 351 | 1.882E |
| 3 | 457 | 1.454E | 533 | 1.622E |
| 4 | 608 | 1.287E | 718 | 1.435E |
| 5 | 757 | 1.160E | 903 | 1.293E |

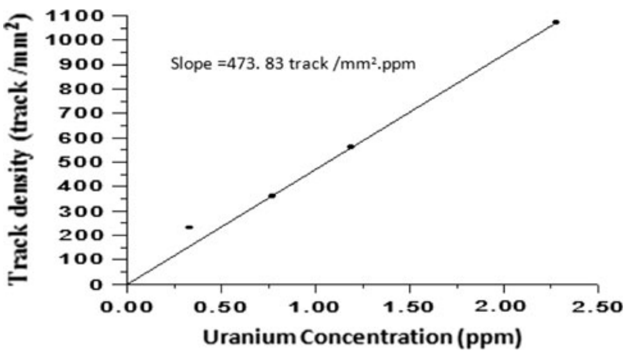


**Fig. 6** Represent the calibrations curve for uranium standard samples and track density

## Results and discussion

In this study, a new technique for detecting α-emitters in uterine tissues was utilized. Table 1 shows the range of α-particles in uterine tissue; the energy of α-particles ranged from 1 to 5 MeV. The range of α-particles varied and depended on the target density of the uterus and density of CR-39 NTD. The range of α-particles in the target decreased with increasing density; thus, the range of α-particles in CR-39 NTD was less than the range of α-particles in the uterus because the average density of uterine samples was less than the density of CR-39 NTD. The same results for restricted energy loss are shown in Figs. 7 and 8, and the relationship between the range of α-particles and their energy is shown in Fig. 9.

The α-emitters concentration was determined in 30 uterine samples by means of the CR-39 NTDs counting technique, the results of which are shown in Table 2. The maximum 0.0691 ppm and minimum 0.0180 ppm concentrations of particles were found in Sedakan and in Dukan, respectively; the average value was 0.0330 ppm, when compared the result with the result (0.12 ppm) in Asumadu-Sakyi et al. [24] is higher than it and is agree with the result reported by the researcher [8] infected human tissues by application of detector CR-39. The concentrations were (0.031 –0.6 ppm) [26] the study conducted to calculate the concentrations of alpha emitters in biological. The uterus tissues have been selected for being the reproductive organ which is increasingly affected by radiation than others. Also the results of fresh uterus are significant ($p < 0.001$) when used non-parametric tests

**Table 2** Evaluation of concentration of alpha emitters and radium concentration in fresh uterus for women suffer the tumor in the gonads in Iraqi Kurdistan region by passive method

| N.S. | Location | Age/years | Con. of alpha emitters (ppm) |
|---|---|---|---|
| 1 | Dukan | 27 | 0.0180 |
| 2 | Erbil center | 28 | 0.0184 |
| 3 | Rawanduz | 29 | 0.0195 |
| 4 | Halabjay taza | 29 | 0.0212 |
| 5 | Shekhan | 30 | 0.0215 |
| 6 | Kalar | 31 | 0.0218 |
| 7 | Kfry | 31 | 0.0220 |
| 8 | Khalakan | 32 | 0.0238 |
| 9 | Shaqlawa | 32 | 0.0242 |
| 10 | Zaweta | 33 | 0.0263 |
| 11 | Sharawany | 33 | 0.0264 |
| 12 | Rania | 33 | 0.0265 |
| 13 | Darbandikhan | 34 | 0.0268 |
| 14 | Arbat | 34 | 0.0304 |
| 15 | Halabjay kon | 44 | 0.0313 |
| 16 | Makhmor | 35 | 0.0318 |
| 17 | Takea | 35 | 0.0320 |
| 18 | Bardarash | 36 | 0.0333 |
| 19 | Said sadiq | 37 | 0.0349 |
| 20 | Chwarqurna | 40 | 0.0366 |
| 21 | Sulaymania | 41 | 0.0388 |
| 22 | Taqtaq | 41 | 0.0393 |
| 23 | Qaladza | 41 | 0.0395 |
| 24 | Chamchamal | 42 | 0.0398 |
| 25 | Koya | 43 | 0.0423 |
| 26 | Penjween | 43 | 0.0427 |
| 27 | Harer | 43 | 0.0474 |
| 28 | Khurmal | 44 | 0.0478 |
| 29 | Deana | 44 | 0.0579 |
| 30 | Sedakan | 45 | 0.0691 |
| ** | | | 0.0330 |

** Mean

**Table 3** Means of participants' age and their laboratory data

| Variable | Mean (±SD) | Median |
|---|---|---|
| Age (years) | 36.33 ± 5.701 | 35.00 |
| Track density in fresh uterus | 15.679 ± 5.696 | 14.97 |
| Conc. of alpha emitters in fresh uterus | 0.033 ± 0.090 | 0.24 |
| Number of participants = 30 | | |

**Table 4** Correlations between participants' age and their laboratory data

| Variables | Age |
|---|---|
| Fresh uterus-track density | |
| Spearman correlation | 0.958 |
| *p* value | <0.001 |
| Fresh uterus-alpha emitters | |
| Spearman correlation | .958 |
| *p* value | <0.001 |

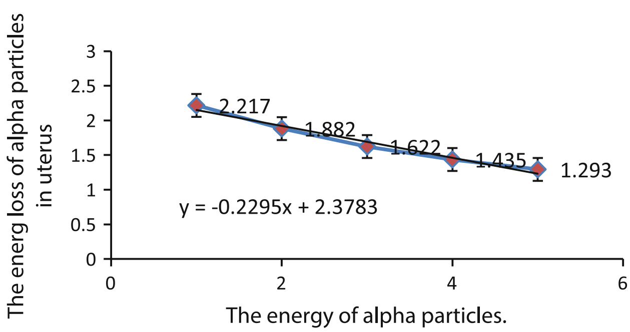


**Fig. 7** The relation between the energy loss of alpha particles in uterus and the energy of alpha particles using program SRIM

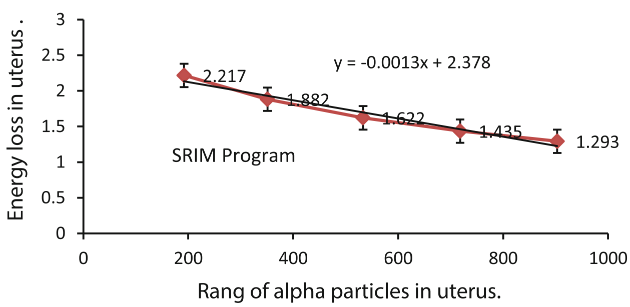


**Fig. 8** The energy loss is a function to the range of alpha particles in uterus

The results also showed that the concentration of alpha emitters varied from one woman to another, depending on her age and the allergic reaction of her uterus to the radiation. The geological formation of the area under study was also found to influence radon concentration. In Sedakan the hazardous effect of α-particles resulted from increasing ionizing radiation in the environment. The density of ionization brings about special problems to the uterus and

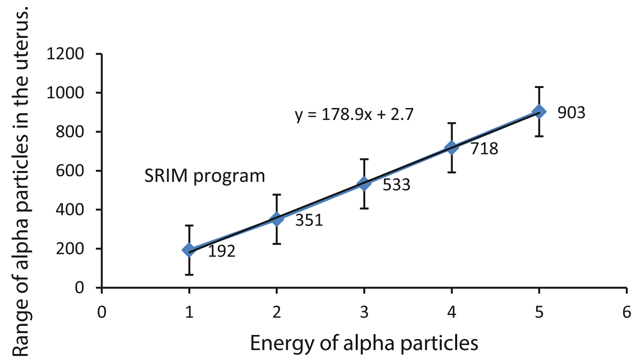


**Fig. 9** The relation between range of alpha particles in uterus with the energy of alpha particles

ovaries because the damage (protein breakage) is concentrated within a few cells. When charged particles pass through a CR-39 detector, they break the molecular bonds of the CR-39 material to form nuclear damage trails with high ionization [3].

## Conclusion

The SSNTD technique was used to investigate α-particle emitters from radon gas in 30 fresh uterine samples taken from women in different locations in Iraqi Kurdistan. The levels of these gases must be examined so that radon contamination can be prevented in the future. Limited research has been done in this field, especially in Iraqi Kurdistan. The issues in this research are very important in strengthening the link between radon, radon progeny, α-particles, and women's fertility. Further studies are necessary to arrive at more definite conclusions. The results also show that the concentration of alpha emitters varies from one woman to another, depending on the woman's age, the allergic reaction of her uterus to radiation, and the geological formation of the area under study. The results obtained were generally lower than the normal levels set by the European regional reference laboratory for radon measurements organized by the IAEA and the EPA.

## References


1. Nikezic D, Yu KN (2007) Computer simulation of random measurements with nuclear track detectors. Silvan J. Bianco, Kowloon Tong, pp 119–150
2. Bliss LT, Daniel K, Jing C, Jan MZ, Kevin PB, Dorothy M (2006) Assessment and management of residential radon health risks. Radiation Protection Bureau, Health Canada, Ottawa. J Toxicol Environ Health Part A 69:735–758
3. Rosalie B (2000) The problem, the seed, no immediate danger, prognosis for a radioactive earth. Rosalie B, pp 15–63

4. Kendall GM, Smith TJ (2002) Doses to organs and tissues from radon and its decay. Prod J Radiol Prot 22:389–406
5. El-Ghossain MO, Saleh RMA (2007) Radiation measurements in soil in the middle of Gaza-Strip using different type of detectors. 15(1):23–37. ISSN1726-6807, http://www.iugaza.edu.ps/ara/research
6. Jon L (2005) Challenged conceptions: environmental chemical and fertility. www.healthandenvironment.org/working_groups/fertility, womenshealth.stanford.edu/environment/fertility.html
7. Hamza VZ, Mary NM (2009) Cytogenetic damage in human blood lymphocytes exposed in vitro to radon. Mutat Res 661:1–9
8. Nada FK (2004) Radiological study of a biological sample selected. PhD. thesis college of education. Al. Mustansiriyah University
9. Obed RI, Ademola AK, Ogundare FO (2011) Radon measurements by nuclear track detectors in dwellings in Oke-Ogun area, South-Western, Nigeria. Radiat Prot Dosim, pp 1–7
10. Hussein AS (2008) Radon in the environment: friend or foe? In: Proceedings of the 3rd environmental physics conference, 19–23 Feb. Aswan, Egypt-43
11. Semprini L, Istok J (2006) Radon-222 as a natural tracer for monitoring the remediation of NAPL contamination in the subsurface
12. Nikezic D, Yu KN (2004) Formation and growth of tracks in nuclear track materials. Mater Sci Eng 46:51–123
13. Spellman WJ (2004) Modeling and measurement of radon diffusion through soil for application on mine tailings dams. MSC thesis, University of the Western Cape
14. Yousuf RM, Husain MM, Najam LA (2009) Measurement of radon concentration levels in spring water in Iraq. Jordan J Phys 2(2):89–93
15. Rahman SU, Matiullah BF, Nasird T, Anwarb J (2011) Monitoring of indoor radon levels around an oil refinery using CR-39-based radon detectors. Indoor Built Environ Pak:000;000:1–6
16. Žunić ZS, Miljević NR (2009) Environmental and health impact assessment of ammunition containing transuranic elements. Hdb Env Chem 209–251. doi:10.1007/698_2008_1
17. Tsivou M, Livadara D, et al (2009) Stabilization of human urine doping control samples: II. Microbial degradation of steroids. Anal Biochem 388:146–154
18. Saad AF, Abdalla YK, Hussein NA, Elyaseery IS (2010) Radon exhalation rate from building materials used on the Garyounis University campus, Benghazi, Libya, Turkish. J Eng Env Sci 67–74. doi:10.3906/muh-0810-17
19. Sekn JK, Alam MM, Kabir MI, et al (2006) Measurement of alpha emitters concentration in some soft drinks. Bangladesh J 2(1):35–40
20. Hayam A, Abdel G (2007) Enhancement of radon exposure in smoking areas. Environ Geochem Health 29:249–255. doi:10.1007/s10653-007-9082-4
21. Mahlobo M, Farid SM (1992) Radon dosimetry using plastic nuclear track detector. J Islam Acad Sci 5(3):153–157
22. Sen JK et al (2006) Measurement of alpha emitters concentration in some soft drinks. Bangladesh J Phys 2(1):35–40
23. Karim MS et al (2010) Measurement of uranium concentrations in human blood in some the regions of Baghdad governorate. Ibn Al-Haitham J FO R Pure Appl Sci 23(2):24
24. Asumadu-Sakyi AB, Fletcher JJ, Oppen OC, Quashie FK, Wordson DA, Adjei CA, Amartey EO, Darko EO, Amponsah P (2011) Preliminary studies on geological fault location using solid state nuclear track detector. Res J Environ Earth Sci 3(1):24–31
25. Rubyie AQM (2007) Radioactive detection on the blood samples of cancer patients diseases by using CR-39 detector and its effect on cytogenetic. MSc Thesis Al-Nahrain University
26. Ibraheem MH (2003) Determination of depleted uranium concentration in leukemia samples. M.Sc thesis college of education, Al. Mustansiriyah University