

Determination the Natural Radiation Activity in Female Human Urine Samples in Kirkuk City by Using Two Technique Rad7 and CR-39 Detector

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Abstract

Background: The basic components of the environment, such as air, water, and soil, typically contain radioactive materials in naturally occurring circulation. Typically, a variety of techniques are used to convey radioactive materials to people, animals, and plants. The residence time of radioactive elements in the environment and the transit of these elements to the human body are both affected by the carriers' various physical and chemical properties

Materials and methods: In this current work, radon concentration in cancer-sick urine samples in Kirkuk was measured using a Rad-7 and CR-39. CR-39 detector 400 μm thick and area $(1 \times 1) \text{ cm}^2$. Chemical editing of the alpha particle traces was captured using the CR-39 track detector. "Alpha rays" or "alpha radiation" coming from the radon listed in the models. This study was conducted on 60 urine samples from people of different ages (between 22 and 80 years old), all of whom had cancer problems.

Results: The result showed that the highest radon concentration using a detector Rad7 (3240 Bq/m^3) Average concentration (1492.07 Bq/m^3) and radon concentration when using CR-39 detector (3066 Bq/m^3), average radon concentration (1404.13 Bq/m^3), concentration uranium (9.77 ppm), radioactivity (0.093 Bq) and highest annual impact dose (81.74 mSv/y). In addition, the results showed that the concentration of radon gas. Concentration uranium was varied from person to another, depending on the allergy of that person to the radiation.

Conclusion: There is evidence of health problems and evidence of the relationship between radiation and cancer. In general, the obtained results were above than of the normal levels.

Key words: Radon gas, Rad7, CR-39, cancer, Alpha decay, urine

Introduction

The basic components of the environment, such as air, water, and soil, typically contain radioactive materials in naturally occurring circulation. Typically, a variety of techniques are

used to convey radioactive materials to people, animals, and plants. The residence time of radioactive elements in the environment and the transit of these elements to the human body are both affected by the carriers' various physical and chemical properties [1]. One of the most significant natural radiation sources for people is radon gas, which can be found in soil, water, and air. Atomic number 86 [2] radon is a radioactive gas that is chemically inert. According to Baeza et al. (2018) and Moreno et al. (2018), the primary source of radon gas is the naturally occurring radioactive decay of uranium and radium in habitats like groundwater, soil, and air [3]. Radioactivity is a specific type of radiation emitted by radioactive substances. Radioactivity is a constant phenomenon surrounding the human environment. According to Warren's classification of environmental elements, radioactivity is contaminated by water, air, and the earth in one or another amount B. Contaminated animal and plant foods are the result of this phenomenon due to the presence of radionuclide elements [4].

Pollution is “the extent to which the physical and biological components of the Earth/atmosphere system are contaminated to such an extent that normal environmental processes are impaired” [5]. Most of the damage caused by radiation is due to its biological effects on living organisms and organic systems, which depends on different factors, the type of radiation (gamma, beta, X-ray alpha, neutrons) and the type of exposure, e.g.: internal or external), the sensitivity of various organs of the body to the storage of radioactive material, and the type of organ and its sensitivity to radiation exposure, absorbed dose, age, sex, and health status of the person exposed. Radiation affects living organisms in two ways: direct and indirect [6]. Accordingly knowing the concentration of the radon gas in our body is significant to assess its impact of radiation [7]. Alpha particle is massive and causes a great lot of ionization when it gets into contact with a body or ingested, and causes single strand and double strand DNA breaks. In addition to this, it causes indirect genotoxic and nongenotoxic effects on cells, which can lead to malignancy [8].

Materials & Methods

Urine Samples

A fluid produced by the body as a result of the blood purification process as it passes through the kidneys and is excreted through a process called urination. Any abnormality in this fluid can reveal the condition. Many diseases can be diagnosed with a urinalysis. Daily urine output varies between (1-2) L/day (for normal adults). Urine is mainly water, but also contains some dissolved substances, so its density is close to that of water, 1 g/cm^3 , but slightly higher, so the density of normal urine is about $(1.001-1.035) \text{ g/cm}^3$ [9]. Since urine is a liquid that is excreted by the kidneys through a process called urination, it contains radiation after the filtration process [10]. Urine is considered the best sample for testing for excess radon intake. In addition, urine was used as part of epidemiological investigations to assess radionuclide levels in the meals of Iraqi inhabitants with high background radiation and to evaluate public exposure to natural radiation. Human uranium consumption can be monitored through urine tests, and radon levels in human urine have been measured physically through physical research [11].

Rad7 device

The Rad7 is a flexible tool that can serve as the foundation of a complete radon measurement system. It can be applied to a variety of situations and for a variety of goals. A true real-time radon monitor is the Rad7. This enables the measurement period's varying radon concentrations to be determined [12]. The Rad7 instrument is used to gauge radon levels. This is highly helpful since it allows for the study of variables that affect radon levels over time. Changes in temperature, wind speed, relative humidity, and even an understanding of how the air is moving through the room can all be considered as factors. Continuous radon monitors come in a variety of forms now, from fixed to portable monitors like the Rad7. The portability of the device extends its usefulness, as it can not only take measurements at

specific points, but can also be used to identify points of entry of radon gas into a space through cracks or crevices. The common term for radon is "sniffing," which is useful for damage control. Rad7 has a periodically populated cell. The battery is filled with air through a small pump that draws air into the battery at preselected intervals. In this defined cell, either radon or ^{218}Po can decay, the decay products are determined and the cycle repeats [13]. Rad7 is measured using a solid-state alpha particle detection cell capable of generating an alpha energy spectrum in the 0-10 MeV range with a resolution of 0.05 MeV to distinguish between alpha particles emitted by the progeny of ^{220}Rn and ^{222}Rn . Semiconductor detectors convert the alpha radiation produced by the decay of radionuclides such as ^{218}Po or ^{214}Po into electrical signals [12]. The internal sample cell of the Rad7 is a 0.7-liter hemisphere coated with an electrical conductor. The ion-implanted planar solid-state α -silicon detector is located in the center of the Rad7 solid-state detector in Figure (1).

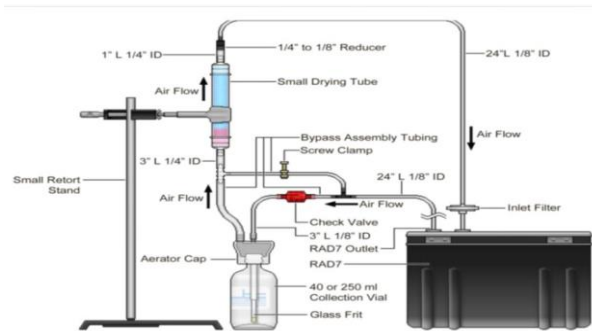


Figure (1) RAD7 solid state detector [14]

Table 1: The Rad7 detection systems [15]

Protocol	Cycle	Recycl	Mode	Thoron	PUMP
		e			
Watt-40	00:05	4	Watt-40	Off	Grab

Nuclear track detector CR-39

The CR-39 nuclear tracking detector was employed in this work despite the fact that there are other varieties of solid-state nuclear tracking detectors. The compound known as CR-39, polyallelic diglycol carbonates (PADC), was found in 1978 [16]. It is among the most significant organic nitrogen-free detectors. One of the most delicate plastics utilized for nuclear tracking is this one. The most prevalent commercial-scale detector, the CR39, can pick up alpha energy between 0 and 77 MeV. It is a Columbia resin-based CR-39 truncated polymer, which is a short polyallyl chain joined by carbonate-diethylene glycol groups in a three-dimensional

network [17]. The CR-39 is constructed from a single sheet with a primer of some kind in the frame. The CR-39 monomer has a saturated chain-like molecular structure and a molecular weight of 274.2707 g/mol. In general, chain structures are more radiation-sensitive than other types of structures. The density of CR-39 is 1.32 g/cm³. The refractive index value is $n=1.504$ [18]. NaOH or KOH can be used to hole the detector. On the surface of the etched detector, traces between 20 keV and 1.02 MeV can be seen [19]. The CR-39 detector is one of the most commonly used solid-state nuclear track detectors because it can record the number of tracks, locations, and orientations (zenith angle, azimuth angle), as well as be known by knowing the charge, mass, and energy of the track parameters [19].figure(2) Nuclear track detector CR-39



Figure (2) Pieces of CR-39 Nuclear Track Detector

Method

Urine samples were collected from 60 cancer patients between the ages of 22 and 80. It should be noted that all women have cancer problems (various types of cancer and radiation therapy). The samples were collected at the Oncohematology Center in Kirkuk, Iraq. Each sample is stored individually in a special test tube. These tubes are marked with the respective numbers of the female. The urine sample is then placed in a freezer (4 °C) and transfer them to a laboratory for the purpose of measuring the radon concentrations in two ways, the first by means of a RAD7 detector and the second method using a CR_39 detector installed in a cover (cup) size (5ml) the detector was installed by transparent adhesive and after the samples were installed at a distance (3cm) From the detector the samples are then stored for (60) days for the purpose of self-irradiation of the excrement samples and after the passage of the period the CR_39 detector is lifted for the purpose of conducting chemical skimming. For the purpose of showing Track Figure (3a,b,c) type of Track of alpha particle on CR-39 detector different samples , the CR-39 reagents were skimmed with a sodium hydroxide solution (6.25 N) for five hours and at temperature (70° c), and the process of preparing the abrasive solution is dissolved (12.25gm) from sodium hydroxide (NaOH) granules in (50ml) of distilled water for the solution on the required standard. After the chemical scraping process, CR-39 reagents are placed under the photosynthesis. To calculate the systematic effects, the light microscope is used and the irregular effects are neglected because they are caused by impurities or dust that settled on the microscope lens.

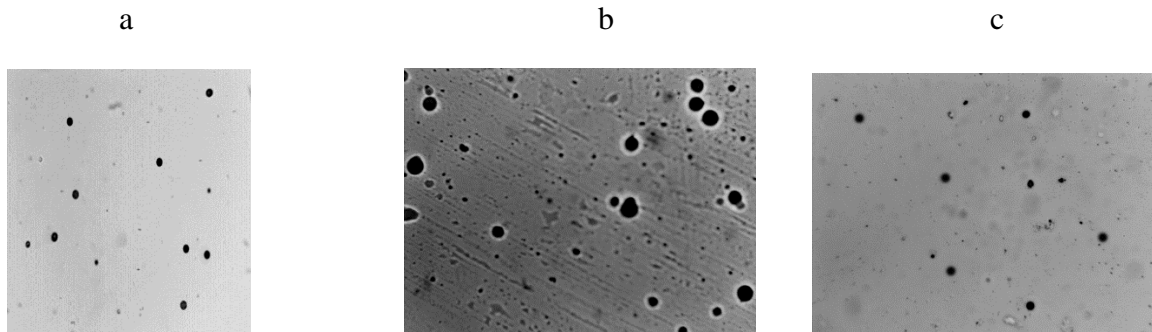


Figure (3a, b, c) Type of Track of alpha particle on CR-39 detector different samples

Calculation

The track detector technology CR-39 was used to determine radon concentrations in urine sample by recording the tracks of alpha particles on the detector's surface according to the following connection [20]. The equation was used to obtain the track density (track / cm²)

$$\rho \text{ (Track *cm}^2\text{)} = \text{Number of Track* Area of view Track.....(1)}$$

The density in the blood samples represented traces of particles produced by radon during exposure. Equation was used to compute the concentration of alpha particles C_{Rn} in urine samples [21] (Bq/m³).

$$C_{Rn} \text{ (Bq/m}^3\text{)} = \rho / K \text{ (2)}$$

Where ρ represent track density on exposed detector (Tr/cm²), t represents exposure time of the urine sample (60 d), and K represent calibration factor (diffusion constant). K was measured using the relationship below, using the parameters of the urine cup [22].

$$K = 0.25 r (2\cos\theta_c - r/r_a) \text{ (3)}$$

Where r represent the radius of the tube ($r= 1.75\text{cm}$), θ_c represent critical angle of the CR-39 detectors ($\theta_c = 35^\circ$), and r_a represents the range of alpha particle in air ($r_a = 4.15\text{ cm}$)[23], Thus diffusion constant $k = 0.52(\text{Tr.cm}^{-2}/\text{Bq}\cdot\text{m}^{-3}\cdot\text{d})$.

Radioactive effectiveness A of radon from samples used in Bq units can also be found depending on the size of the sample in urine sample (m³) V and that of the relationship [24]

$$A = C_{RN} V \text{ (4)}$$

Using the ideal radiation balance law the number of atoms uranium is found in samples of the mass W_u (gm) concentration units (ppm) is equation [24].

$$N_U \lambda_U = N_{Rn} \lambda_{Rn} \text{(5)}$$

$$W_U = N_U A_U / N_{av} \text{(6)}$$

$$C_U(\text{ppm}) = W_U / W_s \text{(7)}$$

Where λ_U constant decay equal ($4.883 \times 10^{-18} \text{ d}^{-1}$), A_U Mass number of uranium ²³⁸U, N_{av} Represents the number of avocadro It equals $6.022 \times 10^{23} \text{ mol}^{-1}$, W_s Sample mass used
 The annual effective dose (AED) in terms of (mSv/y) units was obtained using the relation [25]

$$\text{AED (m Sv/y)} = C \times F \times H \times T \times D \text{ (8)}$$

where (H) is the occupancy factor which is equal to (0.8), (T) is the time in hours in a year, (T=8760 h/y), and (D) is the dose conversion factor which is equal to [9×10^{-6} (m Sv) / (Bq.h.m⁻³)]

Result and discussion

The current results showed that the concentration level of radon in the urine for the tested samples effective dose rate received by the person, it is important to take into account the conversion coefficient from the absorbed dose and the indoor occupancy factor. The annual effectiveness has been calculated from the measured radon concentration in all samples using the equation that is described in more details in the study of [26, 27]. In addition, The highest values the concentration Radon in used Rad7 in samples urine for female with breast cancer (2830Bq/m³) and used equation (2) to find the concentration Radon used CR-39 (2555Bq/m³) used (7) equation the find uranium concentration (9.77ppm), used (4) equation the find radiation activity (0.081Bq) used (8) equation the find annual effective dose(71.39mSv/y) table (2). The highest values the concentration Radon in used Rad7 in samples urine for female with bladder cancer (1820Bq/m³) and used (2) equation the find the concentration Radon used CR-39(1725Bq/m³). uranium concentration (4.00ppm), radiation activity (0.052Bq) annual effective dose(51.21mSv/y) table (3). The highest values the concentration Radon in used Rad7 in samples urine for female with uterine cancer (3060Bq/m³) and the concentration Radon used CR-39(3066Bq/m³). Uranium concentration (3.67ppm), radiation activity (0.088Bq) annual effective dose (77.20mSv/y) table (4). The highest values the concentration Radon in used Rad7 in samples urine for female with kidney cancer (2030Bq/m³) and the concentration Radon used CR-39(2108Bq/m³). Uranium concentration (1.95ppm), radiation activity (0.058Bq) annual effective dose(51.21mSv/y) table (5). The highest values the concentration Radon in used Rad7 in samples urine for female with lung cancer (2030Bq/m³) and the concentration Radon used CR-39(2060Bq/m³). Uranium concentration (9.76ppm), radiation activity (0.058Bq) annual effective dose (51.21mSv/y) table (6). The highest values the concentration Radon in used Rad7 in samples urine for female with laryngeal cancer (1410Bq/m³) and the concentration Radon used CR-39(1533Bq/m³). Uranium concentration (7.75ppm), radiation activity (0.040Bq) annual effective dose (35.57mSv/y) table (7). The highest values the concentration Radon in used Rad7 in samples urine for female with (Pancreas - stomach - gallon – spleen) cancer (3240Bq/m³) and the concentration Radon used CR-39(2990Bq/m³). Uranium concentration (3.14ppm), radiation activity (0.093Bq) annual effective dose (81.74mSv/y) table (8). results showed that the concentration of radon gas was varied from one patient to another, and this large variation of the radon concentration can be explained depending on the allergic reaction of the body to the radiation and the response of the body to the radiation and also on the age of the person. In the case of age increasing, the exposure time to the radiation increases as well and this leads to the increase in the accumulated dose. Knowing of these concentrations is extremely important, as it reveals whether urine has received such doses of radioactive materials. It is worth mentioning that the issues in this research are very important in strengthening the link between radon and urine. The intensity of the annual effective dose, on the other hand, was also varied from one person to another, depending on the exposure period to the radiation [28]. Fig 45 shows that the relationship between the concentration of radon and the annual effective dose is linearity because when the radon concentration is increased, the annual effective dose is also increased. From the obtained results, the radon concentration in urine samples was above than the global permissibility limiting of exposure to radon (200 Bq/m³). In general, radon gas has more effects than another radiation. This is due to the fact that the former has the ability to produce biological damage more than any other radiation by a factor of 100 times [29]. In addition, radon has high LET

values and it gives alpha when the body absorbs it by inhalation and ingestion. The average annual effective dose in the studied samples was about 35.77 mSv/y¹, and this is quite above the range of 3–10 mSv/y¹ that reported by the ICRP [30]. Therefore, there is evidence of health problem and the human urine is safe. The average annual effective dose intake no corresponds to a very large component of the total effective dose from natural sources (2.4 mSv/y¹) [31]. As a result, there is evidence of health problems in this case as well. EPA noted that the radon levels were large than 4 pci/L and still pose a health. Risk but can be reduced [32]. However, the concentration of radon in our samples is very large than this value. The EPA has suggested that the immediate intervention is required [33].

Table 2. It shows Radon gas concentrations in cancer patients Breasts' uranium concentration, radioactivity of radon and effective annual dose (AED) of radon concentration in urine samples with cancer patient Breasts

Symbols	Age	The number of chemical doses	Type of injury	C _{Rn} (Bq/m ³) RAD7	CR _n (Bq/m ³) CR-39	Cu (ppm)	AED(mSv/y)	A _{RN} (Bq)
R3	45	3	Breasts	2230	1916	2.166	56.26	0.064
R4	70	2	Breasts	1620	1588	1.55	40.87	0.046
R5	54	2	Breasts	1220	1490	1.18	30.77	0.035
R6	50	6	Breasts	2240	1475	2.166	56.51	0.064
R7	50	8	Breasts	2630	2156	2.53	66.35	0.075
R8	45	10	Breasts	1220	1277	1.18	30.77	0.035
R9	65	4	Breasts	1220	1610	1.18	30.77	0.035
R10	80	2	Breasts	406	425	3.85	10.24	0.011
R11	38	3	Breasts	1610	1405	1.55	40.61	0.046
R13	40	3	Breasts	1820	1677	1.75	45.91	0.052
R16	40	8	Breasts	1010	1086	9.77	25.48	0.029
R18	42	2	Breasts	1010	1045	9.77	25.48	0.029
R20	70	2	Breasts	1220	1198	1.18	30.77	0.035
R22	46	4	Breasts	606	613	5.69	15.28	0.017
R23	47	3	Breasts	811	606	7.75	20.46	0.023
R24	52	2	Breasts	2020	1073	1.95	50.96	0.058
R25	37	1	Breasts	1620	1820	1.55	40.87	0.046
R26	49	1	Breasts	809	766	7.75	20.41	0.023
R27	55	2	Breasts	1420	1405	1.35	35.82	0.040
R30	32	2	Breasts	2830	2204	2.73	71.39	0.081
R38	52	16	Breasts	2430	2555	2.33	61.30	0.069
R39	37	6	Breasts	1220	1259	1.18	30.77	0.035
R42	52	2	Breasts	2020	2026	1.95	50.96	0.058
R43	77	3	Breasts	807	605	7.78	20.35	0.023
R46	42	3	Breasts	1010	1022	9.76	25.48	0.029
R52	50	2	Breasts	1210	1235	1.14	30.52	0.034
R53	42	8	Breasts	608	602	5.87	15.33	0.017
R54	75	10	Breasts	2830	2453	2.73	71.39	0.081
R55	65	4	Breasts	1420	1469	1.35	35.82	0.040
R56	46	3	Breasts	1410	1054	1.35	35.57	0.040
R57	45	4	Breasts	1010	1064	9.76	25.48	0.029
R58	60	2	Breasts	1420	1437	1.35	35.82	0.040
R59	50	8	Breasts	1010	940	9.76	25.48	0.029
R60	51	8	Breasts	807	926	7.75	20.35	0.023

Table 3. It shows Radon gas concentrations in cancer patients Breasts' uranium concentration, radioactivity of radon and effective annual dose (AED) of radon concentration in urine samples with cancer patient Bladder

Symbols	Age	The number of chemical doses	Type of injury	C _{Rn} (Bq/m ³) Rad7	C _{Rn} (Bq/m ³) CR-39	C _u (ppm)	AED(mSv/y)	A _{RN} (Bq)
R1	65	3	Bladder	1210	1198	4.00	30.52	0.034
R2	61	6	Bladder	1220	1192	1.18	30.77	0.035
R21	46	1	Bladder	1410	1437	1.36	35.57	0.040
R31	65	8	Bladder	1820	1725	1.75	45.91	0.052

Table 4. It shows Radon gas concentrations in cancer patients Breasts' uranium concentration, radioactivity of radon and effective annual dose (AED) of radon concentration in urine samples with cancer patient Uterine

Symbols	age	The number of chemical doses	Type of injury	C _{Rn} (Bq/m ³)	C _{Rn} (Bq/m ³) CR-39	C _u (ppm)	AED(mSv/y)	A _{RN} (Bq)
R12	36	2	Uterine	1220	1150	1.18	30.77	0.035
R19	50	1	Uterine	404	438	3.67	10.19	0.011
R34	61	10	Uterine	3060	3066	2.97	77.20	0.088
R35	50	3	Uterine	1210	1118	1.14	30.52	0.034
R49	47	6	Uterine	1430	1045	1.38	36.07	0.041
R50	52	3	Uterine	1420	1490	1.35	35.82	0.040

Table 5. It shows Radon gas concentrations in cancer patients Breasts' uranium concentration, radioactivity of radon and effective annual dose (AED) of radon concentration in urine samples with cancer patient kidney

Symbols	age	The number of chemical doses	Type of injury	C _{Rn} (Bq/m ³)	C _{Rn} (Bq/m ³) CR-39	C _u (ppm)	AED(mSv/y)	A _{RN} (Bq)
R29	63	6	kidney	2030	2108	1.95	50.21	0.058
R36	54	1	kidney	2020	1916	1.95	50.96	0.058
R40	53	3	kidney	1620	1277	1.55	40.87	0.046
R41	42	2	kidney	1220	1226	1.17	30.77	0.035
R47	53	1	kidney	1210	1107	1.14	30.52	0.034
R51	47	2	kidney	1620	1485	1.55	40.87	0.046

Table 6. It shows Radon gas concentrations in cancer patients Breasts' uranium concentration, radioactivity of radon and effective annual dose (AED) of radon concentration in urine samples with cancer patient Lung

Symbols	age	The number of chemical doses	Type of injury	C _{Rn} (Bq/m ³)	C _{Rn} (Bq/m ³) CR-39	C _u (ppm)	AED(mSv/y)	A _{RN} (Bq)
R33	41	3	Lung	2030	2060	1.95	51.21	0.058
R44	50	2	Lung	809	718	7.78	20.41	0.023
R45	50	6	Lung	1010	821	9.76	25.48	0.029
R48	60	2	Lung	406	638	3.67	10.24	0.011

Table 7. It shows Radon gas concentrations in cancer patients Breasts' uranium concentration, radioactivity of radon and effective annual dose (AED) of radon concentration in urine samples with cancer patient Laryngeal

Symbols	age	The number of chemical doses	Type of injury	C _{Rn} (Bq/m ³)	C _{Rn} (Bq/m ³) CR-39	C _u (ppm)	AED(mSv/y)	A _{RN} (Bq)
R14	35	1	Laryngeal	811	460	7.75	10.46	0.023
R17	22	3	Laryngeal	1410	1533	1.36	35.57	0.040

Table 8. It shows Radon gas concentrations in cancer patients Breasts' uranium concentration, radioactivity of radon and effective annual dose (AED) of radon concentration in urine samples with cancer patient (pancreatic, stomach, colon, spleen)

Symbols	age	The number of chemical doses	Type of injury	C _{Rn} (Bq/m ³) Rad7	C _{Rn} (Bq/m ³) CR-39	C _u (ppm)	AED(mSv/y)	A _{RN} (Bq)
R15	66	2	pancreatic	2430	2407	2.33	61.30	0.069
R28	62	8	stomach	1820	1752	1.75	45.91	0.052
R32	63	2	colon	3240	2990	3.14	81.74	0.093
R37	24	2	spleen	2650	2409	2.56	66.85	0.076

Conclusion

The tables and figure obtained concentrations of radon recorded by. Using Rad-7 and CR-39 all values of the concentrations was Highest than the acceptable levels that recorded by (ICRP, 2009), so concluded that these results were higher than the accepted levels due to type of injury cancer, age and the number of chemical doses. Results obtained show that radon concentration in samples urine of female cancer patient group is higher. The results are this study indicates to the health risk assessments by showing association between radon concentration in urine and cancer.

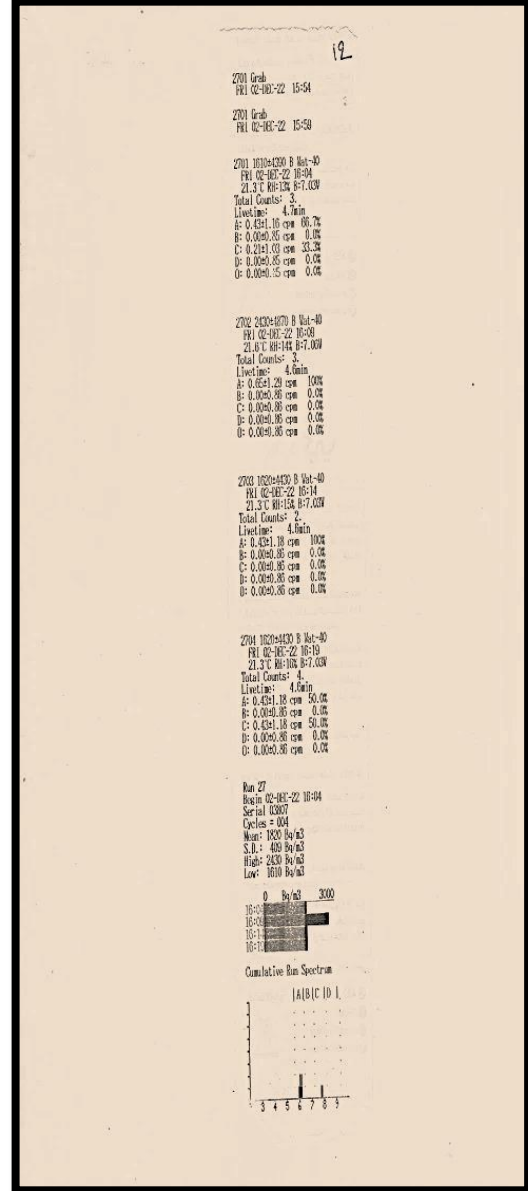
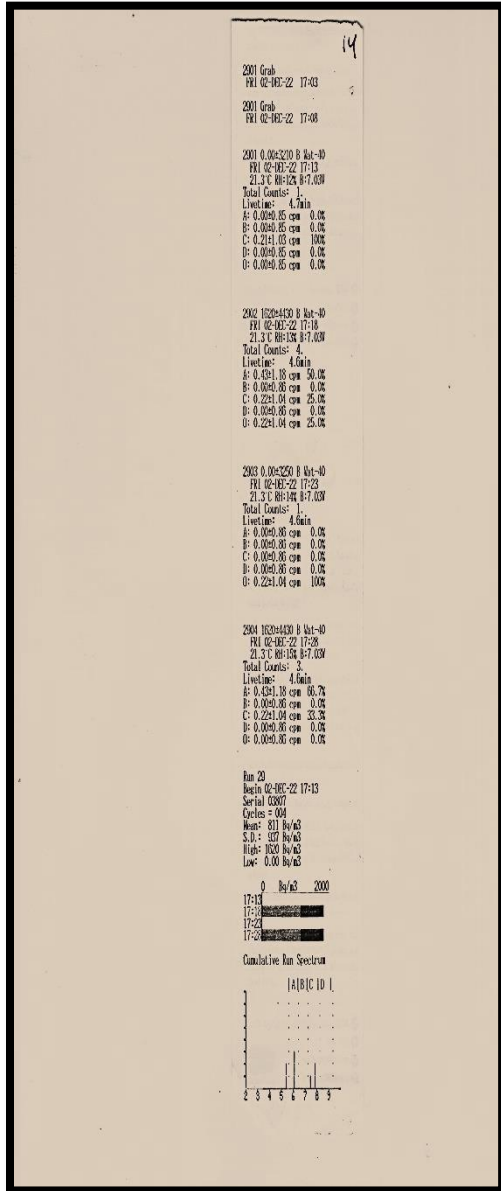
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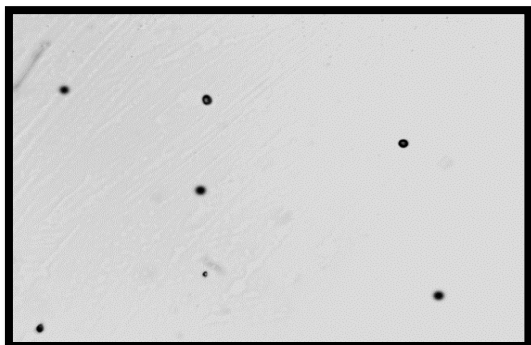
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Appendix

Fig (46): Radon concentration in urine samples measured by Rad7 in Bq/m³ unit



R₃₂



R₁₉

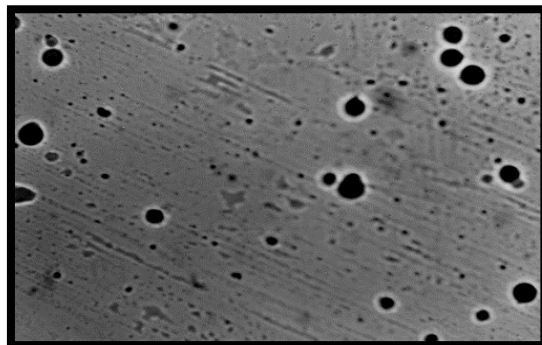


Fig (47): Type of Track of alpha particle on CR-39 detector different samp

