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# Radon Concentrations and Annual Effective Dose in Cigarette Samples (Domestic and Importer) At the Iraqi Markets

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**Abstract:** In present work, radon gas concentrations were measured for (48) samples of cigarette that it was collected from market of Iraq, using plastic nuclear track detectors CR-39.The annual effective dose from use of these cigarette were determined. The results show that, Radon concentration ranges from (0.868 to 624.576) Bq/m$^3$ with average value (123.375) Bq/m$^3$ .The radon concentrations emerged from most investigated samples was significantly higher than the background level.
**Keywords:** Radon gas, tobacco leave, cigarette, CR-39 detector and Iraqi markets.

## 1 Introduction

Tobacco is an agricultural product processed from fresh leaves of plants in the genus Nicotania. It contains minute quantities of radioactive isotopes that pose a radiation exposure hazard to those who intentionally or passively inhale it. Smokers inhale the Polonium (a radioactive component of Tobacco), which settles in "hot spots" in the lungs and can cause cancer. This is because, $^{210}$Po emits alpha particles upon its decay and this radiation has a very destructive effect on tissues because virtually all of its very high ionizing energy is expended within the tissue. Due to its double positive charge, limited range in tissue and enormously high energy, an alpha particle can produce huge numbers of ion pairs in substances with which it interacts [1].Tobacco fields and plants also have the higher concentration of Uranium and consequently large contents of $^{210}$Po and $^{210}$Pb belonging to Uranium and radium decay series. These radio-nuclides have long association with tobacco plants. $^{210}$Pb and $^{210}$Po, decay products of the Uranium series get dissolved in water and are first transported to plants and subsequently to the human being. Also, the uptake of radionuclides into roots from the soils and phosphate fertilizers along with direct deposition of $^{210}$Pb by rainfall represents the principal mechanism of incorporation of $^{210}$Pb and $^{210}$Po into the tobacco plants. This phenomenon may cause high intake of Uranium and its radioactive decay products leading to harmful effects in human being [2].Radon-222 is one of many decay products of Uranium. Uranium occurs naturally in soil but in much Higher, concentration in phosphate rock from which fertilizer is made. There are two pathways leading from Uranium to Polonium in tobacco: through the air and through the roots [3].The plants roots are naturally related to microorganisms, and these associations can have direct or indirect impacts on the mobility, availability and acquisition of elements by plants [4-7]. The radiological effect of the uses of fertilizers in soil is due to the internal irradiation of the respiratory organ by the alpha particles, short lived radon-thoron progeny and the external irradiation of the body by gamma rays emitted from the radionuclides. Radon is carcinogenic to humans and responsible for main natural radiation exposure to human being [8-11].Many studies worldwide have measured the radon concentrations in tobacco cigarette samples to ascertain the levels of contamination [12-15].
The aim of the present work is to measure the radon gas levels in different types of cigarette are available in Iraq markets using nuclear track CR-39 detector.

## 2 Experimental Section

### *2.1 Collection of the Samples*

Forty eight types of cigarette (domestic and importer) are collected from market of Iraq. We divided these samples into 13 groups according to the producing country as shown in Table (1).

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**Table 1:** Show cigarette Samples according to the producing country.

| No. | Group | Samples Names | Samples Code | Origin |
|---|---|---|---|---|
| 1 | G1 | Nicepen | T1 | UAE |
| 2 | | Place | T2 | UAE |
| 3 | | Pylon | T3 | UAE |
| 4 | | Veteran | T4 | UAE |
| 5 | | MOND | T5 | UAE |
| 6 | | AFFIR | T6 | UAE |
| 7 | | BON | T7 | UAE |
| 8 | | BOSS | T8 | UAE |
| 9 | | CARAVAN | T9 | UAE |
| 10 | | HATAMEN | T10 | UAE |
| 11 | | MURAD | T11 | UAE |
| 12 | | DZIRE | T12 | UAE |
| 13 | | MASTER | T13 | UAE |
| 14 | G2 | BENTLY | T14 | HKJ |
| 15 | | VICEROY | T15 | HKJ |
| 16 | | MIKADO | T16 | HKJ |
| 17 | | BLOWRED | T17 | HKJ |
| 18 | | FIVE STARS | T18 | HKJ |
| 19 | | ROYAL FIVE | T19 | HKJ |
| 20 | G3 | KENT | T20 | GERMANY |
| 21 | | L8M | T21 | GERMANY |
| 22 | | ELEGANCE | T22 | GERMANY |
| 23 | | ASHFORD | T23 | GERMANY |
| 24 | | GOLDSEAL | T24 | GERMANY |
| 25 | G4 | FISHER | T25 | USA |
| 26 | | MIDLOND | T26 | USA |
| 27 | | GHAMDAN | T27 | USA |
| 28 | | MIAMI | T28 | USA |
| 29 | G5 | ASPEN | T29 | ENGLAND |
| 30 | | BUSINESS | T30 | ENGLAND |
| 31 | | MAIWAND5 | T31 | ENGLAND |
| 32 | G6 | ESSE | T32 | KOREA |
| 33 | | PINE | T33 | KOREA |
| 34 | | GLORY | T34 | KOREA |
| 35 | G7 | SUMER | T35 | IRAQ |
| 36 | | IRAQ | T36 | IRAQ |
| 37 | G8 | BRILIANT | T37 | FRANCE |
| 38 | | PLATIEN | T38 | FRANCE |
| 39 | G9 | NAPOLI(SIV) | T39 | ITALY |
| 40 | | NAPOLI(RED) | T40 | ITALY |
| 41 | G10 | MM | T41 | BULGARIA |
| 42 | | PRESTTEGE | T42 | BULGARIA |
| 43 | G11 | CRAVEN | T43 | TURKEY |
| 44 | | LUCKYSTRIKE | T44 | TURKEY |
| 45 | G12 | GOULOISES | T45 | EUROPEAN |
| 46 | | OMEGA | T46 | EUROPEAN |
| 47 | G13 | ROSEMAN | T47 | EGYPT |
| 48 | | GOLDN (N) | T48 | EGYPT |

## *2.2 Preparation of the Samples*

Tobacco of cigarette samples have been dried, ground homogenization and sieved. The samples are dried before radon concentrations measurement for (2-4) days at a temperature of (42-44) $^{o}$C to avoid any humidity adsorption, and to maintain the actual weight. The dried tobacco was having been ground and milled using a blender to obtain equal size particles. Later, equal weight (8) g of each sample under study (using a high sensitive digital weighting balance with a percent of ±0.01%). Then the samples have been kept in the containers. Then have been put in to the one container technique. A CR-39 SSNTD with a thickness of (1) mm and a density of (1.31) g.cm$^{-3}$ has been used in this study. The containers are covered with a thin membrane, which separates radon from dust and other types of radiation, by permitting diffusion of radon into the container. We coded each sample into a specific code in order to distinguish between it. The containers have been left at room temperature for (48) days exposure time.

## *2.3 Sample Container*

These containers of 6 cm mouth diameter, (4) cm bottom diameter and (7) cm height are made of polypropylene, to enhance electrical conductivity and to avoid the problem of electrostatic charge and is an impermeable with a tight container to prevent the escape of radiogenic gases (Radon). The SSNTD (CR-39) is cut into (2) cm$^2$ piece. A piece of (CR-39) detector was fixed at the top of the container shown in Figure (1).

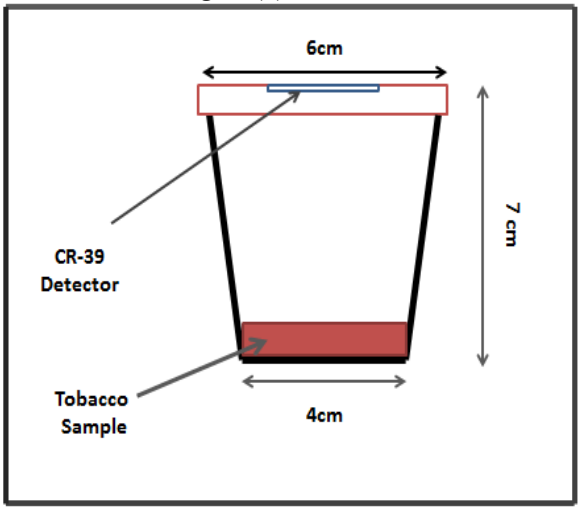


**Fig.1:** Sample container.

## *2.4 Chemical Etching*

CR-39 detector is etchedof sodium hydroxide (NaOH) solution at (70) $^{o}$C temperature for (5) hours, solution of (6.25) normality which is prepared by dissolving (100) gm of (NaOH) in (0.4) liter of distilled water [16]. After preparing the etching solution, it is kept for (24) hours until it becomes homogeneous. During this time the detectors are carefully removed from the plastic containers and as possible, taking care of keeping the surface of the detectors clean from scratches. At last the detectors have been

removed from the solution and extensively washed by distilled water, and dried by soft tissue papers.

### *2.5 Track Observation and Counting*

The TASLIMAGE system is designed for both easy use in routine neutron and radon dosimetry and as a more flexible research analysis system shown in Figure (2).
The unique feature of the system is our TASLIMAGE software, developed by TASL. The software scans the plastic at a higher magnification than many other etched track readers, providing a better quality of track image for processing and better discrimination between tracks and background features.
The key features of TASLIMAGE are:

- Fully automatic scanning of dot-codes and etched tracks.
- Fully automatic focus by software.
- Highly sophisticated image analysis techniques to discriminate between etched tracks and background features.
- Automatic background assessment of each detector.
- Complete detector readout takes between 30 and 60 seconds depending on user selectable options.
- The scan data is automatically converted to dose, and the results are displayed immediately in the record-keeping database provided as part of the **TASL*IMAGE*** software. The data can also be exported to other programs such as Excel [17]

.

**Fig.2:** TASL*IMAGE* System.

### *2.6 Calculations*

The track density (ρ) recorded on the detector, attenuation factor of $^{222}$Rn, (k) is the calibration coefficient of measuring system in terms of (0.0324 Track cm$^{-2}$ day$^{-1}$/Bq.m$^{-3}$)[11] and the exposure time (t) were applied to determine the$^{222}$Rn concentration (C) from the relation [18-19]:

$$C = \frac{\rho}{K\,t} \qquad (1)$$

The annual effective dose equivalent, D (in units of mSv.y$^{-1}$)is computed from the integrated $^{222}$Rn concentration using the following formula [18-19]:

$$\boldsymbol{D}=\frac{0.4\times C\times 3.88\times 7000}{3700\times 170} \qquad (2)$$

Where C is the integrated $^{222}$Rn concentration in Bq/m, 0.4 is the equilibrium factor, 3.88 mSv.WL/M is the ICRP conversion factor [20].

## 3 Results and Discussion

Radon concentrations ranges from (0.868 to 624.576) Bq/m$^3$ with average value (123.3754) Bq/m$^3$.Whereas highest value has been recorded in sample (T9) which is made in UAE, while lowest value has been recorded in (T8) which is made in UAE as shown in Table (2) and in Figure (3). Also from Table (2), it can be noticed that, the annual effective dose (D) in all samples of tobacco were varied from (0.01mSv /y) to (10.79mSv/y) with an average value of (2.13mSv/y).

Table (3) and Figure (4) show average radon concentrations in tobacco samples for (13) groups, the highest value of radon concentration has been found in G2 which is made in HKJ (Hashemite Kingdom of Jordan) and lowest value of radon concentration has been found in G7 which is made Iraq.

In all the for 48 samples different cigarette in Iraqi market surveyed in the present work, the annual effective dose is less than even the lower limit of the recommended range (3-10 mSv/y) (ICRP, 1993) [21]. Finally, we can say that all the results obtained in this study are less than the results obtained by some researchers earlier study conducted on some of the samples tobaccos used in the Iraqi mark and other countries [22].

## 4 Conclusions

The results of this study indicate the existence of a wide range of variations in radon contents of cigarette consumed in the Iraqi markets. Based on the results obtained from this study the concentrations of $^{222}$Rn in 48 cigarette samples showed that the highest value of radon concentration appears in HKJ (Hashemite Kingdom of Jordan) cigarette and lowest value of radon concentration appears in Iraqi tobaccos. Annual effective doses due to radon from the inhalation of various cigarette smokers are less than even the lower limit of the recommended by ICRP1993.

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**Table 2:** Radon concentrations and annual effective dose in cigarette samples.

| No. | Groups | Samples Codes | C ( Bq/m$^3$) | D (mSv/y) |
|---|---|---|---|---|
| 1 | G1 | T1 | 32.99 | 0.57 |
| 2 | | T2 | 25.17 | 0.43 |
| 3 | | T3 | 140.63 | 2.43 |
| 4 | | T4 | 28.19 | 0.49 |
| 5 | | T5 | 42.53 | 0.73 |
| 6 | | T6 | 118.14 | 2.04 |
| 7 | | T7 | 189.24 | 3.27 |
| 8 | | T8 | 0.87 | 0.01 |
| 9 | | T9 | 624.58 | 10.79 |
| 10 | | T10 | 143.26 | 2.47 |
| 11 | | T11 | 72.05 | 1.24 |
| 12 | | T12 | 23.44 | 0.40 |
| 13 | | T13 | 135.42 | 2.34 |
| 14 | G2 | T14 | 290.80 | 5.02 |
| 15 | | T15 | 609.38 | 10.53 |
| 16 | | T16 | 12.15 | 0.21 |
| 17 | | T17 | 136.28 | 2.35 |
| 18 | | T18 | 40.80 | 0.70 |
| 19 | | T19 | 314.24 | 5.43 |
| 20 | G3 | T20 | 206.73 | 3.57 |
| 21 | | T21 | 169.27 | 2.92 |
| 22 | | T22 | 159.72 | 2.76 |
| 23 | | T23 | 59.90 | 1.03 |
| 24 | | T24 | 20.23 | 0.35 |
| 25 | G4 | T25 | 175.56 | 3.03 |
| 26 | | T26 | 209.24 | 3.61 |
| 27 | | T27 | 224.83 | 3.88 |
| 28 | | T28 | 155.38 | 2.68 |
| 29 | G5 | T29 | 158.85 | 2.74 |
| 30 | | T30 | 167.19 | 2.89 |
| 31 | | T31 | 46.01 | 0.79 |
| 32 | G6 | T32 | 20.18 | 0.35 |
| 33 | | T33 | 27.78 | 0.48 |
| 34 | | T34 | 41.67 | 0.72 |
| 35 | G7 | T35 | 24.31 | 0.42 |
| 36 | | T36 | 13.02 | 0.22 |
| 37 | G8 | T37 | 20.83 | 0.36 |
| 38 | | T38 | 148.44 | 2.56 |
| 39 | G9 | T39 | 122.02 | 2.11 |
| 40 | | T40 | 154.96 | 2.68 |
| 41 | G10 | T41 | 308.16 | 5.32 |
| 42 | | T42 | 24.31 | 0.42 |
| 43 | G11 | T43 | 27.24 | 0.47 |
| 44 | | T44 | 94.62 | 1.63 |
| 45 | G12 | T45 | 54.69 | 0.94 |
| 46 | | T46 | 55.56 | 0.96 |
| 47 | G13 | T47 | 50.35 | 0.87 |
| 48 | | T48 | 0.88 | 0.01 |
| **Average** | | | **123.38** | **2.13** |

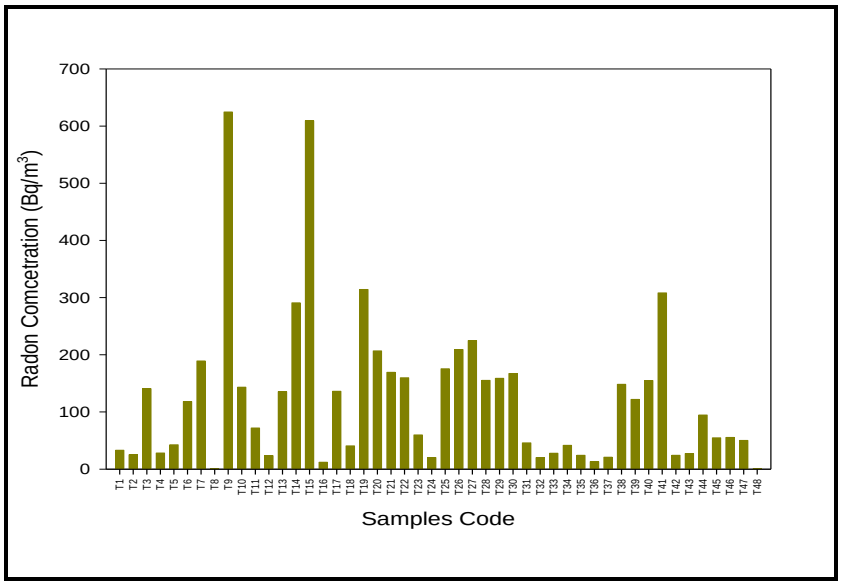


**Fig. 3:** Radon Concentrations of cigarette Samples.

**Table 3:** Average radon concentration of cigarette samples in all groups.

| No. | Groups | Average Radon Concentration (Bq/m$^3$). |
|---|---|---|
| 1 | G1 | 121.268 |
| 2 | G2 | 233.940 |
| 3 | G3 | 123.169 |
| 4 | G4 | 191.251 |
| 5 | G5 | 124.017 |
| 6 | G6 | 29.873 |
| 7 | G7 | 18.662 |
| 8 | G8 | 84.635 |
| 9 | G9 | 138.491 |
| 10 | G10 | 166.232 |
| 11 | G11 | 60.928 |
| 12 | G12 | 55.121 |
| 13 | G13 | 25.607 |

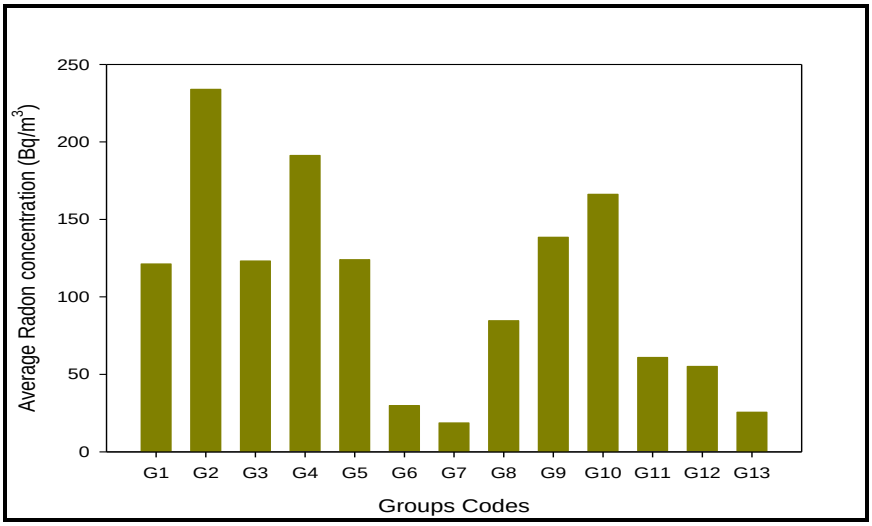


**Fig. 4:** Represented average radon concentrations in cigarette samples in all groups.

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