

## Determination of radon concentration in the imported tea in Al-Diwaniyah Governorate markets, Iraq using nuclear track detector LR-115

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### ABSTRACT

Radon concentration was determined in eleven different imported samples of tea that commonly use, collected from Al-Diwaniyah Governorate local markets in Iraq, using the SSNTD RL-115 detector. The results showed that the radon concentration differed in different tea types based on the origin of the tea trademark, where Cihan tea exhibited the highest radon concentration of  $55.53 \text{ Bq m}^{-3}$ , while Balabel tea displayed the lowest value of  $21.65 \text{ Bq m}^{-3}$ . These results indicate that radon concentrations were within safe limits for the consumer compared to the limits set by the (ICRP)  $200 \text{ Bq m}^{-3}$ . This study will contribute to covering radiation studies on tea due to the proliferation of trademarks and insufficient studies on it.

**Keywords:** Radon concentration, SSNTD RL-115 detector, Al-Diwaniyah Governorate, Tea.

**Article type:** Research Article.

### INTRODUCTION

Radiation is found around us in our environment. It is either natural or man-made used for various reasons. Therefore, we receive different levels of radiation doses that affect the cells of the organism and DNA, which will cause mutations and changes in the embryos. This radiation is transmitted to humans in different ways including water and food through soil (Tykva & Berg 2004; Mansour Bahmany *et al.* 2018; Cannon & Kiang 2022). The progress of transmission of radioactive pollutants to humans increases when the food chain is further contaminated. The various substances surrounding the human being, as well as food and water, contain a reduced dose of breathable air. These sources may be the basic origins of the natural radioactive dose which affects the persons. Hence, the body can be contaminated with these materials by the organism cells, which absorb the radioactive materials and drinking water as well (Shahbazi Gahrouei *et al.* 2013). About 50% of people's natural exposure is from radon gas, which is the main cause of lung and gastrointestinal cancers when a person is exposed to it through inhalation and digestion. Then it can reach other body tissues, exposing the internal organs to radiation. It is believed that radon intake increases the risk of stomach cancer (Shahbazi Gahrouei 2013; Appleton 2013), once it is after radon enters the human body, emits alpha particles, and then turns into radioactive polonium, which emits alpha particles and then turns into lead (Oudah & Al Hamzawi 2020). The local radiation studies on tea are not enough, because it is a food that is widely consumed by people. Also the presence of many trademarks in the markets. So, the number of local studies on selected trademarks and others must be increased. There are some of the local and international studies on radon concentrations in tea, for example, Battawy *et al.* (Battawy *et al.* 2016) and Poursharif *et al.* (Poursharif *et al.* 2015), followed by other studies in the same context on medicinal herbs, coffee, and milk like Al-Sawaf *et al.* (Al Sawaf *et al.* 2009), Al-Goubory (Al Goubory 1999), and Aswood *et al.* (Aswood 2009). In the case of tea studies, according to the research mentioned in (Aswood 2009), radon-222 in imported tea samples measured by the LR-115 detector ranged between  $40 \text{ Bq m}^{-3}$  and  $220 \text{ Bq m}^{-3}$ . In this

study, we will calculate the radon gas concentrations in canned tea available in the markets by using LR-115 detector.

### MATERIALS AND METHODS

Eleven samples of tea were prepared by exposing them for 60 days to the LR-115 detector with dimensions  $1 \times 1$  cm<sup>2</sup> and a thickness of 200  $\mu$ m. The tea brands were as follows: Al-Barari, Al-Tuffahetein, Lipton, Cihan, Green apple tea, Black tea, Aleasl tea, Al-Otuor, Lipton green, Ceylon, and Balabel. One of the techniques for examining the traces of alpha particles as they pass through the detector and are released from the radon gas in the sample is the long-term measurement technique, the LR-115 detector was classified among them. The tea samples were placed in the cylindrical irradiation tube (Fig. 1). After drying the samples and grinding them into a fine powder to ensure the uniform separation and distribution of all components, then 5 g was taken.

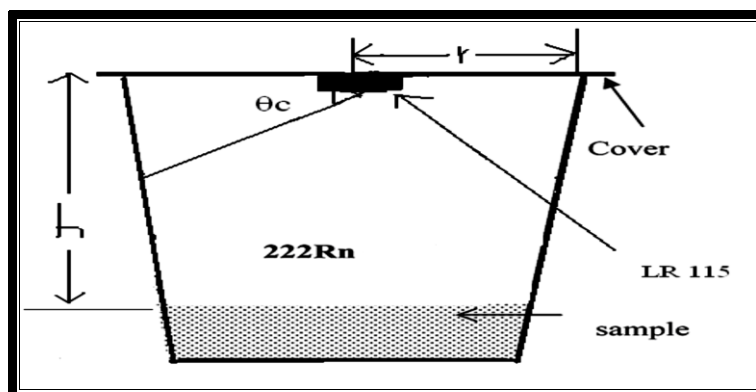


Fig. 1. LR-115 detector with the sample in the container.

All chambers were closed well for a period of time and left to obtain a secular equilibrium. This period amounted to 22 days. Afterward, the chamber covers were replaced with others for the prevention of radon gas leakage from the samples. Then the detector was placed under the new covers and closed again. Hence, the space left between the sample and the LR-115 was 9.5 cm, preventing the thoron from getting inside. Detector pieces were lifted from the irradiation chamber after 60 days and chemically treated to show traces of alpha particles. This process was performed with NaOH aqueous solution (6.25 N) at  $60 \pm 1$  °C. In the case of the radiation background for the same period (60 days), it was measured using the same irradiation chamber. However, without a sample, Alpha-Tracks in RL- 115 could be counted in units of tracks per cm<sup>2</sup> using the optical microscope (type Motic, Malaysia) with 400 X magnification (Fig. 2).



Fig. 2. Optical microscope and etched tracks in RL- 115 in Cihan tea.

### Calculations

The K factor has an important role in calculating the radon gas concentration. The K factor also participates in the number of paths equation (Obayes & Oudah 2022):

$$C_a = \frac{\rho}{K T} \quad (1)$$

where  $\rho$  track density (Tr/cm<sup>2</sup>) which can be calculated by [11]:

$$\rho = \frac{\text{No. of track}}{\text{Area}}$$

where  $C_a$  ( $\text{Bq cm}^{-3}$ ) is radon concentration inside the cylindrical tube air space, and  $T$  is irradiation time (s). During the irradiation process importance of the  $K$  calibration factor emerge, its value depends on the design of the detector chamber.  $D$  is the track density rate represented by (Al Mashhadani *et al.* 2020):

$$(Tr \text{ cm}^{-2} \text{ s}^{-1}) = K C_a \quad (2)$$

Noteworthy, the geometry of the chamber affects the value of  $K$ , so its value for the U-shaped cylinder is (Barillon *et al.* 1993):

$$K = \frac{1}{4} r \left( 2 \times \cos \theta_c - \left( \frac{r}{R\alpha} \right) \right) \quad (3)$$

where  $r$  is the radius of the container equal to 2.11 cm.  $\theta_c$  of the LR-115 is the angle that determines the existence of traces. If  $(\theta)$  is the angle between the etched tracks and the detector surface less than the critical angle  $\theta_c$ , the traces do not appear unless the vertical component of the etching rate on the detector surface is greater than the general etching rate. The critical angle took for LR-115 to be  $25^\circ$ . By substituting the above values for the parameters in Eq. 3, taking into account that  $R\alpha$  is the range of the alpha particle equals 4.15 cm, the  $K$  for the cylindrical tube is  $0.687 \text{ Track cm}^{-2}/(\text{Bq m}^{-3}) \cdot \text{day}$ , then the value of the rate of track density is:

$$D_{Rn} = \frac{1}{4} C_a r \left( 2 \times \cos \theta_c - \left( \frac{r}{R\alpha} \right) \right) \quad (4)$$

Through Eq. 4, the radon concentration in the air space can be calculated inside the cylindrical chamber, and then the radon concentration content within the samples can be calculated in the studied samples as in Eq. 5 (Al Mashhadani *et al.* 2020):

$$C_s = \lambda_{Rn} C_a ht/L \quad (5)$$

$\lambda_{Rn}$  is the radon decay constant in the unit of  $\text{day}^{-1}$  equal to 0.1814;  $h$  is the space amidst the face of the sample and the detector's roofless surface, which equals to 9.5 cm.  $L$ : The layer thickness of the sample (1.7 cm),  $t$ : the period of exposure, which equals to 60 days.

### Calibration Curve for the standard sample

To obtain the calibration curve for radon gas in the studied samples, standard samples of radon gas with different concentrations should be prepared (20-150  $\text{Bq m}^{-3}$ ) provided by the International Atomic Energy Agency IAEA, with the use of the RL- 115 detector to detect traces of alpha particles in the standard samples. Fig. 3 illustrates the calibration curve of radon gas in the studied samples by comparing it with the intensity of traces calculated on the RL- 115 detector with the standard samples. From the regression equation of  $y = 6.0296X$ ,  $R^2 = 0.9974$ , a linear calibration was observed (Fig. 3). Then we calculated the regression factor, the results were tested as  $\text{Bq m}^{-3}$ .

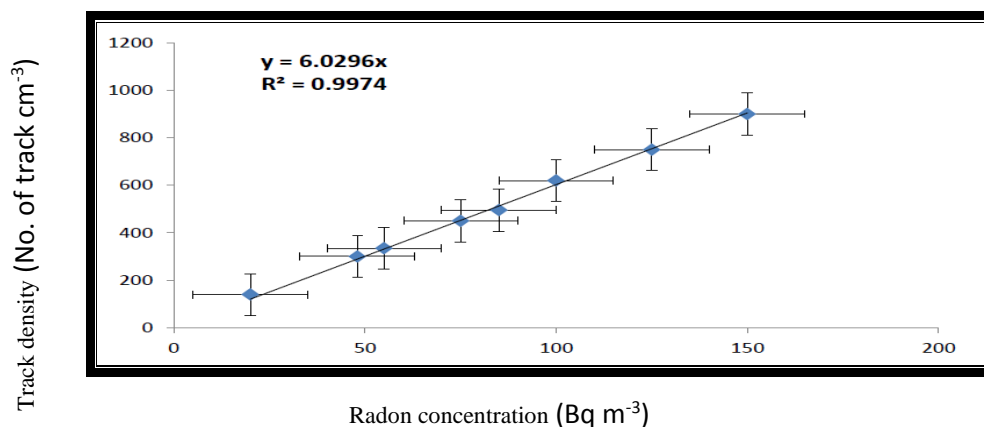


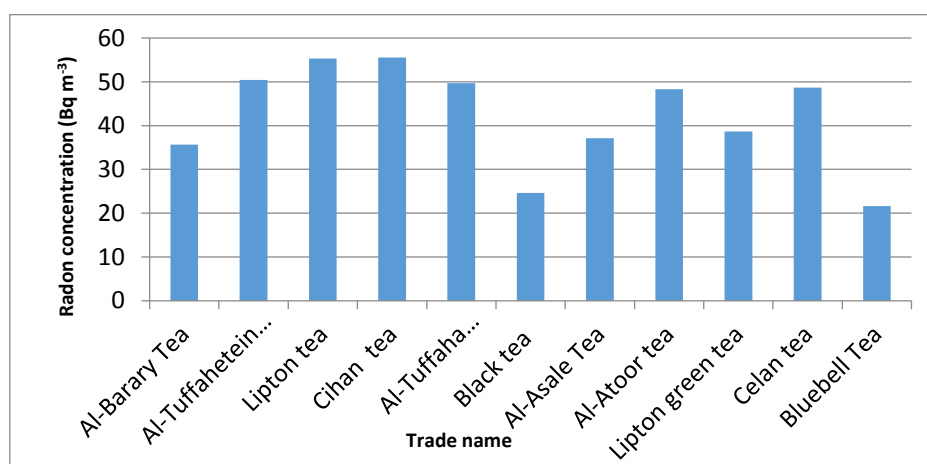
Fig. 3. The track density and radon concentration of standard samples.

## RESULTS AND DISCUSSION

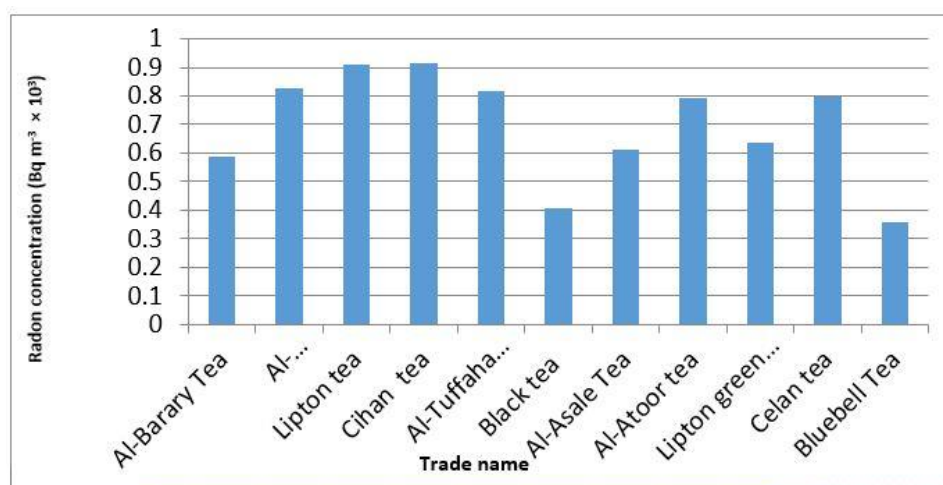
Table 1 and Figs. 4-5 illustrate the trade names of samples, in addition to the radon concentration values inside the detector space and inside the samples. Therefore, the radon level in the samples ranged between 21.65 and 55.53  $\text{Bq m}^{-3}$ , while in the chamber ranged between 0.356 and  $0.913 \times 10^3 \text{ Bq m}^{-3}$ . Bilabil tea (S11) recorded the lowest calculated values, while the highest value in Cihan tea (S4). However, it remained below the permissible range from ICRP which is  $200 \text{ Bq m}^{-3}$  (ICRP 1993).

**Table 1.** Radon concentrations inside the chamber space and the samples.

NO	Trade name	Tracks density (tracks/cm <sup>2</sup> )	Sample thickness (L/cm)	C <sub>a</sub> (Bq m <sup>-3</sup> × 10 <sup>3</sup> )	C <sub>s</sub> (Bq m <sup>-3</sup> )
S1	Barari	870	1.7	0.586	35.64
S2	Al-Tuffahetein	1181	1.7	0.829	50.42
S3	Lipton tea	1198	1.7	0.91	55.34
S4	Cihan tea	1342	1.7	0.913	55.53
S5	Green apple	1084	1.7	0.817	49.69
S6	Black tea	582	1.7	0.405	24.63
S7	Alasal tea	769	1.7	0.61	37.10
S8	Al-Otuor tea	1020	1.7	0.794	48.29
S9	Lipton green	917	1.7	0.636	38.68
S10	Ceylon tea	1050	1.7	0.8	48.65
S11	Balabel tea	590	1.7	0.356	21.65



**Fig. 4.** Radon concentration in samples ( $\text{Bq m}^{-3}$ ).



**Fig. 5.** Radon concentrations ( $\text{Bq m}^{-3}$ ) inside the chamber space.

## CONCLUSION

This study indicates that the radon concentrations are diverse with different kinds of tea based on the origin of the canned samples. also, the measured radon levels are within safe limits for the concentrations of radionuclides naturally present in tea, these concentrations were below the level of 200 Bq/ m<sup>3</sup> as recommended by the ICRP, and using these samples will not pose any threat to human safety.

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