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Measurement of Radon Gas Concentration in Imported Original and Counterfeit Cosmetic Powders in Iraq Using Irradiation Chambers and Solid-State Nuclear Track Detectors CR-39

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Abstract− In the uranium-238 decay sequence, radium-226 decays to generate radon-222, an inert radioactive gas, contributes significantly to natural background radiation. Its alpha emissions are a primary cause of lung cancer, second only to smoking. Although radon studies primarily focus on indoor air, food, and water, cosmetic powders, especially those with mineral-based raw materials, may contain naturally occurring radioactive materials (NORM), posing a potential health risk The purpose of this investigation is to ascertain radon concentrations in imported and counterfeit original cosmetic powders commonly used in Iraq. Samples were exposed for two months in airtight irradiation chambers with solid-state nuclear trace detection chambers (CR-39). The detectors were chemically etched for four hours at 70°C using 6.25 mg of sodium hydroxide. Radon concentrations were computed in Becquerel per cubic meter and alpha particle traces were counted under an optical microscope. This study highlights the need for radiological surveillance in the cosmetics industry, especially for counterfeit items with unregulated manufacture.

Keywords− Radon-222; Cosmetic Powders; Counterfeit Cosmetics; Iraq; CR-39 Detector; Irradiation Chamber; Natural Radioactivity; NORM

I. INTRODUCTION

When uranium-238 decays and creates radium-226, a radioactive gas known as radon-222 is produced. It is colorless and odorless, and because it is radioactive, it presents major health risks. The International Agency for Research on Cancer has classified radon as a Group 1 carcinogen [1], which associates prolonged exposure with an increased risk of lung cancer. The main exposure route is inhalation, however when it comes to cosmetic powders used on the face and body, other routes such dermal absorption and inhalation of resuspended particles are very worrisome.

Whether authentic or fake, cosmetic powders frequently include natural mineral ingredients such mica, talc, zircon, and monazite. Naturally occurring radioactive materials (NORMs) may be present in these minerals [2] discovered that fake cosmetics manufactured from uncontrolled and low-cost raw materials could have higher concentrations of radioactive substances such as thorium and uranium, which raises the possibility of long-term low-dose exposure from regular use.

The cosmetics industry in Iraq is mostly dependent on imports. Concern regarding the possible inclusion of radioactive contamination in these products is developing as a result of increased demand, lax regulatory compliance, and the broad availability of counterfeit goods. In spite of this, there aren't many scientific research in the Iraqi market that explicitly look into radon levels in cosmetic powders.

There is a general exposure risk in the area, as evidenced by recent studies conducted in Iraq that showed higher radon concentrations in a variety of biological and environmental samples, including soil [3] and human urine [4] The accuracy of radiation measurement has increased due to advancements in detection techniques, particularly those that use CR-39 nuclear track detectors [5,6]

Since these powders come into direct touch with the skin and can be inhaled when applied, it is crucial to look into the levels of radon in both genuine and fake cosmetics. This study intends to assess the amount of radon in widely used cosmetic powders in Iraq, compare the levels of the original and fake items, and aid in the creation of future safety regulations to shield the general public's health from undiscovered radiological hazards.

II. METHODS

10 distinct imported cosmetics samples, both original and non-original, from well-known, highly traded brands, were gathered from the State of Iraqi's local beauty facilities. Following the collection procedure, each sample was weighed using a sensitive balance. Subsequently, the samples were put into 6.2 cm cylindrical test tubes with a 3.8 cm diameter are used as plastic cylinder irradiation chambers. and a 5.58 cm air length and the sample hight was 0.62 cm , as seen in Fig.1

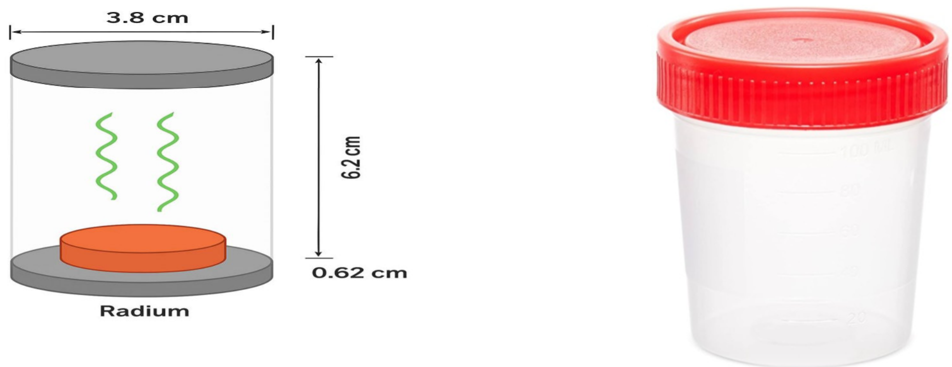

Figure 1. The cylindrical irradiation chamber

To stop leaks and make sure the models weren't contaminated by outside sources, After the cylindrical tubing was tightly sealed, the tube's cap was covered with silicone. This was carried out while keeping in mind that the sample surface and the surface of the inner cover that contained the CR-39 were separated by 5.58 cm. The samples and nuclear reagents were then exposed for 150 days in order to get the ideal equilibrium between radium and its daughters from radon isotopes. The nuclear track detector has an approximate area of 1 × 1 cm^2 and a thickness of 400 μm.

To prepare the scale of the start, the Electronic Scale is used with a 0.1gm allergy to measure the chemical mass (NAOH), (KOH) used to prepare the chemical cream solution, after which the scattering material prepared in a German-made water bath from (MEMMERT W200) was placed in a temperature (C ° 0-100) accurately (° C 1 ±) to perform the chemical cream for the detector exposed to alpha particles.

The detector and the cream solution are placed together in a covered glass spin to ensure that the concentration of the solution does not change the result of evaporation.

Samples were detected using a modern optical microscope (10.5LCD Digital Microscope, 8.0M, Android Pad) equipped with a screen to display antiquities directly without the need for an outdoor camera to photograph and display antiquities and measure their countries as well as to measure the fish removed from the detector surface. This microscope is equipped with three emotional lenses with a zoom (4,10,40 X) and an oily lens with an enlargement (100x) and contains two lenses of two eyes, each with a zoom (10x) used to calculate the number of antiquities. Where the diameters and thickness are measured by the Pixel (Pixel) and then converted to (μM) according to the type of lens used and its enlargement laboratories, as seen in Fig. 2.

A B

Figure 2. A. The water bath ; B. The digital microscope

Following the conclusion of the radiation balancing and exposure duration, the sample containers' seals and reagents are taken out. In order to start the process of displaying the nuclear tracks using the chemical etching technique, a sensitive The amount of sodium hydroxide needed to create the skimming solution is determined using a balance with an accuracy of 0.01g. Chemical scavenging nucleic reagents with (6.25 N) and NaOH. The straw solution container is heated to 70°C in a water bath to perform the chemical scaling procedure. The skimmer solution is heated using a German-style water bath.

With a precision of 1°C, its temperature ranges from 70°C. A CR-39 detector with a temperature range of 70°C and an accuracy of 1°C is attached to be placed inside the etching solution. After the chemical etching solution attacks and dissolves the damaged portion of the detector for seven hours, the soluble material is left in the container with the straw solution. Following that, distilled water was used to wash and dry the track detector.

At this point, the tracks are found using a precision camera-equipped microscope, choosing the right magnification of (×40), and Using a specific lens that is separated into several boxes according to the average number of tracks, the area unit's tracks are counted. For example, each nuclear track detector has 20 fields. The radon-222 concentration was calculated using the following formulas:

For the sealed-cup approach, the diffusion constant (k), which differs between systems based on geometrical dimensions, can be found using this relation [7]:

$$K=\frac{1}{4}r\left(2cos\theta c-\frac{r}{R\alpha}\right)\text{...........}(1)$$

r: The radius of the irradiation tube is 3.5 cm.

θc: the critical angle for the detector and is about 35°.

$R\alpha$: the range of alpha particles produced from radon in air of 4 cm.

The following relation [8] was used to determine the samples' density of tracks (ρ):

$$\text{Tracks density } (\rho) = \frac{\text{Average number of total track}}{\text{Area of field view}} \text{ ....} (2)$$

The sealed-cup determined by the equation is included in the air's Radon concentrations (Cair) [9]:

$$C_{air}=\frac{\rho}{KT} \text{ ....} (3)$$

Where:

t = exposure time (days) of distributed detectors

Therefore, equation was used to determine the radon gas concentration in the cosmetics samples[10]:

$$C_X=\frac{\lambda Rn\ Cair\ ht}{L} \text{ ....} (4)$$

Where:

C_x: Radon concentration in the sample ($Bq.m^{-3}$)

C_{air}: The radon concentration in air ($Bq.m^{-3}$)

λ: Dissociation constant of radon equal to $0.1814\ d^{-1}$

h: Height the air tube

t: Irradiation time

L: Sample thickness

Radon and Radium Concentration

1. Radon Concentration (C_{Rn}): The quantity of radon gas activity per air volume or per sample volume.

• Common units:

• $Bq\cdot m^{-3}$ (Becquerel per cubic meter) for air.

• $Bq\cdot kg^{-1}$ (Becquerel per kilogram) for solid or powder samples.

• Example formula (for CR-39 detectors):

$$C_{Rn}=\frac{\rho}{K} \text{ ....} (5)$$

Where:

• C_{Rn}= Radon concentration ($Bq\cdot m^{-3}$)

• ρ = Trace density ($traces\cdot cm^{-2}$)

• K = Calibration factor ($traces\cdot cm^{-2}$ per $Bq\cdot m^{-3}\cdot day$)

Sometimes the exposure time (t) is taken into account:

$$C_{Rn} = \frac{\rho}{KT} \quad ....(6)$$

2. Radon concentration (C_{Ra}): The amount of radium activity in a material, typically derived from radon exhalation under sealed conditions.

• Common unit: $Bq \cdot kg^{-1}$

• Formula (sealed container technique):

$$C_{Ra} = \frac{CRn.\lambda}{1-e^{-\lambda t}} \quad .... (7)$$

Where:

• C_{Ra} = Radium concentration ($Bq \cdot kg^{-1}$)

• C_{Rn} = Radon concentration ($Bq \cdot m^{-3}$ inside the sealed container)

• λ = Radon decay constant (λ = 0.181 day^{-1})

• t = Exposure time (days)

III. RESULTS

Because counterfeit powders employ unregulated mineral sources that may be enhanced with uranium and thorium, they are predicted to have higher radon levels than original powders. According to similar research, mineral-based cosmetics have higher levels of natural radioactivity [11,12]. Natural radioactivity in consumer products should not cause doses greater than 1 mSv/year, according to international guidelines like those issued by the International Atomic Energy Agency [1] , Import restrictions and consumer warnings may be necessary for any counterfeit goods that surpass these thresholds.

The results of this study may promote radiological screening of additional personal care items and will be used as a foundation for laws on cosmetic safety.

The current study used a CR-39 nuclear track detector to measure the radon concentrations in ten imported cosmetics samples from various sources (original and non-original well-known brands) (Samples Code: CS#) that were gathered from local beauty cosmetics in Iraq. The results of this study reveal that there is a difference between the minimum and maximum concentrations of radon gas in each sample, as indicated by the recorded values of radon concentration (Bq/m3) for imported cosmetics samples in TableI below.

TABLE I

Measured Radon Concentrations in Imported Cosmetics Samples from Various Origins (Original & Non-Original Famous Brands) from Iraqi Local Beauty Centers

No.	Sample Name	Made From	Sample Code	Radon-222 Concentration C_{air} (Bq.m^{-3})	Radon-222 Concentration C_x (Bq.m^{-3})
1	Foundation	France	CS1	0.009677	2.113526
2	Regular Powder	China	CS2	0.007846	1.921388
3	Huda Beauty Powder	Italy/UAE	CS3	0.004969	1.216879
4	Regular Eyeshadow	Indonesia	CS4	0.008631	2.113526
5	Huda Beauty Eyeshadow	Iyaly/UAE	CS5	0.008369	2.04948
6	Tint	South Korea	CS6	0.004708	1.152833
7	Sunscreen	South Korea	CS7	0.0068	1.665203
8	Makeup Remover	France	CS8	0.008892	2.369712
9	Lipstic	USA	CS9	0.008369	2.04948
10	Blusher	Italy	CS10	0.005492	1.344971
Average				0.068547	16.78652

This is because the foundation values used in the production of all cosmetics vary, which has an impact on the radon concentration. It was discovered that the concentrations of 222Rn in the air were 0.068547 Bq.m-3, whereas the concentrations in the sample were 16.7865241 Bq.m-3. The maximum radon concentration in the air (0.009677 Bq.m-3) is equal to the maximum radon concentration in the MAX FACTOR (Foundation) (2.369712 Bq.m-3). As seen in Figures 3 and 4, the lowest radon concentration in air was 0.004708 Bq.m-3, while the lowest radon concentration in the FlashPink (Tint) sample was 1.152833 Bq.m-^{3}.

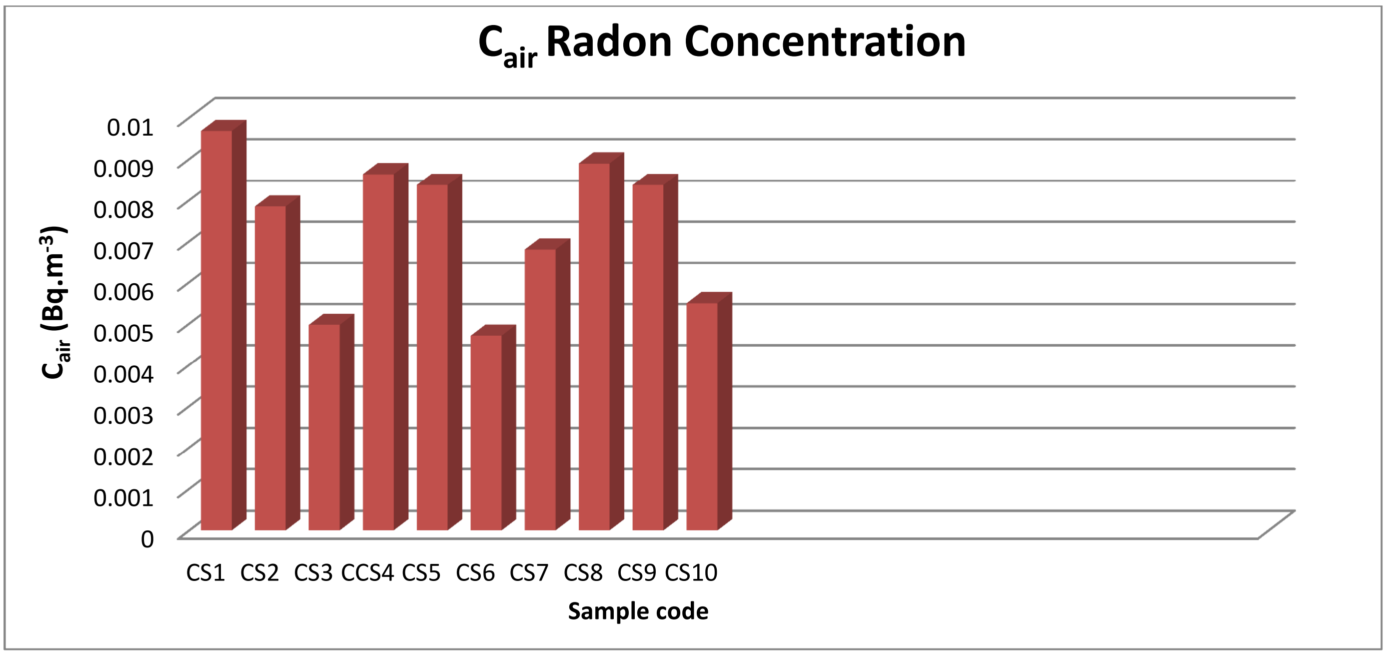

Figure 3. The concentration of 222Rn in air for cosmetics samples.

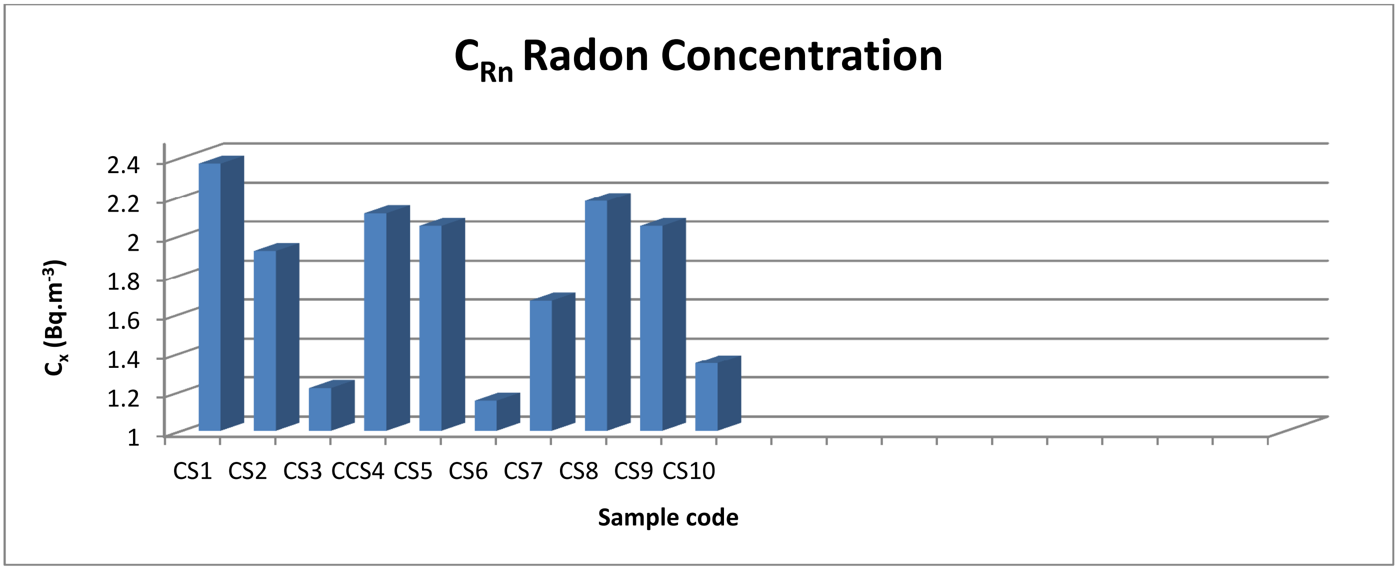

Figure 4. The concentration of 222Rn for cosmetics samples.

IV. CONCLUSION

The amount of radon gas emitted from various cosmetic powders was measured in the current investigation using CR-39 nuclear track detectors. The results indicated that the samples under study had an average radon concentration of about 1.8 Bq·m^{-3}, with a range of about 1.15 to 2.37 Bq·m^{-3}. The measured values are more than two orders of magnitude below the international reference limits recommended by the World Health Organization (100 Bq·m^{-3}), the U.S. Environmental Protection Agency (148 Bq·m^{-3}), and the ICRP (100–300 Bq·m^{-3}). Based on these concentrations, the projected yearly effective dose for users was around 0.03 mSv·y^{-1}, well below the 1 mSv·y^{-1} public dose limit. This strongly implies that there is no radiological health risk associated with radon exposure from the cosmetic powders under investigation.

But the study also draws attention to several crucial factors. The sample size was small, and future research must address methodological and data presentation errors. Future research should also include larger sample sizes, distinct differentiation between genuine and fake products, and simulation of real-world exposure scenarios, as exposure is dependent not only on the amount of radon released from the product but also on actual usage conditions (such as amount applied and ventilation).

This study evaluates the radon levels in imported cosmetic powders for the first time in Iraq. The findings should draw attention to the possible radiological harm posed by fake cosmetics and stress the need for radiological evaluations to be included in laws governing cosmetic products.

Using a CR-39 nuclear track detector, the amount of radon (222Rn) in a few imported cosmetics samples from different sources (original and non-original well-known brands) collected from Iraqi local beauty cosmetics was determined.

The average concentration of (^{222}Rn) in imported cosmetics samples is 16.78652 Bq/m3, with a range of 1.1 to 17.83 Bq/m3.

According to these findings, From the standpoint of radon concentration, most imported cosmetics samples from different origins (both original and non-original well-known brands) from local beauty cosmetics in Iraq are safe to use without posing a significant radiological risk to women in general and Arab women in particular.It was discovered that there are no health hazards and that The cosmetics sample's radon levels are within globally permissible limits. The average readings were below the ICRP and EPA-recommended acceptable levels [1, 11].

In conclusion, even though the cosmetic powders examined in this study do not exhibit dangerous radon levels and are safe from a radiological perspective, ongoing observation and more thorough examinations are advised, especially for fake goods with questionable raw material sources.

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