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ASSESSMENT OF ALPHA EMITTERS IN THE URINE OF PATIENTS WITH THYROID DISEASES BY CR-39 TECHNIQUE

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Abstract: *The best way to observe internal exposure to radioactive or hazardous contaminants in the human body is to analyze urine samples. Urine samples from people with thyroid cancer, those with thyroid disorders, and healthy participants are analyzed for alpha emission rate [E α]. The present study has yielded results about alpha particles, which are described in this research. **Objective:** This study focuses on the natural radioactivity of alpha emitters in the urine samples collected from participants. **Method:** The CR-39 detector technique is used to determine the alpha emissions in patients' urine samples by finding their percentages. CR-39 is a simple and convenient method for determining alpha emission in biological samples. **Results:** The results indicate that the alpha emitters levels in blood samples are higher in S₁₀ at 0.278 mBq.cm⁻² and lower in S₂₈ at 0.013 mBq/cm², respectively, based on calculations performed on 0.5 g of the samples. We also found the rate of alpha emission of urine samples in mBq.cm⁻² as follows: (in people with thyroid disorders is 0.063± 0.006777, while the papillary thyroid carcinoma is 0.076 ± 0.009, and in control (healthy donors' group) is 0.069± 0.008563). **Conclusions:** These values indicate that they are acceptable within the permissible limits within allowable limit 0.04Bq/cm² compared to previous studies. Therefore, these cases do not pose any risk to human life and are not regarded as causes of disease.*

Keywords: alpha emitters, CR-39, thyroid disorders, urine, SSNTDs

1. Introduction

One popular method of stabilizing a heavy, unstable nuclide is the product of a particle's emission. The identity of α particles with 4He^{2+} is established as early as 1903, and the monoenergetic nature of α rays was also soon recognized. When decay occurs between the ground states of mother and daughter nuclei, the decay energy is called ground-state decay energy [1]. The analysis of urine samples is a

crucial biomarker for assessing the presence of radiological and toxicological pollutants within the human body. This method provides a dependable indicator of internal exposure. Radiological and toxic contaminants brought about by human and military activity have significantly impacted the environment in Iraq. This has led to an elevation in the levels of environmental pollutants and an increase in the incidence of cancerous diseases. Utilizing the neutron activation technique in

conjunction with the CR-39 detector has proven to be a valuable method for estimating uranium concentrations in biological specimens, as has been previously documented [2]. Throughout history, individuals have been exposed to natural radiation originating from cosmic rays and other radioactive substances present in the earth's crust since its formation, provided that they consist of radioactive neutrons. The particles of alpha, beta, and gamma have been dissolved. Nutrients are supplied to the human body through the consumption of food. The primary origin of the natural radiation background in the environment is attributed to radionuclides in air, soil, water, and building materials. There are three significant isotopes include uranium, thorium, and potassium. Uranium is a heavy and radioactive metal that emits alpha particles (α) at a constant dissolution rate of 1.5×10^{-10} per year. Its radioactive activity is 12.4×10^3 Bq/kg, and its density at 25°C is 19.05 g/cm^3 . Uranium is characterized by its silver-white appearance, toxicity, and the melting point of 1132 C . Uranium is present in varying quantities in natural reservoirs such as rocks, soil, water, air, flora, fauna, the human anatomy, and other sources. The uranium concentration is contingent upon the soil type and, subsequently, the rock that constitutes the soil [3]. In this pilot experiment, samples of urine are employed to identify background alpha emitters. The CR-39 detectors follow ionizing particles. To produce high-ionization nuclear damage tracks, charged particles must first disrupt the chemical bonds that hold CR-39 detectors together. In environmental research, such as its use in detecting alpha particles in the environment, as in our current research, the nuclear trace detector CR-39 is used because of its high detection efficiency and high sensitivity to low concentrations of these particles.

2. Methodology

Study groups: The biological samples are gathered from Amir Al-Momineen specialist hospital/clinic for thyroid diseases as part of the hospital's mission to Kufa University. The three groups of participants have no previous occupational uranium exposure. The study population comprised of individuals with ages ranging from 15 to 75 years. The research is carried out on a sample size of 33 urine specimens collected from individuals with papillary thyroid carcinoma and thyroid disorders (38) and 20 samples from healthy donors. The thyroid activity—table 1 represents the information about all participants.

Sample collection: Urine is the most common biological sample used for internal radiation dose assessment. The radionuclides in urine are often present in trace quantities [4]. The total number of urine samples collected is 91, with male and female volunteers representing the three groups. The participants are briefed on how to manage the samples to prevent contamination. The samples are stored in cool boxes and in a refrigerator at four $^\circ\text{C}$ in the same hospital. The volunteers completed a comprehensive questionnaire about demographic information such as age, gender, location, health status, radiotherapy, thyroxine therapy, thyroidectomy, vitamins taken, and smoking habits. A total of 52 patients and healthy donors provided urine samples from different regions in Iraq, ranging from 18 to 65 years old. The samples that are taken from healthy donors according to BMI and thyroid function tests (the control group). About 20 ml of urine samples are taken from each one.

Thyroid function test: the Cobas e-411 analyzer is used to evaluate thyroid function. For all patient TG, A-TG, T3, T4 and TSH levels determined in serum blood and healthy donors, the TSH with BMI is determined. The

blood is centrifuged at 3000 rpm for 10 minutes to prepare serum.

Solid-state nuclear track detectors (SSNTDs) meet efficiency and selectivity requirements in cluster radioactivity studies. Here, plastic plates are used to detect ionizing particles in the form of damage tracks only when the ionizing rate exceeds a threshold typical of the detector material. These detectors can ignore low-ionizing particles to find heavier clusters. SSNTDs are chemically etched after nuclear irradiation to increase the damaged region from angstrom to micrometer scale, making it visible under a microscope [1]. The CR-39 detector is suitable for alpha detection. It is a type of organic nuclear track reagent with a hydrocarbon composition ($C_{12}H_{12}O_7$) and a hydrogen content of (6.6%) and is symbolized by CR (Columbia Resin) [5].

Natural exposure duration:

The CR-39 detector is immersed in urine with a volume of 20 ml and left for 126 days [6], as shown in Figure 1.



Figure 1: A detector with sample in PVC tube

Background radiation (ρb): A CR-39 detector was also put in the blank tube to calculate the background.

Chemical etching: It is believed that the material's preferential etch ability along the latent track is caused by local defects and brought on by thermal spikes. It is produced

along the track by electron collision cascades or directly by atomic displacements brought on by locally intense electric fields resulting from the ionization burst close to the particle path (the so-called "ion explosion spike") [1]. During the natural exposure period, the α -particle enters the TASTRAK plastic track detector; it creates a trail of damage along its path [7]. This damage is invisible but may be revealed by chemical etching. The detector is immersed in 6.25 N NaOH at 98°C for one hour[8], prepared by dissolving 62.5 g of NaOH in 250 ml of distilled water[6].

Depending on the material used, the etching process might take a few minutes to more than an hour. The physical processes that result in the etching ability of a latent track are not yet fully explained by a complete and satisfying theory[9]. The solution is heated in a water bath. The water bath used in the present work is type Clifto with a digital temperature display, with a range of approx. Figure 2 shows the water bath used in the study.



Figure 2: The detectors inside the water bath

See track under microscope: After etching, the detectors are scanned under a 400x optical microscope (HIGHTOP) with a digital camera and software to estimate the alpha track density per square centimetre [10]. Fig.3 shows the track in the digital camera.



Figure 3: Tracks under the microscope

Calculations:

We need to calculate the efficiency of the CR-39 detector by determining two parameters.

Then, using equation 1 to calculate the efficiency,[11]

$$\eta = 1 - \frac{V_B}{V_t} \dots \dots 1$$

V_B founded by equations 2 [10].

$$V_B = \frac{1}{2} \frac{\Delta h}{\Delta t} \dots \dots 2 \quad \mu\text{m/s}$$

Δh is the thickness of the layer removed from the detector's surface in μm , Δt : time of etching process.

The efficiency in the current study is 0.85%. The number of tracks averaged over fields of view is calculated for each detector. The density of the tracks (ρ) for each detector is calculated according to Equation 3 [12].

$$\rho = \frac{N_{avg}}{A} \dots \dots 3 \quad \text{track.cm-2}$$

N_{avg} The average number of total tracks

A Number of fields of view

The alpha emission rate ($E\alpha$) is calculated using the formula 4,[13]:

$$E\alpha = \varepsilon * \frac{\rho s - \rho b}{T} \% \dots \dots 4. \text{ Bq.cm-2}$$

Where T is the exposure time (seconds), ρs is the number of tracks produced by the samples in track cm-2, and ρb is the number of background tracks.

Statistical analysis

The statistical analysis is carried out by spss program version 26 for Mac. ANOVA test was used for mean comparison among groups.

3. Results & discussion

We obtained the track density for alpha emission rate in unit mBq/cm2 by using a CR-39 detector for different types of thyroid diseases in Table (1), the maximum value obtained is 0.278 mBq/cm2 in S10, which belongs to a female from Najaf (25-35) years old, and the minimum value of urinary uranium is 0.013 mBq/cm2 for a female from Nasiriya (35-45) years old in S28, both these values belong to patients with papillary thyroid carcinoma. The mean value of alpha emission in urine samples for the thyroid disorder group is 0.063 ± 0.006 , while the papillary thyroid carcinoma is (0.076 ± 0.009) and in the control group is 0.069 ± 0.008 , as shown in Figure (4), there is no a statistically significant in mean differences among groups, these results represented in Table (2). ANOVA test results showed that there is a difference between the groups(single p-value), but there is no significant difference between the groups where is the p-value >0.05 as shown in Table (3). In Table (4) we use the Post Hoc Tests to compare each group pair while adjusting the p-value. The Bonferroni test is used to determine the nature of the differences among groups; the mean of alpha emission is not significantly different among groups of p-value =1.000.

Table (1): Summery about the participants in the study with their information's

Valid		frequency	%	Valid percent	Cumulative percent
Thyroid case	papillary thyroid carcinoma	37	38.1	38.1	20.6
	thyroid disorders	40	41.2	41.2	100.0
	Control (healthy donors)	20	20.6	20.6	20.6
	Total	97	100.0	100.0	
Gender	Female	78	80.4	80.4	80.4
	male	19	19.6	19.6	100.0
	Total	97	100.0	100.0	
Age interval	15-25	10	10.3	10.3	10.3
	25-35	24	24.7	24.7	35.1
	35-45	28	28.9	28.9	63.9
	45-55	19	19.6	19.6	83.5
	55-65	7	7.2	7.2	90.7
	65-75	9	9.3	9.3	100.0
	Total	97	100.0	100.0	
Smokes case	Nonsmoker	90	92.8	92.8	92.8
	Smoker	7	7.2	100.0	100.0
	Total	97	100.0	100.0	

Table (2): Alpha emission rate in the study groups in mBq.cm⁻²

Thyroid case	Mean	N	SD	Max	Min	Std. Mean
papillary thyroid carcinoma(1)	.07574	33	.052185	.278	.013	.009084
thyroid disorders.(2)	.06346	38	.041774	.184	.014	.006777
Control (healthy donors) (3)	.06957	20	.038295	.151	.025	.008563
Total	.06926	91	.044999	.278	.013	.004717

Table (3): ANOVA test for difference between study groups

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.000	2	.000	.110	.896
Within Groups	.172	76	.002		
Total	.172	78			

Table (4): Multiple Comparisons by Post Hoc Tests/ Bonferroni

I	J	Mean Difference (I-J)	SD	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1	2	-.006829	.015231	1.000	-.04412	.03046
	3	-.004782	.013020	1.000	-.03666	.02709
2	1	.006829	.015231	1.000	-.03046	.04412
	3	.002047	.013246	1.000	-.03038	.03448
3	1	.004782	.013020	1.000	-.02709	.03666
	2	-.002047	.013246	1.000	-.03448	.03038

Figure (5) shows a comparison by the means between males and females. It is found that the alpha emission rate in females 0.07 mBq.cm⁻² is higher than that in males 0.065 mBq.cm⁻². Many previous studies, such as ref, have confirmed this result. [11,14]. This may return to the fact that the total blood volume in females is usually lower than in males [15,16].

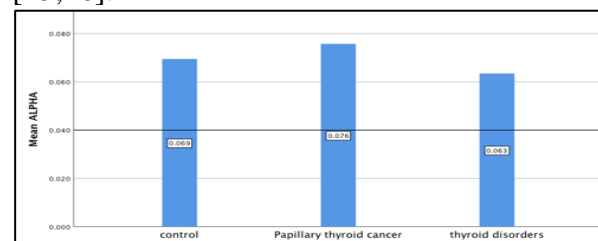


Fig. 4: Alpha emission rate by mean in the study groups

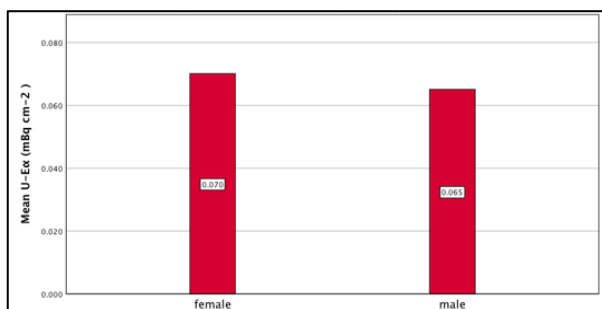


Figure 5: alpha emission rate according to gender

Also, the results show that the mean alpha emission rate in smokers 0.072 mBq.cm⁻² is higher than in nonsmokers 0.069 mBq.cm⁻² as in Figure 6. for each age group.

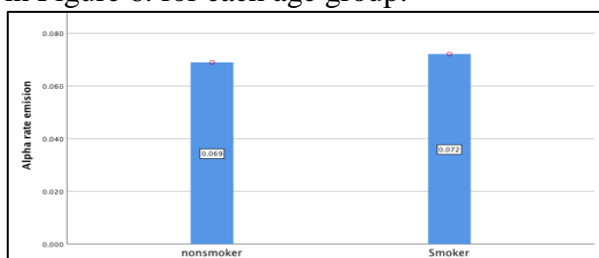


Figure 6: alpha emission rate according to smoker case

For both gender and smoking variables, there are no significant differences. The average alpha particle emission in unit mBq/cm² is 0.094, 0.086, 0.057, 0.060, 0.069 and 0.080 in age intervals 15–25 yr, 25–35 yr, 35–45 yr, 45–55 and 55–65 yr, respectively. There is a difference in age group regarding the age variable, but it is not significant (p=0.878). These results are shown in Figure 7.

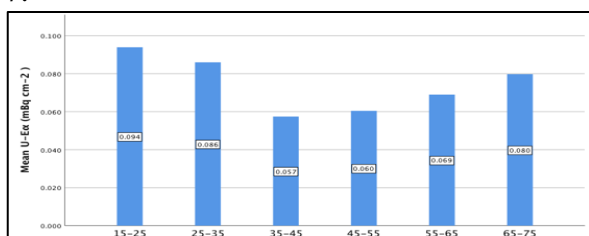


Figure 7: alpha emission rate according to age interval

Conclusions

In this study, the results show a slight increase in the rate of alpha particle emission in people with thyroid cancer who have been diagnosed as having a high level of TSH, followed by the control group, whose TSH value is within the normal range. The lowest among people with multiple thyroid disorders who suffer from inactivity according to their TSH values. The data showed no alpha particles or contaminants in the urine of Iraqi patients with thyroid diseases at concentrations of potential harm.

The study exhibits both high and low levels of alpha emitters that calculated 0.076 mBq.cm⁻² and 0.065 mBq.cm⁻², in 20 ml of urine samples are respectively.

Ethical

Clinical samples were acquired from the Amir Al-Momineen specialist hospital/clinic for thyroid illnesses in Iraq / Najaf as part of the hospital's mission to Kufa University.

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