# DETERMINATION OF URANIUM CONCENTRATION IN TEETH MALE SAMPLES USING FISSION TRACKS IN CR-39 FROM DIFFERENT COUNTRIES.

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**Abstract**

The aim of this project is to measure the uranium concentration in teeth male samples collected from different nationalities.

The uranium concentration in teeth samples were measured by using CR-39 track detector. The nuclear reaction is used as a source of nuclear fission fragments is (n, f) obtained by the bombardment of U-235 with thermal neutrons with flux (5000 n $cm^{-2}s^{-1}$) from (Am-Be) neutron source. The concentration values were calculated by a comparison with standard samples which prepared. The obtained results show that the concentration is ranging from (0.72± 0.1ppm) in Egypt to (0.24 ± 0.03ppm) in Pilipino for male, the uranium concentration was the highest in Egypt for male.

## Introduction

There are two main sources of radiation are found in the environment, natural radioactivity source (which include terrestrial cosmic rays and cosmogenic) and manmade radioactivity sources (which include medical, fallout and nuclear power). [1-3]. Natural Uranium consists of $^{238}U$ (99.275%), $^{235}U$ (0.720%) and $^{234}U$ (0.005%) with half life ($4.49\times10^9$ year) [4], it's found in nature in different forms and the human body contains (90 µg) as average result from food chain, about 66% are found in bones and teeth, 16% in the liver, 8% in the kidneys and 10% in other tissues. The average annual intakes of uranium by adults are estimated to be (460 µg) from ingestion [1].

All natural elements with atomic numbers Z>83 are radioactive. There are four distinct natural decay series[2] which are represented in Table (1).

Natural radioactivity in earth crust belongs to the primordial radio nuclides, which are widely distributed through the earth's crust and have long half-lives. They can be divided in to those that occur singly such as potassium-40 and rubidium-87 whose half-lives ($1.3\times10^9$) and ($4.8\times10^{10}$) years respectively [2], and those which occur in series chains such as uranium-238 series, actinium series, thorium series and neptunium series. The importance of these chains comes according to their half life, abundance in nature and type of radiation emitted from them[3].

***Table (1)***
***Natural Radioactivity Series[4].***

| Series | First isotope | Half life(years) | Last isotope |
|---|---|---|---|
| Uranium | $^{238}U$ | $4.49\times10^9$ | $^{206}Pb$ |
| Actinium | $^{235}U$ | $7.10\times10^8$ | $^{207}Pb$ |
| Thorium | $^{232}Th$ | $1.39\times10^6$ | $^{208}Pb$ |
| Neptunium | $^{237}Np$ | $2.14\times10^6$ | $^{209}Bi$ |

Neptunium series does not occur in nature because of its half life is $2\times16^6$ y which is much smaller than the age of the universe $3\times10^9$ y.

### Man-Made Radioactivity Sources

Over the last few decades man has "artificially" produced several hundred radionuclides, and the power of the atom used for a wide variety of purposes, medicine, weapon the production of energy detection of fires, illuminating watches and prospecting for minerals. All increase the radiation dose both to individual people and to man-kind as a whole.

Individual doses from man–made sources of radiation vary greatly. Most people received relatively small amount of artifical radiation, but few get many thousand times the amount they receive from natural sources.

The variability is generally greater for man -made sources than for natural ones. Most made sources, too, can be controlled more readily than most natural ones, through exposure to external irradiation to fall-out from past nuclear explosion [5].

**Solid state nuclear track detector**

A solid state nuclear track detector or SSNTD (also known as an etched track detector or a dielectric track detector) is a sample of a solid material (photographic emulsion, crystal, glass or plastic) exposed to nuclear radiation (neutrons or charged particles), etched, and examined micro-scopically. The tracks of nuclear particles are etched faster than the bulk material, and the size and shape of these tracks yield information about the mass, charge, energy and direction of motion of the particles. The main advantages over other radiation detectors are the detailed information available on individual particles, the persistence of the tracks allowing measurements to be made over long periods of time, and the simple, cheap and robust construction of the detector.

The basis of solid state nuclear track detection is that charged particles damage the detector within nanometers along the track in such a way that the track can be etched many times faster than the undamaged material. Etching, typically for several hours, enlarges the damage to conical pits of micrometer dimensions that can be observed with a microscope. For a given type of particle, the length of the track gives the energy of the particle. The charge can be determined from the etch rate of the track compared to that of the bulk. If the particles enter the surface at normal incidence, the pits are circular; otherwise the ellipticity and orientation of the elliptical pit mouth indicate the direction of incidence.

SSNTDs are commonly used to study cosmic rays, long-lived radioactive elements, radon concentration in houses, and the age of geological samples.

A material commonly used in SSNTDS is polyallyl diglycol carbonate (PADC), also known as Tastrak, CR-39. It is a clear, colorless, rigid plastic with the chemical formula $C_{12}H_{18}O_7$. Etching is usually performed in solutions of caustic alkalis such as sodium hydroxide, often at elevated temperatures for several hours [6].

**Track Geometry**

The geometry of track etching presented in simplest case by simultaneous action of two etching processes chemical dissolution along the particle track at a linear rate $V_T$ and general attack on the etched surface and on the interior surface of the etched track at lesser rate $V_B$ as shown in Fig.(1).

There are many parameters used to describe the geometry of etched track, these are:

1. Full length of latent track(L)
2. Thicknesses of surface removed by etching (h).
3. Diameter of etch pit (D)
4. The track length (L) at etching time (t) is given by the following equation:

$$L = V_T T \quad \text{..... (1)}$$

The surface (R) is also being removed at a rate $V_B$, so that [95].

$$R = V_T \cdot t - V_B \cdot t \quad \text{.....(2)}$$

Where $V_T$ is the track etch rate, $V_B$ is Bulk etch rate.

When track etch rate ($V_T$) is constant and the particle penetrates normally, then the surface thicknesses (h) is given by:

$$h = V_B \cdot t \quad \text{.....(3)}$$

The diameter of the etch pit (D) is related to $V_B$ and $V_T$ according to thye following relation:

$$D = 2V_B . t [( V_T - V_B ) / ( V_T + V_B )] ½ \quad \text{.....(4)}$$

Equation (4) shows that, the diameter (D) and the length of the etched track (L) depend essentially on the competitive effects of $V_T$ and $V_B$. When $V_B = V_T$ both (L) and (D) vanishes and then no track produces [7].

From the above relations concluded the thicknesses of surface remover by etching depend on etching time.

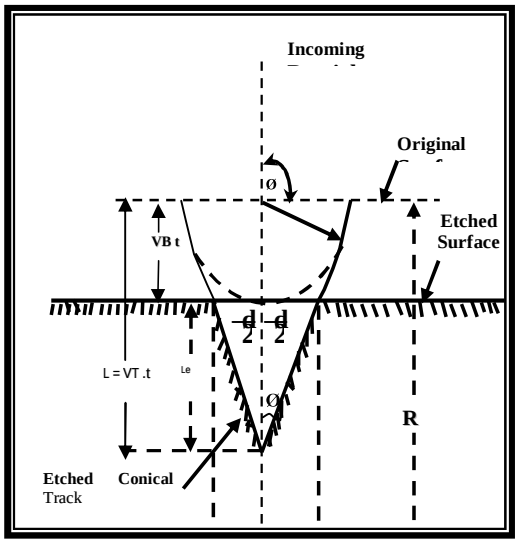


***Fig. (1) : Track geometry for particle penetrates a detector material normally [8].***

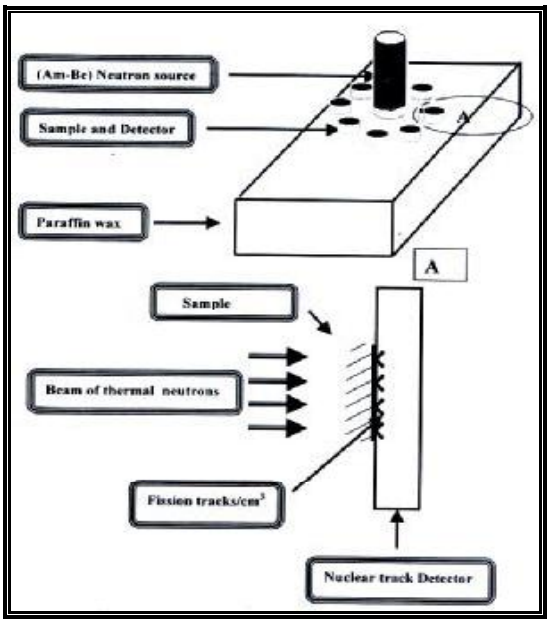


***Fig. (2): The irradiation of the detectors and samples to the neutron source [9].***

**Experimental part:**

The countries which teeth samples were collected from (Egypt**,** India, UAE**,** Pilipino**,** Indonesia**,** Korowai**)** as shown in Table (2).

The teeth samples were dried and then crushed and sieved (2 mm diameter). (0.5g) weight of the powdered teeth samples and the standard which prepared of different uranium concentration were pressed into a pellet of (1 cm) diameter and (1.5 mm) thickness.

**Irradiation source**

The pellet were covered with (CR-39) detecter and put in a plate of paraffin wax at a distance of (5 cm) from (Am-Be) neutron source with thermal neutrons flux ($5\times10^3$ n/ $cm^2$.s). Neutron source emits fast neutrons from the (α, n) reaction such as:

$$^{9}Be + \alpha \longrightarrow {}^{12}C + {}_0{}^1n + 5.76\ MeV \ldots (5)$$

This source consists of a rod of (Am-Be) surrounded by a paraffin wax. The paraffin wax is usually used for moderating the fast neutrons to thermal neutrons. The neutron source with flux ($5\times10^3$ n/ $cm^2$.s) was used to irradiated the sample as shown in Fig.[2].

The detector's were etched in 6.25N NaOH solution at 60 ˚C for 6 hours then washed by distilled water, dried and the number of fission tracks produced was then counted by using the optical microscope.

The density of fission track (ρ) in the detecter was calculated according to the following relation:

$$\rho = N_t/A \quad \ldots\ldots (6)$$

Where:

ρ: Track density

$N_t$: Average no. of total pits (tracks).

A: area of field view.

The Uranium concentration in the teeth samples where measured by comparison between track densities of teeth sample and standard from equation [10].

$$C_x/\ \rho_x\ (\text{sample}) = C_s/\ \rho_s$$

$$C_x = C_s\ .\ (\rho_x/\ \rho_s)$$

$$C_x = \rho_x/\text{slop} \quad \ldots\ldots (7)$$

Where:

$C_x$: uranium concentration for unknown samples.

$C_s$: uranium concentration for standard samples.

$\rho_x$ : induced fission tracks density for unknown samples.

$\rho_s$ : induced fission tracks density for standard samples.

The relation between tracks densites of uranium concentrations for the standard samples as shown in Fig.(3).

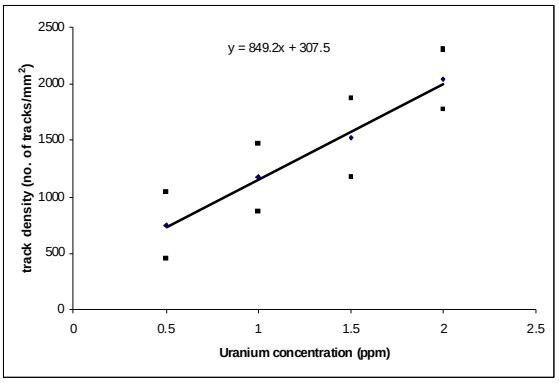


***Fig.(3):The relation between tracks density and uranium concentration (ppm) for standard teeth samples.***

In this research the results obtained from ten male tooth samples from different countries. The results include the measurements of the uranium concentration for male samples which where obtained using solid state track detectors (CR-39) as shown in Table (3).

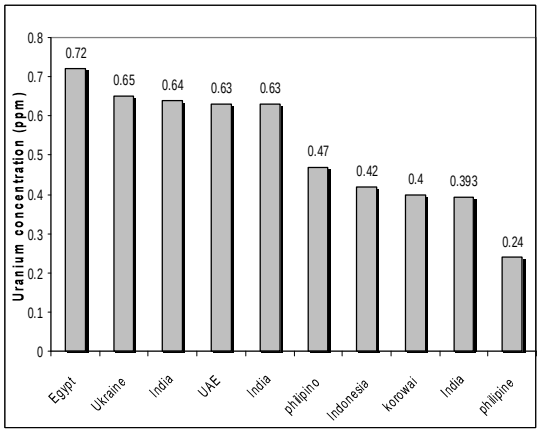


***Fig.(4): Uranium concentration in male tooth samples.***

***Table (2)***
***Male samples from different nationalities.***

| Model | Age year | Gender | Nationality |
|---|---|---|---|
| 1 | 43 | Male | Egypt |
| 2 | 52 | male | Ukraine |
| 3 | 40 | male | India |
| 4 | 36 | male | UAE |
| 5 | 40 | male | India |
| 6 | 42 | male | Philipino |
| 7 | 52 | male | Indonesia |
| 8 | 42 | male | Korowai |
| 9 | 46 | male | India |
| 10 | 38 | male | Pilipine |

***Table (3)***
***Uranium concentration in male tooth samples.***

| Model | Age year | $\rho_x$(tracks/mm$^2$ )±б | Uranium concentration ppm |
|---|---|---|---|
| 1 | 43 | 6149 ± 916.8 | 0.72 ± 0.1 |
| 2 | 52 | 5592.6 ±1059.7 | 0.65 ± 0.12 |
| 3 | 40 | 58090.6 ± 453 | 0.64±0.053 |
| 4 | 36 | 5397.8 ± 881 | 0.63 ± 0.1 |
| 5 | 40 | 5369.9 ± 717 | 0.63 ± 0.08 |
| 6 | 42 | 4034.3 ± 532.2 | 0.47±0.062 |
| 7 | 52 | 3589.3 ± 312.1 | 0.42±0.036 |
| 8 | 42 | 3338.8 ± 350 | 0.4 ± 0.04 |
| 9 | 46 | 3338.8 ± 071.4 | 0.393 ± 0.12 |
| 10 | 38 | 2086.8 ± 312 | 0.24 ± 0.03 |

**Results and discussion**

The uranium concentration in samples was found to be the maximum concentration (0.72 ppm) in an Egyptian male of age 43 years, in contrast the minimum uranium concentration was (0.24 ppm) in Pilipine male of age 38 years shown in Fig. (4).

One of the important ways of human exposure to uranium is through ingestion. The major portion of the body burden of uranium in the general public is derived from ingestion of food and drinking water, depending on where one lives and on one's diet, exposure to natural uranium varies and continues over an entire lifetime.

In addition to uranium intake from food and water, some uranium ingestion may also follow hand-to-mouth contact in presence of uranium-containing dusts, uranium particles deposited in the upper airways are cleared from the lungs by mucociliary action, swallowed, and eventually reach the gastro-intestinal tract.

Great deal can be learned about radiation dose and organ and tissue retention from the natural uranium content of the body. This uranium is obtained normally throughout life both from daily inhalation intake and through ingestion of food. These data show quantitatively the steady-state tissue

concentrations from continuous intake from sources that cannot be avoided.

The age dependence of the natural concentration of uranium and thorium in the skeleton was investigated using human vertebrae bone[11]. The thorium concentration differed only marginally with respect to age group, indicating that its behavior in the body and could be age-independent.

Conversely, the uranium level in bones and teeth was found to change for the age groups tested, an indication of age-specific deposition. The age profile for uranium was comparable to the calcium turn-over rate, indicating that uranium deposition is probably, in part, dictated by this metabolic process, showing the role of present uptake into the uranium concentration in bones for populations exposed to sign [12].

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**الخلاصة**


قياس تركيز اليورانيوم في نماذج اسنان الرجال لدول مختلفة باستخدام عد اثار شظايا الانشطار في كاشف الاثر CR-39

الهدف من البحث هو قياس تركيز اليورانيوم في نماذج اسنان الرجال جمعت من دول مختلفة ثم قياس تركيز اليورانيوم في نماذج الاسنان بأستخدام تقنية عدآثار شظايا الانشطار في كاشف الاثر النووي CR-39 الناتجة عن قصف نوى اليورانيوم 235 بالنيوترونات الحرارية من المصـــــدر النيوتروني Am-Be بفيـض نيوتروني (5000 $nc^{-2}s^{-1}$) وتم تحديد التراكيز بالحسابات المعتمدة على المقارنة مع النماذج القياسية والتي تم تحضيرها في المختبر والنتائج المستحصلة تبين ان تراكيز اليورانيوم تتراوح ما بين( 0.7 ppm ) في مصر الى (0.24 ppm) في الفلبين ومن النتائج تبين ان أعلى تركيز كان في دولة مصر واقل تركيز في الفلبين.