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Mathematical Modeling of the Calculation of Uranium Concentrations in the Urine Samples of the Factories Workers due to the Number of Working Years

Ammar A. Battawy[1,*], Ghassan Ezzulddin Arif[2], Shadia Majeed Noori[2], Nada F. Tawfiq[3], Mohamad Suhaimi Jaafar[4] , Iskandar Shahrim Mustafa[4]

[1] *Department of physics, College of Education for Pure Sciences , Tikrit University, Tikrit , Iraq*
[2] *Department of Mathematics, College of Education for Pure Sciences , Tikrit University, Tikrit , Iraq*
[3] *Department of Physics, College of Science, AL -Nahrain University, Baghdad , Iraq*
[4] *School of Physics, USM , Malaysia*

E-mail: [*]ammar_physics@yahoo.com

Abstract
The current study aims to build a mathematical model in order to assist the researchers to calculate the uranium concentrations in urine samples for labors in factories whom spend several years of work. So a new mathematical model is constructed by several parameters. The proposed mathematical model covers samples for labors who are working in many factories in selected locations in Iraq and whom might be exposed to the radiation materials in their works, depending on the period of works. Our calculated values have shown conformity with the experimental data of other researchers.

Keyword: Mathematical modeling; Proposed model; Uranium concentrations; Working years; Urine samples for workers.

Introduction
In this work, we have constructed empirical formula for modeling physical processes. By counting on the mathematical modeling, we have proposed a mathematical model to solve the problem of calculating the uranium concentrations in the urine samples of labors in factories. We can define the Mathematical modeling as the process of creating a mathematical representation of some phenomenon in order to gain a better understanding of that phenomenon, and "to evaluate the results of the laws of nature, to apply the conditional statements to the particular conditions which happen to prevail or happen to interest us. We should formulate the laws of nature through mathematical language to be an object for the use of applied mathematics” [1]. Therefore, Mathematical modeling is an area of applied mathematics that focuses on studying mathematics of the real world such as its use to assist the process of decision making in various fields. It also utilizes known mathematical concepts of physics.

The fact is that both the pure and applied mathematics have a great value in materials science. In general, mathematics play a more sovereign role in physics. Accordingly, one of the goals of the present study is to review the role of mathematics in health physics as mathematics is now used in everyday physics. Physical applied mathematics generally refers to the study of mathematical problems with direct physical application. This area aims at developing new mathematical models and making fundamental advances in the mathematical and physical sciences. “The formulation of physical theories in the language of mathematics often leads to new physical predictions which were quite unexpected on purely physical grounds" [2]. Meanwhile, this field of Physical Applied Mathematics requires a study of the modeling. In this regard (the application of mathematics to physics), a major fact must be mentioned that the equations should be of a simple form due to the fact that equations of simple form do seem to work.

Health physics is a systematic organization of knowledge about the interaction between radiation and organic or inorganic matter. It is a versatile science that is based upon physics, chemistry, biology and medicine.

Radiation and radiation emitters (radio nuclides) can expose the whole body (direct exposure) or expose tissue inside the body when inhaled or ingested. Different types of radiation vary in their ability to damage different kinds of tissue. All kinds of ionizing radiation can cause cancer and other effects. The main difference in the ability of alpha particles, beta particles, gamma-rays and x-rays to cause health effects is the amount of their energy. Their energy calculates how far they can penetrate into tissue. It also calculates how much energy they are able to transmit directly or indirectly to tissues and the resulting damage [3].

Alpha-emitters like uranium, for example, enter the bodies through the food we eat, or the water we drink and the air we breathe and also by absorption through the skin. The alpha emitters may consist of small, fine particles and coarse, big particles. The big particles are caught in the nose, sinuses, and upper part of the lung where they are blown out or pushed to the throat and swallowed. The small particles are inhaled down to the lower part of the lung. If they do not dissolve easily, they stay there for years and cause most of the radiation dose to the lung [4].

A small part of the alpha emitting elements swallowed will also be found in the blood, and the blood carries it throughout the body. Most of it leaves through the urine in a few days, but a little stays in the kidney and bones [5].

People can be exposed to ionizing radiation from natural and man -made sources of ionizing radiation outside the body. Since 1991, when depleted uranium weapons were first used in conflict, exposure may occur to people working or living in areas where depleted uranium munitions were used and where they hit target and formed various oxides and uranium compound. Equipment contaminated with depleted uranium oxides can become a source of contamination when the oxides are re-suspended or otherwise dislodge during transit [6].

Ionizing particles passing through polymeric track detectors produce latent track, which are trails of radiation damage. The best means of observing the tracks is by etching the SSNTDs material with a chemical solution, which preferentially attacks the damaged material and enlarges the original track to a size, which is visible in the optical microscope [7].

In this work, a new mathematical model is constructed by following general steps and guide lines to calculate the averages of uranium concentrations in urine samples for factories workers based on the number of working years.

Layout of study

The goal of this work is to create a mathematical model which is proposed to calculate the averages of uranium concentrations in urine samples for workers working in factories according to the number of their working years. The mathematical model is constructed by counting on several manual attempts to find the suitable mathematical equation in conducting the calculations [8, 9]. So after several trials, depending on general guidelines and typical steps followed in constructing the proposed mathematical model, it is found that the best mathematical model is given as:

$$U(W) = 1.66\,\lambda\,\sqrt[4]{W^{0.75}}$$

Where U refers to uranium concentrations (μg/L), W is referring to the rate center of working years, and λ is a parameter appropriate for Phosphate group (λ= 1), Glasses factory group (λ= 0.56), Detergent Chemicals group (λ= 0.62), North Fertilizer Plant group (λ = 0.69), and Mishraq Sulphur group (λ= 0.68), and other groups (λ= 6). The experimental results of uranium are taken from the data of the researcher, Abdullah [10]. While, λ parameter is calculated throughout applying the mathematical model for each factory separately so that the rate of errors is lowered and be minimum.

Calculations and Discussion

When applying the proposed mathematical model, we have got perfect and conformed results. The error percent was less than 0.004 in Phosphate factory, according to working years extending form (16-20) and from (21-25) as shown in Table and Fig. 1. While in Glasses factory, the error percent was 0.00 in the working years that extend from (6-10). This reflects a well conformity between the resulted values and the experimental data as shown in Table and Fig. 2. Besides, the error percent is 0.004 due to the working years from (21-25). In the Detergent Chemicals, the error percent is 0.0006 in the working years that extend from (6-10), and 0.006 in the working years from (11-15) as shown in Table and Fig. 4. But in the other periods of the working years, we got an error percent more than 0.01 as shown in Tables and Figs. 3, 5, 6, and 7.

Conclusions

We found a number of numerical solutions and we chose the best solution to apply it for calculating the averages of uranium concentrations in urine samples for factories workers based on the number of working years for each rate. To get better results, the parameters λ= 0.56, λ= 0.62, λ= 0.68, λ= 0.69, and λ= 1 are used, with variable (W) between 3 and 28 as input data, to get uranium concentrations between $1.32 \le U \le 3.39$. We found that the rate of error is so small when comparing it with the experiential data. The conclusion of the calculations represents the output data of the mathematical model, which are well conformed to the experimental data. Thus, this work helps to solve the physical problem of calculating the uranium concentrations. Moreover, it is important to mention that more input data used in the model leads to a difficulty of constructing a mathematical model that can be applied to all kinds of data.

Table 1: Comparison between the calculations, obtained by the mathematical modeling, of uranium concentrations in urine samples for the Phosphate workers according to the number of working years, and the experimental values of Abdullah [10].

No.	No. of Working Years	Rate Center for Working Years (W)	Uranium Concentration (μg/L)		(%)
			Exp.	Cal.	
1	Below 6	3	2.22	2.03	0.08
2	6-10	8	2.17	2.45	0.12
3	11-15	13	2.63	2.684	0.020
4	16-20	18	2.84	2.853	0.004
5	21-25	23	3.00	2.988	0.004
6	26-30	28	3.39	3.1	0.085

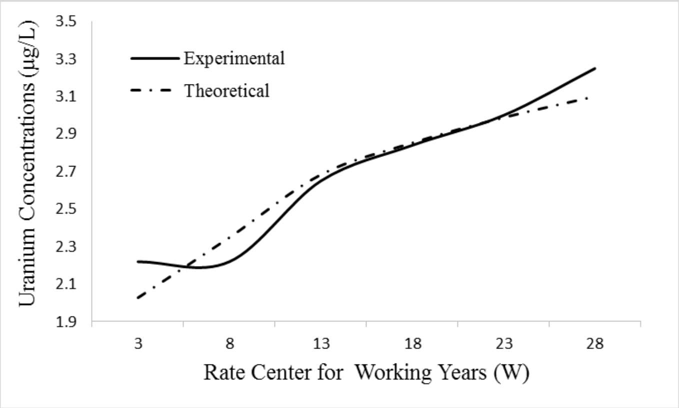

Fig. 1: Comparison between the calculations, obtained by the mathematical modeling, of uranium concentrations in urine samples for the Phosphate workers and the experimental values of Abdullah [10].

Table 2: Comparison between the calculations, obtained by the mathematical modeling, of uranium concentrations in urine samples for the Glasses factory workers according to the number of working years, and the experimental values of Abdullah [10].

No.	No. of Working Years	Rate Center for Working Years (*W*)	Uranium Concentration (µg/L)		(%)
			Exp.	Cal.	
1	Below 6	3	-	1.1368	0.00
2	6-10	8	1.37	1.37	0.00
3	11-15	13	1.44	1.50	0.04
4	16-20	18	1.49	1.597	0.07
5	21-25	23	1.68	1.673	0.004
6	26-30	28	1.80	1.736	0.03

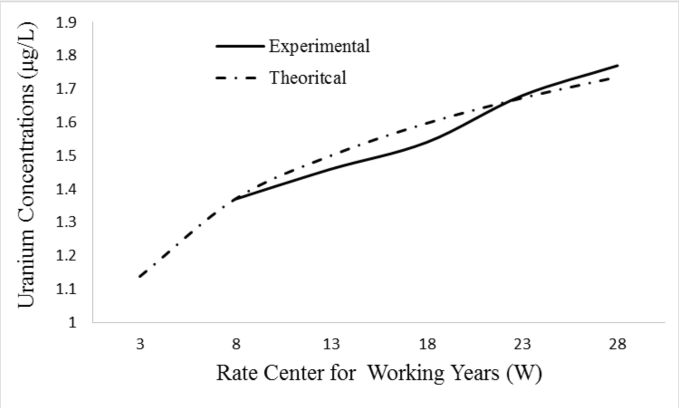

Fig. 2: Comparison between the calculations, obtained by the mathematical modeling, of uranium concentrations in urine samples for the Glasses factory workers and the experimental values of Abdullah [10].

Table 3: Comparison between the calculations, obtained by the mathematical modeling, of uranium concentrations in urine samples for the Ceramic factory workers according to the number of working years, and the experimental values of Abdullah [10].

No.	No. of Working Years	Rate Center for Working Years (*W*)	Uranium Concentration (µg/L)		(%)
			Exp.	Cal.	
1	Below 6	3	1.32	1.218	0.07
2	6-10	8	1.45	1.47	0.01
3	11-15	13	1.54	1.610	0.04
4	16-20	18	1.68	1.711	0.01
5	21-25	23	-	1.792	0.00
6	26-30	28	1.73	1.86	0.07

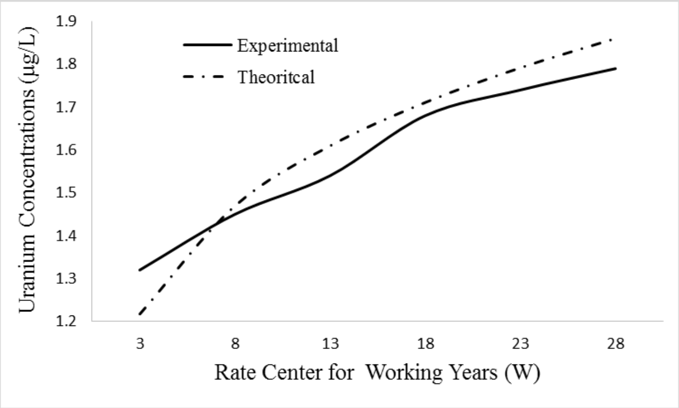

Fig. 3: Comparison between the calculations, obtained by the mathematical modeling, of uranium concentrations in urine samples for the Ceramic factory workers and the experimental values of Abdullah [10].

Table 4: Comparison between the calculations, obtained by the mathematical modeling, of uranium concentrations in urine samples for the Detergent Chemicals workers according to the number of working years, and the experimental values of Abdullah [10].

No.	No. of Working Years	Rate Center for Working Years (*W*)	Uranium Concentration (µg/L)		(%)
			Exp.	Cal.	
1	Below 6	3	-	1.25	0.00
2	6-10	8	1.52	1.519	0.0006
3	11-15	13	1.65	1.66	0.006
4	16-20	18	1.71	1.76	0.02
5	21-25	23	1.87	1.85	0.01
6	26-30	28	-	1.922	0.00

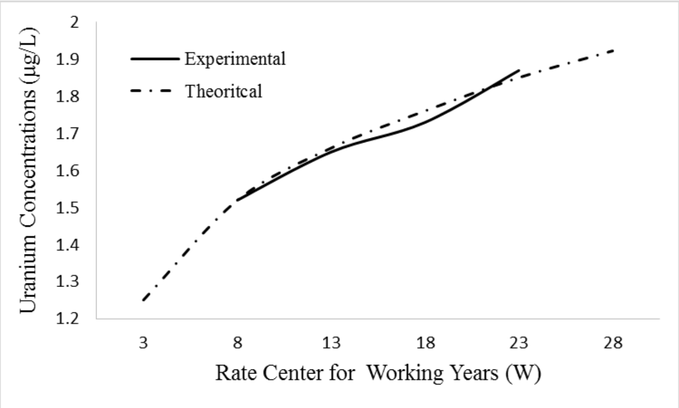

Fig. 4: Comparison between the calculations, obtained by the mathematical modeling, of uranium concentrations in urine samples for the Detergent Chemicals workers and the experimental values of Abdullah [10].

Table 5: Comparison between the calculations, obtained by the mathematical modeling, of uranium concentrations in urine samples for the North oil workers according to the number of working years, and the experimental values of Abdullah [10].

No.	No. of Working Years	Rate Center for Working Years (*W*)	Uranium Concentration (µg/L)		(%)
			Exp.	Cal.	
1	Below 6	3	-	1.218	0.00
2	6-10	8	1.52	1.47	0.03
3	11-15	13	1.58	1.610	0.01
4	16-20	18	1.67	1.711	0.02
5	21-25	23	1.75	1.792	0.02
6	26-30	28	1.76	1.86	0.05

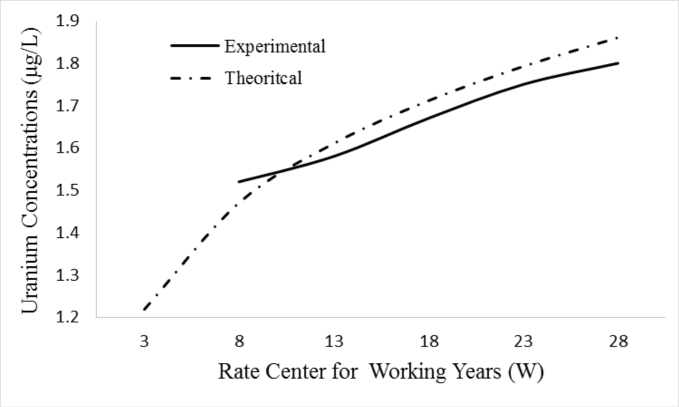

Fig. 5: Comparison between the calculations, obtained by the mathematical modeling, of uranium concentrations in urine samples for the North oil workers and the experimental values of Abdullah [10].

Table 6: Comparison between the calculations, obtained by the mathematical modeling, of uranium concentrations in urine samples for the Mishraq Sulphur workers according to the number of working years, and the experimental values of Abdullah [10].

No.	No. of Working Years	Rate Center for Working Years (*W*)	Uranium Concentration (µg/L)		(%)
			Exp.	Cal.	
1	Below 6	3	1.56	1.38	0.1
2	6-10	8	1.74	1.666	0.04
3	11-15	13	1.78	1.825	0.02
4	16-20	18	-	1.94	0.00
5	21-25	23	-	2.03	0.00
6	26-30	28	1.89	2.1	0.1

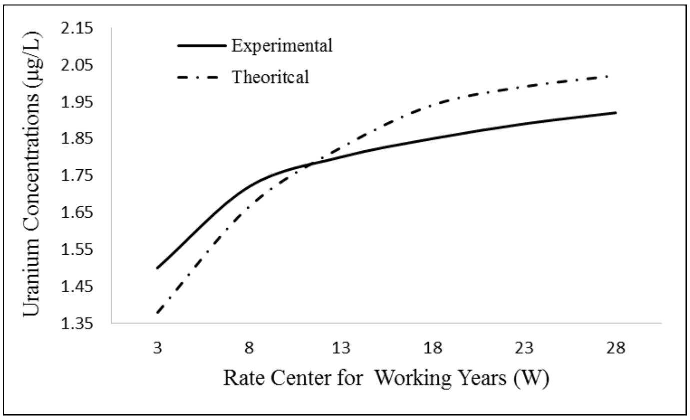

Fig. 6: Comparison between the calculations, obtained by the mathematical modeling, of uranium concentrations in urine samples for the Mishraq Sulphur workers and the experimental values of Abdullah [10].

Table 7: Comparison between the calculations, obtained by the mathematical modeling, of uranium concentrations in urine samples for the North Fertilizer Plant workers according to the number of working years, and the experimental values of Abdullah [10].

No.	No. of Working Years	Rate Center for Working Years (*W*)	Uranium Concentration (µg/L)		(%)
			Exp.	Cal.	
1	Below 6	3	1.59	1.4	0.1
2	6-10	8	1.65	1.69	0.02
3	11-15	13	1.80	1.85	0.02
4	16-20	18	1.85	1.96	0.05
5	21-25	23	2.01	2.06	0.02
6	26-30	28	-	2.139	0.00

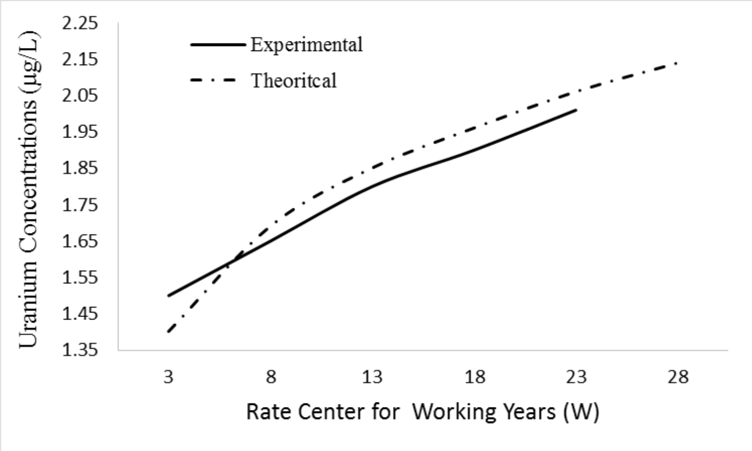

Fig. 7: Comparison between the calculations, obtained by the mathematical modeling, of uranium concentrations in urine samples for the North Fertilizer Plant workers and the experimental values of Abdullah [10].

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النمذجة الرياضية لحساب تراكيز اليورانيوم في عينات الإدرار لعمال المصانع بالاعتماد على سنوات العمل

عمار عبد البطاوي[1]، غسان عزالدين عارف[2]، شادية مجيد نوري[2]، ندى فاضل توفيق[3]، محمد سهيمي جعفر[4]، إسكندر شاه رم مصطفى[4]
[1] قسم الفيزياء ، كلية التربية للعلوم الصرفة ، جامعة تكريت ، تكريت ، العراق
[2] قسم الرياضيات ، كلية التربية للعلوم الصرفة ، جامعة تكريت ، تكريت ، العراق
[3] قسم الفيزياء ، كلية العلوم جامعة النهرين ، بغداد ، العراق
[4] كلية الفيزياء ، جامعة العلوم الماليزية ، ماليزيا

الملخص

تهدف الدراسة الى بناء نموذج رياضي يساعد الباحثين الفيزيائين على حساب تراكيز اليورانيوم في عينات الإدرار لعمال المصانع. بني الموديل الرياضي الجديد بالاعتماد على متغيرات. يقوم الموديل الرياضي المقترح في هذه الدراسه بحساب تراكيز اليورانيوم في عينات الادرار لعمال المصانع الذين يعملون في العديد من المصانع في مواقع مختاره من العراق والذين ربما يتعرضون للاشعاع من جراء العمل. وقد كانت النتائج تتفق مع البيانات والنتائج التجريبية.