Estimating the Amount of Uranium Radiation Effect on the Workers in Selected Chemical Factories by Using the Numerical Spline Method

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Received 19 June 2017 Accepted 24 August 2017

Abstract

The aim of this study is to obtain mathematical models for estimating the effect of uranium radiation on the workers in selected chemical factories in terms the number of years of work by using one of the numerical interpolation methods. We used the spline method to estimate the concentration of uranium radiation in urea samples for selected chemical factories for the number of years of work. where the results of the estimation were close to the experiential results. Then we estimated the effect of uranium radiation on workers for the coming years.

Keywords: Estimation, Spline Method, Mathematical Models, Coming years, Chemical Factories.

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تخمين مقدار تأثير اشعاع اليورانيوم على العاملين في مصانع كيميائية مختارة باستخدام طريقة spline العددية

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الخلاصة

ان الهدف من هذا البحث هو الحصول على نماذج رياضية لتخمين تأثير اشعاع اليورانيوم على العاملين في بعض المصانع الكيميائية بالنسبة لعدد سنوات العمل في المصنع باستخدام احدى طرق الاستكمال العددية حيث استخدمنا طريقة (spline) لتخمين تركيز اشعاع اليورانيوم في عينات اليوريا للعاملين في بعض المصانع الكيميائية بالنسبة لعدد سنوات العمل في المصنع حيث كانت نتائج التخمين قريبة من النتائج التجريبية بعدها قمنا بتخمين مقدار تأثير اشعاع اليورانيوم للعاملين لسنوات لاحقة.

الكلمات المفتاحية : تخمين ، طريقة Spline ، نماذج رياضية، سنوات قادمة، مصانع كيميائية.

Introduction

In this research we studied some numerical estimation methods to calculate the amount of uranium radiation effect on the workers in some chemical factories. We used the numerical spline method to obtain some mathematical models used for estimation. Numerical analysis plays an important role in mathematics and other sciences. We used some numerical interpolation methods for estimation, where the estimated values were approximate values in which the amount of error was too small, so that the approximate values were close to the real values. In recent years there have been many speculative studies where Stephen Balter *et al.* studied techniques to estimate the radiation dose on the skin fluoroscopically [1]. Haregeweyn N. and Yohannes F. Examined and estimated the non-agricultural pollution model (AGNPS) on watersheds in Ethiopia [2]. Michael G., *et al* studied the second generation computer software for internal dose assessment in nuclear medicine [3]. Ilyas. *et al* studied the estimation and comparison of solar radiation spread over Pakistan [4]. Jasmin, I., and Ravichundran S. studied the application of RUSLE2 model for soil erosion assessment using remote sensing and GIS [5]. Degerlier, M, *et al*. also studied radioactivity concentration and dose assessment of soil samples around Adana, Turkey [6]. Firas younes and Waleed studied estimation of net solar radiation in Iraq and its relationship to some radiological and climatic variables [7]. Waleed I. and Fires Hazim studied estimation of long-wave radiation in Iraq [8]. In addition, Saadsh.Sammen studied the prediction of evaporation from the Hemren reservoir using artificial neural networks [9]. As for Tareq Salih Hadi he studied a mathematical model for predicting the expansion of the gated test of Iraqi Portland cement [10]. Sivakumar, S., studied the measurement of natural radiation activity and estimation of risk of radiation in the coastal sediments in the eastern coast of Tamilnadu using the statistical approach [11] .Arshad Ali studied of the estimation of the degrees of temperature for dwarf heat systems from the spectral analysis data [12]. Finally, Najam Ibrahim *et al.* studied the natural radiation activity in selected soil samples from Ur city using a detector [13].

Interpolation and Liner Spline:

Interpolation [14]

It was found that a low order polynomials approximation in each subinterval provides a better approximation to the tabulated function than fitting a single high –order polynomials to the entire range .These connecting piecewise polynomial are called spline functions named after the draftsman device of using a thin flexible strip (called a functions spline) to draw a smooth curve through given points .The points at which two connecting spline meet are called knots .The connecting polynomials could be of any degree and therefore we have different types of spline functions, vis, linear, quadratic, cubic, quantic, etc.

Linear Spline [14]

i=1, 2, …, n Let the given data point be (x_i, y_i)

$a = x_0 < x_1 < x_2 < .... < x_n = b$ Where

i=1, 2, …, n $h_i = x_i - x_{i-1}$ And let

be the spline of degree one defined in the interval $[x_{i-1}, x_i]$ x)(Further, let s_i

Obviously, $s_i(x)$ represents a straight line joining the points (x_{i-1}, y_{i-1}) and (x_i, y_i). Hence, we write

$$s_i(x) = y_{i-1} + m_i(x - x_{i-1}) \quad (1)$$

Where $$m = \frac{y_i - y_{i-1}}{x_i - x_{i-1}}$$

successively in (1).We obtain different spline of degree one valid in setting i=1,2,…n

The subintervals i to n respectively .It is easily seen that $s_i(x)$

Continuous at both the end points.

Application Aspect:

In the application aspect we used spline method for estimating the amount of uranium radiation effect on workers in selected chemical factories.

Spline method

By applying Numerical Spline method on the interval [8, 13] to estimate the average of uranium concentration in urea samples for (Classes factory) workers for their working years in the factory. (w_r) is rate center for working years, $u_c(w_r)$ is Uranium radiation in terms of the number of years of work in chemical factories and we obtained the following:

$$u_c(w_r) = u(w_{r0}) + \frac{u(w_{r1}) - u(w_{r0})}{(w_{r1}) - (w_{r0})}(w_r - w_{r0})$$

$$u_c(w_r) = 1.37 + \frac{1.44 - 1.37}{13 - 8}(w_r - 8)$$

$$u_c(w_r) = 1.37 + 0.014\, w_r - 0.112$$

$$u_c(w_r) = 1.258 + 0.014\, w_r \qquad (2)$$

Table1.

No.	No. of Working Years	Rate Center for Working Years	Classes Factory Exp.	Classes Factory Det.	Absolute Error
1	Below6	3	-	1.3	0.00
2	6-10	8	1.37	1.37	0.00
3	11-15	13	1.44	1.44	0.00
4	16-20	18	1.49	1.51	0.02
5	21-25	23	1.68	1.58	0.1
6	26-30	28	1.80	1.65	0.15

A study shows the experimental values of uranium concentration averages in urea samples for (Classes factory) workers, and the approximated values for their working years in the factory by using numerical spline method on the interval [8,13].

Also by applying Numerical Spline method on the interval [8, 18] to estimate the averages of uranium concentration in urea samples for (Classes factory) workers for their working years in the factory, and we obtained the following**:**

$$u_c(w_r) = u(w_{r0}) + \frac{u(w_{r1}) - u(w_{r0})}{(w_{r1}) - (w_{r0})}(w_r - w_{r0})$$

$$u_c(w_r) = 1.37 + \frac{1.49 - 1.37}{18 - 8}(w_r - 8)$$

$$u_c(w_r) = 1.37 + 0.012(w_r - 8)$$

$$u_c(w_r) = 1.37 + 0.012\ w_r - 0.096$$

$$u_c(w_r) = 1.274 + 0.012\ w_r \qquad (3)$$

Table2.

No.	No. of Working Years	Rate Center For Working years	Classes Factory Exp.	Classes Factory Det.	Absolute Error
1	Below6	3	-	1.31	0.00
2	6-10	8	1.37	1.37	0.00
3	11-15	13	1.44	1.43	0.01
4	16-20	18	1.49	1.49	0.00
5	21-25	23	1.68	1.55	0.13
6	26-30	28	1.80	1.61	0.19

A study shows the experimental values of uranium concentration averages in urea samples for (Classes factory) workers, and the approximated values for their working years in the factory by using numerical spline method on the interval [8,18].

Also by applying numerical Spline method on the interval [8, 23] to estimate the average of uranium concentration in urea samples for (Classes factory) workers for their working years in the factory, and we obtained the following:

$$u_c(w_r) = u(w_{r0}) + \frac{u(w_{r1}) - u(w_{r0})}{(w_{r1}) - (w_{r0})}(w_r - w_{r0})$$

$$u_c(w_r) = 1.37 + \frac{1.68 - 1.37}{23 - 8}(w_r - 8)$$

$$u_c(w_r) = 1.37 + 0.0206666(w_r - 8)$$

$$u_c(w_r) = 1.37 + 0.0206666\ w_r - 0.1653328$$

$$u_c(w_r) = 1.2046672 + 0.0206666\, w_r \qquad (4)$$

Table3.

No.	No. of working years	Rate Center For Working Years	Classes Factory Exp.	Classes factory Det.	Absolute Error
1	Below6	3	-	1.266652	0.00
2	6-10	8	1.37	1.3699952	0.000004
3	11-15	13	1.44	1.4733	0.03
4	16-20	18	1.49	1.4766	0.01
5	21-25	23	1.68	1.6799	0.00001
6	26-30	28	1.80	1.783	0.01

A study shows the experimental values of uranium concentration averages in urea samples for (Classes factory) workers, and the approximated values for their working years in the factory by using numerical Spline method on the interval [8,23].

Throughout the result of table 1, 2, 3 we see that the results of numerical Spline method are better in table 3 where the absolute error is less than other tables.

We have known that the absolute error is the difference between the real value and the estimated value and as the following equation:

$E_{U_C(W_r)} = |\ u_c(w_r) - u^*_c(w_r)\ |$, where $u_c(w_r)$ refers to the real value and $u^*_c(w_r)$ refers to the estimated value [14]، [15], [16].

Mathematical Model Validity

For the validity of mathematical model (4), we used the interpolation and inclusion methods to estimate the averages of uranium concentration in urea samples for (Classes factory) workers. We increased the categories centers from the interval [3,28] to interval [33,43], and we obtained the inclusion in the category center of (13) and (18).

Table4.

No.	No. of Working Years	Rate Center for Working Years	Classes Factory Exp.	Classes Factory Det.	Absolute Error
1	Below6	3	-	1.266652	0.00
2	6-10	8	1.37	1.3699952	0.000004
3	11-15	13	1.44	1.4733	0.03
4	16-20	18	1.49	1.4766	0.01
5	21-25	23	1.68	1.6799	0.00001
6	26-30	28	1.80	1.783	0.01
7	31-35	33	-	1.9328	-
8	36-40	38	-	2.04320	-
9	41-45	43	-	2.15353	-

Shows the validity of mathematical model (4) when expanding the data.

Afigure1shows the validity of the mathematical model (4)) when expanding the data to estimate the averages of uranium concentration in urea samples for (Classes factory) workers.

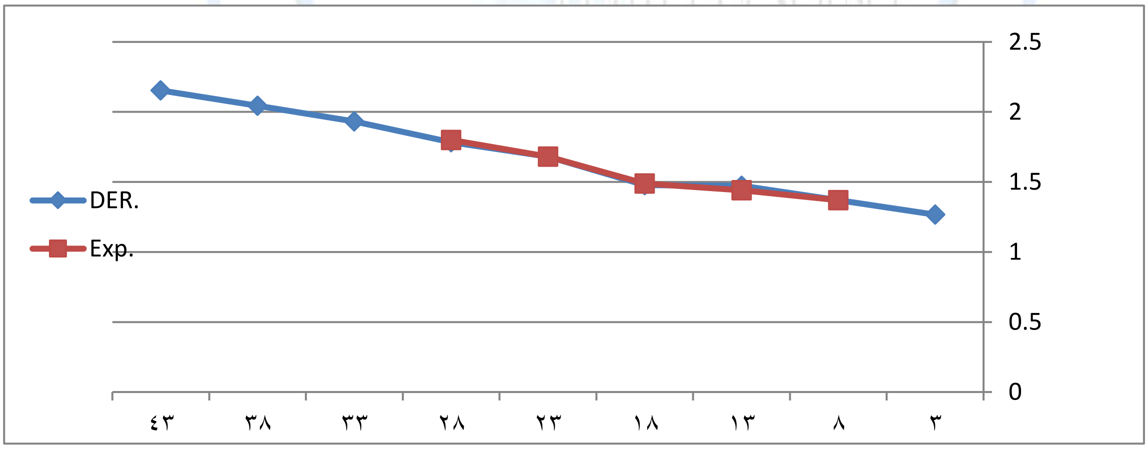

Fig.1: validity of the mathematical model (4) when expanding the data from the interval [3,28] to interval [33,43].

By applying Numerical Spline method on the interval [3,8] to estimate the average of uranium concentration in urea samples for (Ceramic factory) workers for their working years in the factory, we obtained the following:

$$u_c(w_r) = u_c(w_{r0}) + \frac{u(w_{r1}) - u(w_{r0})}{(w_{r1}) - (w_{r0})}(w_r - w_{r0})$$

$$u_c(w_r) = 1.32 + \frac{1.45 - 1.32}{8 - 3}(w_r - 3)$$

$$u_c(w_r) = 1.32 + 0.026(w_r - 3)$$

$$u_c(w_r) = 1.32 + 0.026\, w_r - 0.078$$

$$u_c(w_r) = 1.242 + 0.026\, w_r \qquad (5)$$

Table 5.

No.	No. of Working Years	Rate Center for Working Years	Ceramic Factory Exp.	Ceramic Factory	Absolute Error
1	Below6	3	1.32	1.32	0.000
2	6-10	8	1.45	1.45	0.000
3	11-15	13	1.58	1.58	0.000
4	16-20	18	1.68	1.71	0.03
5	21-25	23	-	1.84	0.00
6	26-30	28	1.93	1.97	0.04

A study shows the experimental values of uranium concentration averages in urea samples for (Ceramic factory) workers, and the approximated values for their working years in the factory by using numerical Spline method on the interval [3,8].

By applying Numerical spline method on the interval [3,13] to the average of uranium concentration in urea samples for (Ceramic factory) workers for their working years in the factory, and we obtained the following:

$$u_c(w_r) = u(w_{r0}) + \frac{u(w_{r1}) - u(w_{r0})}{(w_{r1}) - (w_{r0})}(w_r - w_{r0})$$

$$u_c(w_r) = 1.32 + \frac{1.58 - 1.32}{13 - 3}(w_r - 3)$$

$$u_c(w_r) = 1.32 + 0.026(w_r - 3)$$

$$u_c(w_r) = 1.32 + 0.026\, w_r - 0.078$$

$$u_c(w_r) = 1.242 + 0.026\, w_r \qquad (6)$$

Table 6.

No.	No. of Working Years	Rate Center for Working Years	Ceramic Factory Exp.	Ceramic Factory Det.	Absolute Error
1	Below6	3	1.32	1.32	0.000
2	6-10	8	1.45	1.45	0.000
3	11-15	13	1.58	1.58	0.000
4	16-20	18	1.68	1.71	0.03
5	21-25	23	-	1.84	0.00
6	26-30	28	1.93	1.97	0.04

A study shows the experimental values of uranium concentration averages in urea samples for factory workers (Ceramic factory), and the approximated values for their working years in the factory by using numerical spline method on the interval [3,13].

We see that the mathematical model (5) and(6) have the same formula, so we will apply numerical spline method on the interval [3,18] to estimate the average of uranium concentration in urea samples for (Ceramic factory) workers for their working year in the factory, and we obtained the following.

$$u_c(w_r) = u_c(w_{r0}) + \frac{u(w_{r1}) - u(w_{r0})}{(w_{r1}) - (w_{r0})}(w_r - w_{r0})$$

$$u_c(w_r) = 1.32 + \frac{1.68 - 1.32}{18 - 3}(w_r - 3)$$

$$u_c(w_r) = 1.32 + 0.024(w_r - 3)$$

$$u_c(w_r) = 1.32 + 0.024\, w_r - 0.072$$

$$u_c(w_r) = 1.248 + 0.024\, w_r \qquad (7)$$

Table7.

No.	No. of Working Years	Rate Center for Working Years	Ceramic Factory Exp.	Ceramic Factory Det.	Absolute Error
1	Below6	3	1.32	1.32	0.000
2	6-10	8	1.45	1.44	0.01
3	11-15	13	1.58	1.56	0.02
4	16-20	18	1.68	1.68	0.000
5	21-25	23	-	1.8	0.000
6	26-30	28	1.93	1.92	0.01

A study shows the experimental values of uranium concentration averages in urea samples for (Ceramic factory)factory workers, and the approximated values for their working years in the factory by using numerical spline method on the interval [3,18]

Throughout the result of table (5),(6),(7), we see that the results of numerical spline method are better in table(7) because the absolute error is less than other.

Mathematical Model Validity

For the validity of mathematical model (7), we used the interpolation and inclusion methods to estimate the average of uranium concentration in urea samples for (ceramic factory) workers. We increased the categories centers from the interval [3,28] to interval[33,43], and we obtained the inclusion in the category center of (13) and (18).

Table 8.

No.	No. of Working Years	Rate Center for Working Years	Ceramic Factory Exp.	Ceramic Factory Det.	Absolute Error
1	Below6	3	1.32	1.32	0.000
2	6-10	8	1.45	1.44	0.01
3	11-15	13	1.58	1.56	0.02
4	16-20	18	1.68	1.68	0.000
5	21-25	23	-	1.8	-
6	26-30	28	1.93	1.92	0.01
7	31-35	33	-	2.04	-
8	36-40	38	-	2.16	-
9	41-45	43	-	2.28	-

Shows the validity of mathematical model (7) when expanding the data.

Afigure2 shows the validity of the mathematical model (7) when expanding the data to estimate the average of uranium concentration in urea samples for (ceramic factory) workers.

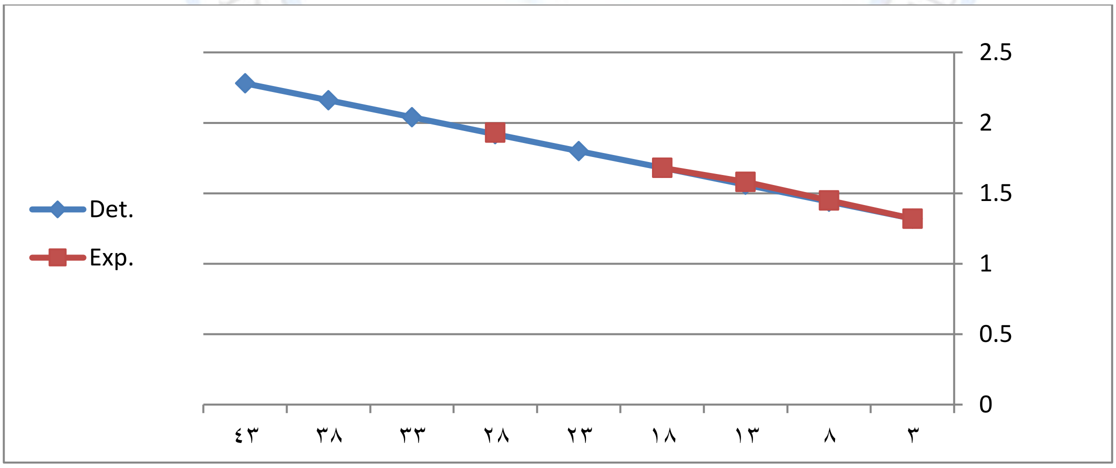

Fig.2: validity of the mathematical model (7) when expanding the data from the interval [3,28] to interval[33,43].

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