# Analysis of Pollution in Al-Fallujah District by Using Estimation of Autoregressive Coefficients

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**Abstract:**

**In this research we analyze the data obtained from Al-Fallujah hospital for the polluted cases and compare it with Al-Yarmouk hospital for the clean cases, using a new method of estimation of autoregressive coefficients.**

**The data obtained from the two hospitals of births for the first five months of 2011.,Also these data are compared with another data taken from Al-Fallujah hospital before 2003 war.**

**The results show high effects on births like the deathof, newly born infants, and mutilation occurred in the hearts, spinal cord and in the nerves system.**

**Key word:- depleted uranium, polluted cases, clean cases, Markov process.**

# تحليل التلوث في منطقة الفلوجة بأستخدام تقدير معاملات الارتباط الذاتي

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**المستخلص**

**لقد قمنا في هذا البحث بتحليل البيانات المأخوذة من مستشفى الفلوجة لولادات الاطفال. سميت ببيانات الفلوجة لانها تعرضت خلال حرب عام 2003 للهجوم بالاسلحة الكيمياوية واليورانيوم المنضب. وتم دراسة أثر هذه الاسلحة على ولادات الاطفال للمدة من 1/ 1/ 2011 ولغاية 31/ 5/ 2011 من خلال البيانات التي تم الحصول عليها من مستشفى الفلوجة**

**ومقارنتها بالبيانات التي تم الحصول عليها من مستشفى اليرموك وللمدة ذاتها . وكذلك تمت مقارنة البيانات مع بيانات اخرى أخذت من عام 2002 أي قبل الحرب.**

**وأظهرت النتائج تأثيراً واضحاً على الولادات من خلال كثرة الوفيات والولادات المشوهة والولادات المصابة بمختلف الامراض.**

**الكلمات المفتاحية**: اليورانيوم المنضب، الحالات المصابة، الحالات السليمة، عمليات ماركوف.

## Introduction:

Fallujah is a city that belongs to Al-Anbar province in the west of Iraq on the bank of Euphrates River, about 60 Km from Baghdad, with 700,000 populations.

At 2003 it was attacked by chemical weapons and depleted uranium.

The effect of these weapons were detected form the cases brought to Fallujah state hospital During our visit to this hospital we noticed , according to government figures of September 2009 , that 24 % of newly born enfants died , one week after their birth , and 75 % were mutilated. The mutilated occurred in the hearts, spinal cord and in the nerves system.

In 2002 however, 530 births were recorded ,with 6 deaths, and one mutilation only.

## 1-A Markov Process [4]

A Markov process $\{x_t\}$ is a stochastic process which when its current state is known exactly, is not altered by additional knowledge concerning its past behavior. One can say it is a system without memory of the past.

For discrete time Markova chain, the state space is finite or countable (in this case it is finite) and whose time index set is t = 0, 1, 2 … k

$P_{ij}^{t,t+1} = P\ [(x_{t+1} = j)/(x_t = i)]$ For all i, j. … (1)

The probability of $x_{t+1}$ being in state j given that $x_t$ is in state i, is called one step transition probability. When the one step transition probabilities are independent of the time variable *t*, we say that the Markov chain has stationary transition probabilities, then:-

$P_{ij}$ the conditional probability that the state undergoes a transition from i to j in one trial.

To estimate the transition probabilities $P_{ij}$, we let $x_j$denote the state after the i transition, then assuming that the initial state $x_0$ to be fixed, the likelihood function for the states 1, 2 … k is

$$f(x_1, x_2, \dots, x_t) = P_{x_0, x_1}, P_{x_1 ' x_2}, \dots., P_{x_{k-1} ' x_k}$$

$$= \prod_{i=1}^{k} \prod_{j=1}^{k} \left(P_{ij}\right)^{n_{ij}}$$

Where $n_{ij}$ is the number of time that the process has been observed to go from state i to state j, Ahmed [1].

It is customary to arrange these probabilities $P_{ij}$ in a matrix form to obtain the following transition matrix *P*:

$$P = \begin{pmatrix} P_{00} & P_{01} & P_{02} & \dots & P_{0k} \\ P_{10} & P_{11} & P_{12} & \dots & P_{1k} \\ \vdots & \vdots & \vdots & & \vdots \\ P_{ko} & P_{k1} & P_{k2} & \dots & P_{kk} \end{pmatrix}$$

Ross [5] proved that the maximum likelihood estimates of $P_i$ is

$\widehat{P_{ij}} = \frac{n_{ij}}{n_i}$ Where $n_i = \sum_{j=1}^{k} n_{ij}$

And$\widehat{P_{ij}}$ is the (intuitive) estimate of $P_{ij}$ the proportion of time that the process leaving state i will enter to state j.

Now to apply this method to our problem, the number of daily visits $n_t$ of patients was recorded during five months. The set { $n_t(l)$} where $n_t$ ($l$) represents the frequency (number of days) that corresponds to each state where $l$ = 0, 1,2,…, k.

According to Box and Jenkins [2] the vector $N_t$ where.

$$N_t = \begin{bmatrix} n_t(0) \\ n_t(1) \\ \vdots \\ n_t(k) \end{bmatrix}$$

Will satisfy the following relation:-

$N_t = P\, N_{t-1}$

$=P^t_{N_0}$; where P is defined in (1)

$= \lambda^t N_0$

Where λ is the largest Eigenvalue of the transition matrix P.

In order to make comparison between the two regions under study,the clean and the polluted, we consider the following, suppose that $\lambda_1$ is the largest eigenvalue of the transition matrix of the clean region $\lambda_2$ is the largest eigenvalue of the transition matrix of the polluted region.

We found that in most of these cases $\lambda_2 > \lambda_1$ so one can conclude the following:

$N_{1t} = \lambda_1^t N_0$ For the clean region

$N_{2t} = \lambda_2^t N_0$ For the polluted region

Therefore: $N_{2t} > N_{1t}$

So we expect that the number of affected individuals in the polluted region is larger than that of the clean region for the same population number.

**1- Eigenvalues and the Population Autocorrelation.**

It is possible to construct a frobenius standard form of the transition matrix by applying Danilevskys method [3] that is for

$$P = \begin{bmatrix} P_{00} & P_{01} & P_{02} & \dots & P_{0k} \\ P_{10} & P_{11} & P_{12} & \dots & P_{1k} \\ \vdots & \vdots & \vdots & & \vdots \\ P_{ko} & P_{k1} & P_{k2} & \dots & P_{kk} \end{bmatrix} \text{ And } Q = \begin{pmatrix} \emptyset_0 & \emptyset_1 & \cdots & \emptyset_k \\ 1 & 0 & \dots & 0 \\ 0 & 1 & \dots & 0 \\ \vdots & \vdots & \dots & \vdots \\ 0 & 1 & \cdots & 0 \end{pmatrix}$$

Where Q = $S^{-1}$ PS and is a non-singular matrix since similar matrices have the same characteristic polynomial, equal eigenvalues.

$\lambda_i$ $S_o$ D($\lambda$) = det (P-$\lambda_I$) = det (Q-$\lambda_I$)

Where

$$D(\lambda) = (\emptyset_0 - \lambda)(-\lambda)^k - \emptyset_1(-\lambda)^{k-1} + \emptyset_2(-\lambda)^{k-2} + \cdots + (-1)^k\emptyset_k$$

$$= (-1)^{k+1}(\lambda^{k+1} - \emptyset_0\lambda^k - \emptyset_1\lambda^{k-1} \dots - \emptyset_k)$$

$$= (-1)^{k+1}\left(\lambda^{k+1} - \sum_{i=0}^{k} \emptyset_i\lambda^{k-i}\right)$$

When D (λ) = 0 we get

$\sum_{i=0}^{k} \emptyset_i \lambda^{-(k+i)} = 1$ …. (2)

From box and Jenkins [2]

$\emptyset(B)\mathcal{P}_k = 0$

Then$\emptyset(B) = 1 - \sum_{i=0}^{k} \emptyset_i \lambda^{i+1} = 0$ … (3)

Comparing (2) and (3) we conclude that the roots of the polynomial $\emptyset(B)$ are equal to the inverses of the eigenvalues, that is

B= $\lambda^{-1}$….. (4)

It can be easily proved that all eigenvalues of the transition matrix are always less than or equal to one, and since the roots of the polynomial $\emptyset(B)$ must be outside the unit circle (to be stationary) (i-e)$\lambda^{-1}$ is outside the unit circle and λ will be within the unit circle. These eigenvalues must be substituted in the general form of the difference equation of the population autocorrelation, Taylor [6].

Therefore

$\rho_i = A_1\lambda_1^j + A_2\lambda_2^j + \cdots + A_k\lambda_k^j$ …. (5)

$$\begin{bmatrix} \lambda_1 & \lambda_2 & \cdots & \lambda_k \\ \lambda_1^2 & \lambda_2^2 & \cdots & \lambda_k^2 \\ \vdots & \vdots & \cdots & \vdots \\ \lambda_1^k & \lambda_1^k & \cdots & \lambda_k^k \end{bmatrix} \begin{bmatrix} A_1 \\ A_2 \\ \vdots \\ A_k \end{bmatrix} = \begin{bmatrix} \rho_1 \\ \rho_2 \\ \vdots \\ \rho_k \end{bmatrix} \text{…. (6)}$$

$$\begin{bmatrix} A_1 \\ A_2 \\ \vdots \\ A_k \end{bmatrix} = \begin{bmatrix} 1/k \\ 1/k \\ \vdots \\ 1/k \end{bmatrix}$$

Then $\frac{1}{k}\sum_{i=1}^{k}\lambda_i = \widehat{p_i}$ and so on $\frac{1}{k}\sum_{i=1}^{k}\lambda_i = \widehat{p_k}$ … (7)

Since $\lambda_i < 1$ for i=1,2,…., k

Then $\widehat{\rho_1} > \widehat{\rho_2} > \cdots > \widehat{\rho_k}$

Therefore the correlogram in this result will give damped exponential curve which coverages to zero-from these estimates $\rho_1$ one can use Yule-walker system of linear equations to find the estimates of the autoregressive coefficients $\emptyset_i$ as:

$$\begin{bmatrix} 1 & \hat{\rho}_1 & \hat{\rho}_2 & \cdots & \hat{\rho}_{k-1} \\ \hat{\rho}_1 & 1 & \hat{\rho}_1 & \cdots & \hat{\rho}_{k-2} \\ \hat{\rho}_2 & \hat{\rho}_1 & 1 & \cdots & \hat{\rho}_{k-3} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ \hat{\rho}_{k-1} & \hat{\rho}_{k-2} & \cdots & \cdots & 1 \end{bmatrix} \begin{bmatrix} \emptyset_1 \\ \emptyset_2 \\ \vdots \\ \vdots \\ \emptyset_k \end{bmatrix} = \begin{bmatrix} \rho_1 \\ \rho_2 \\ \vdots \\ \vdots \\ \rho_k \end{bmatrix} \ldots (8)$$

Application and Analysis:

Data taken is included in the Table NO. 2 additional from Al-Fallujah hospital situated in Al-Fallujah town and also time table NO.3 additional from AL-Yarmulke Hospital situated in Baghdad southwards.

The data include study of the cases of birth for five months from (1-1-2011 to 31-5-2011).

The data in these districts has been compared to clean and polluted cases. It has been limited to Eigen value matrix of transformations (8*8)

Matrix of Al-Fallujah hospital

$$p=\begin{bmatrix} 0.086 & 0.11 & 0.104 & 0.056 & 0.053 & 0.023 & 0.014 & 0.008 \\ 0.002 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0.002 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0.002 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0.002 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0.002 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0.002 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0.002 & 0 \end{bmatrix}$$

Matrix of Al-yarmouk hospital

$$p=\begin{bmatrix} 1.8 & 0.909 & 0.09 & 0 & 0 & 0 & 0 & 0 \\ 0.0181 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0.0181 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0.0181 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0.0181 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0.0181 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0.0181 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0.0181 & 0 \end{bmatrix}$$

The matrices above have been extracted from the data of the additional table. From these matrices we follow the following steps to find the solution:-

Solution steps:

1- Estimation of the population autocorrelation through the Eigenvalues of the transition matrices was established.
2- Parsimony (less number of autoregressive coefficients) was obtained.

3- Comparison between the different regions, clean and polluted, was identified by the largest Eigen values of the corresponding transition matrix.
4- The second order autoregressive model $AR_{(2)}$ was found to be the fittest to the morbidity data of the respiratory disease .
5- The daily visits for three diseases (heart , spinal cord , notochord mutilation ) was recorded in the two maintained hospitals , and the estimates of the coefficient of autoregressive $\phi_i$ for the clean and polluted areas was found in (table-1-) and it is clear from the table that coefficient of autoregressive gave higher values for polluted region than that of the clean region .

Table -1-estimates of the coefficients of autoregressive model by eigenvalues in corporations

| Autoregressive coefficient / Disease | region | ϕ1 | ϕ2 | ϕ3 | ϕ4 | ϕ5 |
|---|---|---|---|---|---|---|
| Spinal cord | 1<br>2 | 0.002<br>0.967 | 0.014<br>0.102 | 0.005<br>0.211 | -0.001<br>0.449 | <br>0.062 |
| Notochord mutilation | 1<br>2 | 0.012<br>0.321 | 0.001<br>0.031 | 0.003 | <br>0.051 | |
| heart | 1<br>2 | 0.729<br>0.694 | 0.081<br>0.433 | 0.024<br>0.062 | -0.031<br>0.042 | <br>-0.006 |

1. Represent clean region
2. Represent polluted region

**Table-2 Data of AL-Fallujah hospital referring the number of polluted cases in a day for first five months of year 2011.**

| D / M | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 | 1 | 0 | 2 | 0 | 1 | 1 | 0 | 4 | 2 | 1 | 6 | 0 | 2 | 3 | 1 | 1 | 2 | 1 | 3 | 0 | 0 | 2 | 0 | 4 | 1 | 2 | 1 | 5 | 1 | ϕ |
| 2 | 1 | 0 | 3 | 0 | 1 | 1 | 2 | 2 | 3 | 4 | 0 | 5 | 0 | 7 | 1 | 3 | 2 | 1 | 1 | 4 | 3 | 2 | 0 | 0 | 2 | 4 | 1 | 3 | / | / | / |
| 3 | 4 | 2 | 1 | 3 | 2 | 1 | 4 | 5 | 7 | 0 | 2 | 1 | 1 | 3 | 4 | 4 | 2 | 0 | 1 | 1 | 3 | 6 | 0 | 2 | 1 | 4 | 5 | 1 | 2 | 2 | ϕ |
| 4 | 5 | 3 | 0 | 2 | 4 | 5 | 1 | 4 | 1 | 3 | 2 | 1 | 4 | 5 | 6 | 2 | 0 | 1 | 0 | 0 | 2 | 3 | 2 | 2 | 3 | 1 | 1 | ϕ | 6 | 2 | / |
| 5 | 6 | 2 | 4 | 2 | 4 | 6 | 2 | 0 | 3 | 1 | 4 | 2 | 2 | 2 | 1 | 3 | 6 | 7 | 3 | 3 | 4 | 2 | 2 | 1 | 3 | 3 | 1 | 1 | 4 | 5 | ϕ |

D: Day M: Month

**Table-3 Data of AL-Yarmouk hospital referring the number of polluted cases in a day for first five months of year 2011.**

| D / M | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 2 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | / | / | / |
| 3 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 2 | 1 | 0 | 1 | 0 |
| 4 | 1 | 0 | 0 | 2 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | / |
| 5 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 |

D: Day M: Month

Conclusion:

The current study showed that the rapid mutilations of infants were because of the smoke coming from depleted uranium.It is known that the smoke can have a direct effect throughout many miles from the center (The ).

But the radial effect weakens as the distance from the center goes further, but still can affect the respiratory and the digestive systems.

5.4 % of it affects the kidneys from dissolvable uranium and 0.4 % is undissovable and goes out of the body after being absorbed by the blood with a high percentage (90 %).
The remaining 10% remains in different parts of the body depleted uranium oxide.
This is undissolvable remains in the lungs for years and will be absorbed slowly by the blood until it goes out with urine.
Table 1 summarizes the result of using our mathematical model (estimation of autoregressive coefficients).

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