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Research article

MODELS EVALUATION TO PREDICT THE DEPOSITION OF URANIUM AND SALMONELLAE IN LATERITIC AND SILTY FORMATIONS AT INDUSTRIAL LAYOUT OF PORT HARCOURT METROPOLIS, NIGER DELTA OF NIGERIA

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Abstract

Modeling the deposition of uranium and salmonellae has expressed in different way, this is done to establish the best fit governing equation and model application for the study area, the results of both developed model at different equation were compared to express their behaviour including level of concentrations at different soil formation, both parameter compare faviourably well by establishing a best fit for the study area. The study location developed concentration at rapid state from their migration process, the expressed figure shows figures in an exponential state, while some maintained the same but experienced decrease base of low observed degree of porosity including change in concentration with respect to increase in depth, this condition exclude the deposition of substrate but focus on the formation influences more, this implies that substrate influences were made insignificant in the deposition and migration of uranium and salmonellae, the study is imperative because it has produces two different model that can be applied for monitoring and prevention of uranium and salmonellae at different direction of migration in the study location.

Keywords: models evaluation, uranium and salmonellae, lateritic and silty formation.

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1. Introduction

Heavy metal contamination of aquatic ecosystems is becoming a prospective global problem. Developing nations such as Nigeria, lack for mechanisms and sensitive tools to detect and observe water quality and are therefore exposed to heavy metal poisoning (Ochieng et al., 2008, Eluozo, 2013). Trace amounts of heavy metals are constantly. Present in fresh waters from terrigenous sources such as weathering of rocks resulting into geo-chemical recycling of heavy metal elements in these ecosystems (Muwanga, 1997; Zvinowanda et al., 2009). Trace elements may be immobilized within the stream sediments and thus could be involved in absorption, co precipitation, and complex formation (Orator and Opuene, 2007; Mohiuddin et al., 2010). Sometimes they are co-adsorbed with other elements as oxides Hydroxides of Fe, Mn, or may occur in particulate form (Awofolu et al., 2005; Mwiganga and Kansiime, 2005). Heavy metals may enter into aquatic ecosystems from anthropogenic sources, such as industrial wastewater discharges, sewage wastewater, fossil fuel combustion and atmospheric deposition (Linnik and Zubenko, 2000; Campbell, 2001; Lwanga et al., 2003; El Diwani and El Rafie, 2008; Idrees, 2009). Trace elemental concentrations in stream sediment compartments can be used to reveal the history and intensity of local and regional pollution (Nyangababo et al., 2005a, Eluozo, 2013). Sentongo (1998); Matagi (1998) and Kansiime et al., (1995) observed significant pollution load by organic and inorganic substances into the Nakivubo ecosystem. Some work on heavy metal loading of Lake Victoria wetlands, Nakivubo Channel and heavy metal pollution in and around Kampala was recognised (Nyangababo 2003; Nyangababo et al., 2005b; Muwanga and Barifaijo, 2006 and Nabulo et al., 2008). The objectives of the present work were to (1) assess the geochemistry of the Nakivubo stream sediments so as to establish the possibility of secondary pollution of the sediments; (2) establish the association among heavy metals and stream physico-chemical characteristics and (3) determine the source apportionment of heavy metals using cluster and factor analyses (Sekabira, et al 2010).

2. Materials and method

Soil samples from several different boring locations, were collected at intervals of one metre each (30cm). Soil sample were collected in five different location, applying insitu method of sample collection, the soil sample were collect for analysis, standard laboratory analysis were collected to determine the uranium and salmonellae concentration through column experiment, the result were analysed to determine the influence on uranium and salmonellae transport between lateritic and silty soil formation in the study area.

Nomenclature

ϕ = Permeability $[LT^{-1}]$

C = Concentration of Uranium $[MTL^{-3}]$

T = Time [T]

y = Distance [L]

$$\theta \frac{\partial c}{\partial t} = D \frac{\partial^2 c}{\partial y^2} \quad \ldots\ldots\ldots\ldots \quad (1)$$

Let $C = T^1Y$

$$\frac{\partial c}{\partial t} = T^1Y \qquad \text{............................... (2)}$$

$$\frac{\partial^2 c}{\partial y^2} = TY^{11} \qquad \text{............................... (3)}$$

$$\theta T^1Y = DTY^{11} = \gamma^2 \qquad \text{............................... (4)}$$

Let $\theta\frac{T^1}{T} = D\frac{Y^{11}}{Y} = -\gamma^2$ .... (5)

$$\int\frac{dT}{T} = \int\frac{-\lambda^2}{\theta}dt \qquad \text{............................... (6)}$$

$$LnT = \frac{-\gamma^2}{\theta}t + a_3 \qquad \text{............................... (7)}$$

$$T = \ell^{\frac{-\gamma^2}{\theta}t + a_3} \qquad \text{............................... (8)}$$

$$T = C_3\,\ell^{\frac{-\gamma^2}{\theta}t} \qquad \text{............................... (9)}$$

$$D\frac{Y^{11}}{Y} = -\gamma^2 \qquad \text{............................... (10)}$$

$$\frac{\partial^2 y}{\partial y^2} + \frac{\gamma^2}{D}y = 0 \qquad \text{............................... (11)}$$

Auxiliary equation

$$M^2 + \frac{\gamma^2}{D} = 0 \qquad \text{............................... (12)}$$

$$M = \pm i\frac{\gamma}{\sqrt{D}} \qquad \text{............................... (13)}$$

$$\therefore\ Y \ = \ ACos\frac{\gamma}{\sqrt{D}}y \ + \ BSin\frac{\gamma}{\sqrt{D}}y \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (14)$$

Combine (29) and (34), we have

$$C_2 \ = \ TY$$

$$C_2 \ = \ C_3\,\ell^{\frac{-\gamma^2}{\theta}t}\ ACos\frac{\gamma}{\sqrt{D}}y \ + \ ASin\frac{\gamma}{\sqrt{D}}y \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (15)$$

3. Validated Theoretical Equation

Theoretical background for 3rd degree polynomial curve fitting

General: $y = a_0 + a_1x + a_2x^2 + a_3x^3 + \ldots\ldots\ldots + a_nx^n$

If the above polynomial fits the pair of data (x, y) it means that every pair of data will satisfy the equation (polynomial).

Thus; $y_1 = a_0 + a_1x_1 + a_2x_1^2 + a_3x_1^3 + \ldots\ldots\ldots + a_nx_1^n \qquad \ldots\ldots\ldots\ldots \qquad (1)$

$$y_2 = a_0 + a_1x_2 + a_2x_2^2 + a_3x_2^2 + \ldots\ldots\ldots + a_nx_2^n \ldots \qquad \ldots\ldots\ldots\ldots \qquad (2)$$

$$y_3 = a_0 + a_1x_3 + a_2x_3^2 + a_3x_2^2 + \ldots\ldots\ldots + a_nx_2^n \qquad \ldots\ldots\ldots\ldots \qquad (3)$$

$$y_4 = a_0 + a_1x_4 + a_2x_n^2 + a_3x_n^2 + \ldots\ldots\ldots + a_nx_4^n \qquad \ldots\ldots\ldots\ldots \qquad (4)$$

Summing all the equations will yield (1 $\rightarrow$)

$$\sum_{i=1}^{i=n} y_i = \sum a_0 + \sum_{i=1}^{i=n} a_1\,x_i + \sum_{i=1}^{i=n} a_2x_i^2 + \sum_{i=1}^{i=n} a_3x_i^3 + \sum_{i=1}^{i=n} a_4x_i^4 + \ldots\ldots + \sum_{i=1}^{i=n} a_nx_i^n$$

$$\boxed{\sum_{i=1}^{i=n} y_i = na_0 + a_1\sum_{i=1}^{n} x_i + a_2\sum_{i=1}^{n} x_i^2 + a_3\sum_{i=1}^{n} x_i^3 + \ldots\ldots + \sum_{i=1}^{n} x_i^n} \qquad \ldots\ldots\ldots\ldots \ (5)$$

To form the equations to solve for the constants $a_0,\ a_1,\ a_2, a_3,\ \ldots\ldots a_n$.

We multiply equations (3.84) by $x_{i,}\ x_i^2,\ x_i^3 \ldots\ldots\ldots\ x_i^n$.

$$\sum_{i=1}^{1} y_i = na_0 + a_1 \sum x_i + a_2 \sum x_i^2 + a_3 \sum x_i^3 + \ldots\ldots + a_n \sum x_i^n \qquad \ldots\ldots\ldots \qquad (6)$$

Multiply equation (6) by x_i

$$x_i \sum y_i = na_0\, x_i + a_1\, x_i \sum x_i + a_2\, x_i \sum x_i^2 + a_3\, x_i \sum x_1^3 + \ldots\ldots.. + a_n\, x_i \sum x_i^n$$

$$\sum y_i\, x_i = a_0 \sum x_i + a_1 \sum x_i^2 + a_2 \sum x_i^3 + a_3 \sum x_i^4 + \ldots\ldots.. + a_n \sum x_i^{n+1} \qquad \ldots\ldots\ldots \qquad (7)$$

Multiply equation (6) by x_i^2

$$x_i^2 \sum y_i = na_0\, x_i^2 + a_1\, x_i^2 \sum x_i + a_2\, x_i^2 \sum x_i^2 + a_3\, x_i^2 \sum x_i^3 + \ldots\ldots.. + a_n\, x_i^2 \sum x_i^n \;.. \qquad (8)$$

$$\sum y_i\, x_i^2 = a_0 \sum x_i^2 + a_1 \sum x_i^3 + a_2 \sum x_i^4 + a_3 \sum x_i^5 + \ldots\ldots.. + a_n \sum x_i^{n+2} \qquad \ldots\ldots\ldots \qquad (9)$$

Multiply equation (3.85) by x_i^3

$$x_i^3 \sum y_i = na_0\, x_i^3 + a_1\, x_i^3 \sum x_i + a_2\, x_i^3 \sum x_i^2 + a_3\, x_i^3 \sum x_i^3 + \ldots\ldots.. + a_n\, x_i^3 \sum x_i^n$$

$$\sum y_i\, x_i^3 = a_0 \sum x_i^3 + a_1 \sum x_i^4 + a_2 \sum x_i^5 + a_3 \sum x_i^6 + \ldots\ldots.. + a_n \sum x_i^{n+3} \qquad \ldots\ldots\ldots.. \qquad (10)$$

Multiply equation (6) by x_i^n

$$x_i^n \sum y_i = a_0 n\, x_i^n + a_1\, x_i^n \sum x_i + a_2\, x_i^n \sum x_i^2 + a_3\, x_i^n \sum x_i^3 + \ldots\ldots.. + a_n\, x_i^n \sum x_i^n$$

$$= a_0 \sum x_i^n + a_1 \sum x_i^{n+1} + a_2 \sum x_i^{n+2} + a_3 \sum x_i^{n+3} + \ldots\ldots.. + a_n \sum x_i^{n+n} \qquad \ldots\ldots..\; n$$

Putting equation (6) to n into matrix form

$$\begin{bmatrix} n & \sum x_i & \sum x_i^2 & \sum x_i^3 & \ldots\ldots \sum x_i^n \\ \sum x_i & \sum x_i^2 & \sum x_i^3 & \sum x_i^4 & \ldots\ldots \sum x_i^{n+1} \\ \sum x_i^2 & \sum x_i^3 & \sum x_i^4 & \sum x_i^5 & \ldots\ldots \sum x_i^{n+2} \\ \sum x_i^3 & \sum x_i^4 & \sum x_i^5 & \sum x_i^6 & \ldots\ldots \sum x_i^{n+3} \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ \sum x_i^n & \sum x_i^{n+1} & \sum x_i^{n+2} & \sum x_i^{n+3} & \ldots\ldots \sum x_i^{n+n} \end{bmatrix} \begin{bmatrix} a_0 \\ a_1 \\ a_2 \\ a_3 \\ \ldots\ldots \\ a_n \end{bmatrix} = \begin{bmatrix} \sum y_i \\ \sum y_i x_i \\ \sum y_i x_i^2 \\ \sum y_i x_i^3 \\ \ldots \\ \sum y_i x_i^n \end{bmatrix}$$

Solving the matrix equation yields values for constants $a_0, a_1, a_2, a_3, ...a_n$ as the case may be depending on the power of the polynomial. From the above matrix; for our particular case; i.e. polynomial of the third order:

$$y = a_0 + a_1x + a_2x^2 + a_3x^3 \tag{11}$$

The equivalent matrix equation will be; (*n = 3*).

$$\begin{bmatrix} n & \sum x_i & \sum x_i^2 & \sum x_i^3 \\ \sum x_i & \sum x_i^2 & \sum x_i^3 & \sum x_i^4 \\ \sum x_i^2 & \sum x_i^3 & \sum x_i^4 & \sum x_i^5 \\ \sum x_i^3 & \sum x_i^4 & \sum x_i^5 & \sum x_i^6 \end{bmatrix} \begin{bmatrix} a_0 \\ a_1 \\ a_2 \\ a_3 \end{bmatrix} = \begin{bmatrix} \sum y_i \\ \sum y_i x_i \\ \sum y_i x_i^2 \\ \sum y_i x_i^3 \end{bmatrix}$$

Table 1: Comparison of Predictive and Validated theoretical Values Uranium and Salmonella at Different Depths

Depths [M]	Predictive Theoretical Values	Validated Theoretical Values
3	0.95	1.2
6	4.84	4.76
9	10.98	10.62
12	19.3	18.84
15	30.0	29.36
18	42.89	42.24
21	58.03	57.44
24	75.42	74.98
27	95.06	94.48
30	116.95	117.0

Table 2: Comparison of Predictive and Validated theoretical Values Uranium and Salmonella at Different Depths

Depths [M]	Predictive Theoretical Values	Validated Theoretical Values
3	1.18	1.22
6	3.85	2.7
9	5.87	4.58
12	7.24	5.87
15	7.96	6.57
18	8.03	6.67
21	7.46	6.18
24	6.24	5.1
27	4.37	3.42

30	**1.85**	**1.14**

Table 3: Comparison of Predictive and Validated theoretical Values Uranium and Salmonella at Different Depths

Depths [M]	Predictive Theoretical Values	Validated Theoretical Values
3	0.48	0.32
6	2.69	2.5
9	4.58	4.33
12	5.87	5.67
15	6.56	6.44
18	6.67	6.33
21	6.17	6.11
24	5.09	5.23
27	3.41	3.22
30	1.13	1.11

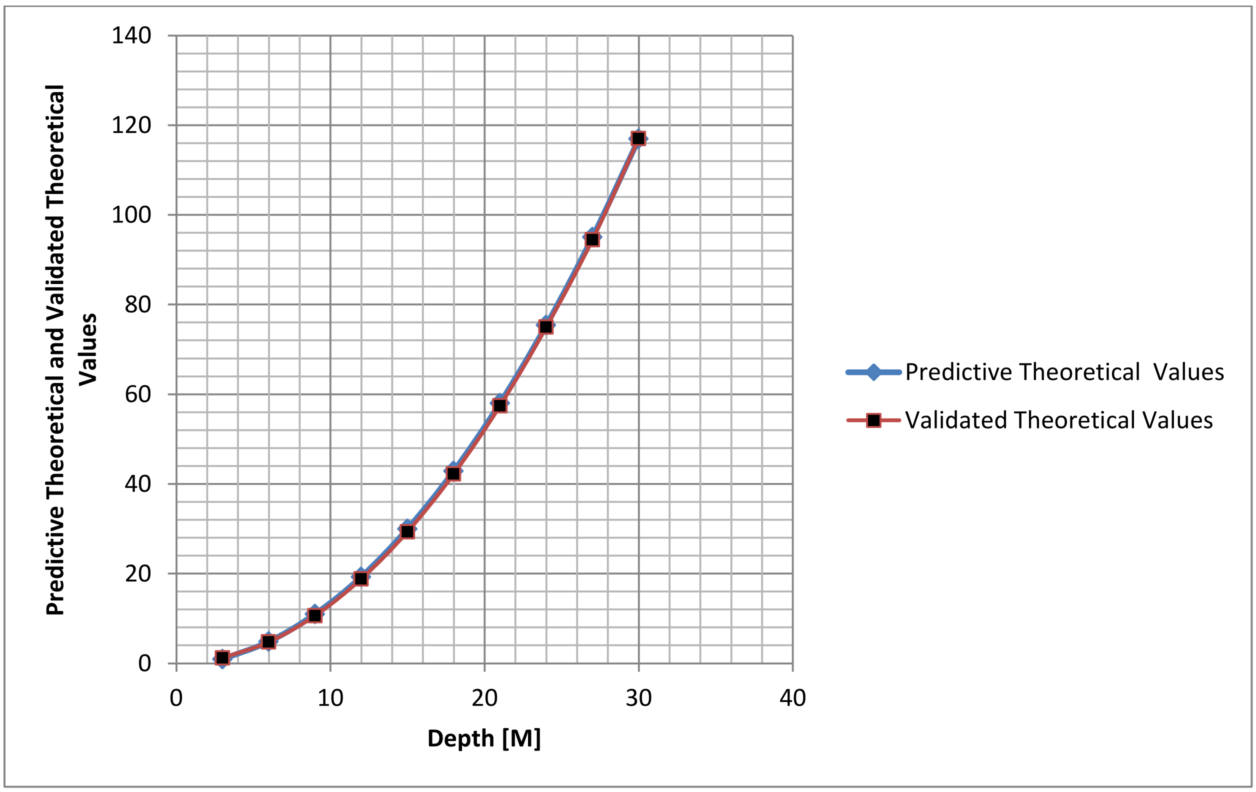

Figure 1: Comparison of Predictive and Validated theoretical Values Uranium and Salmonella at Different Depths

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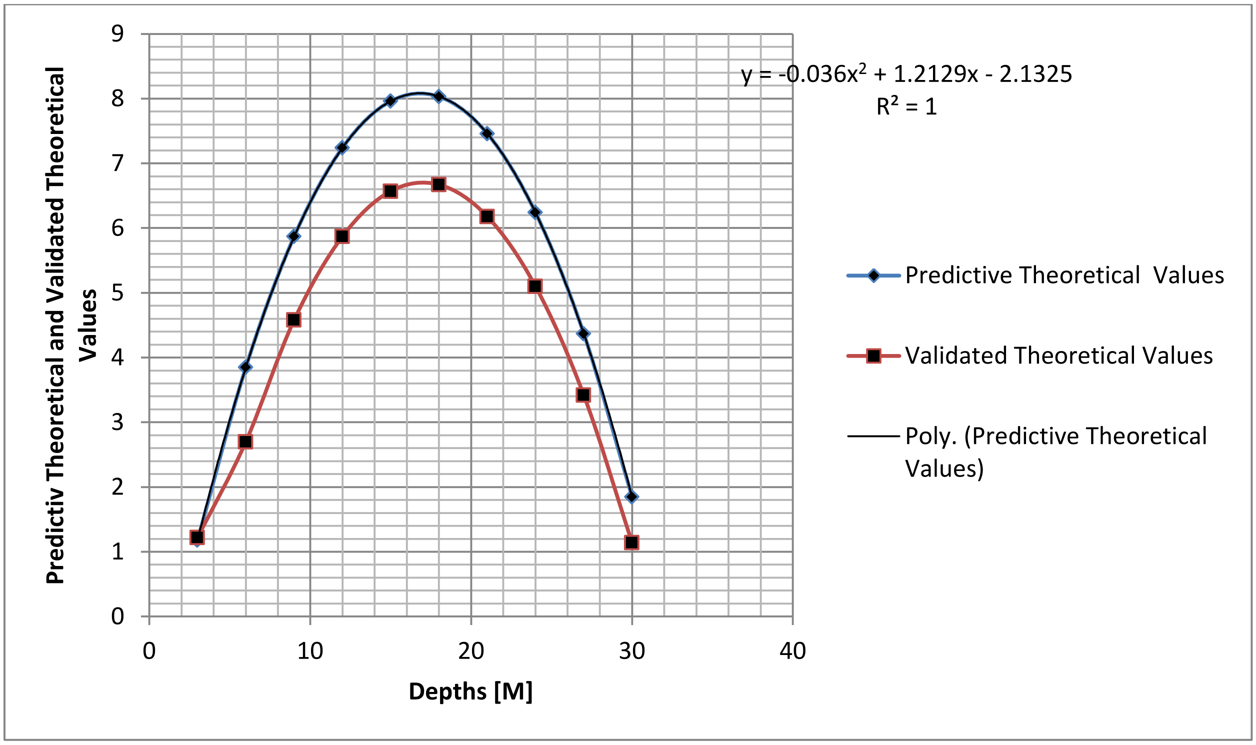

Figure 2: Comparison of Predictive and Validated theoretical Values Uranium and Salmonella at Different Depths

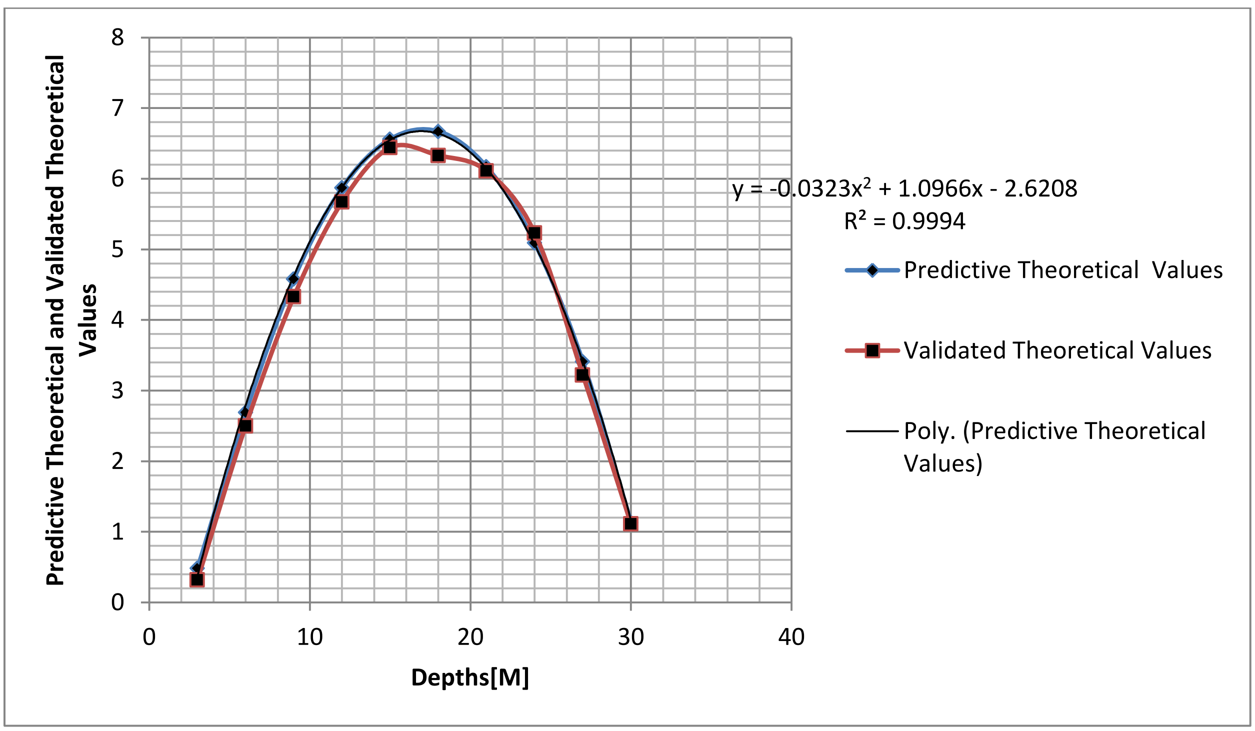

Figure 3: Comparison of Predictive and Validated theoretical Values Uranium and Salmonella at Different Depths

The expression in figure 1 shows that the predictive value rapidly increased to a point where an optimum values were recorded at thirty metres. Similar conditions were observed in the validated theoretical values, rapid increase was experienced from the lowest at three metres to the optimum value observed at thirty metres Figure 2 experienced different condition from figure 1. The predictive theoretical values gradually increased to the optimum values recorded at eighteen metres. In like manner, sudden decrease was observed where the lowest concentration was recorded at thirty metres. Similarly, the validated theoretical values experienced similar condition as gradual increase of concentration were experienced to the point where an optimum value was recorded at the same eighteen metres. Decrease in concentration were gradually observed from twenty-one to the lowest at thirty metres. Figure three expressed a similar condition like figure 2; it gradually increased its concentration from the lowest at three metres to the point where optimum values were observed at eighteen metres. Decrease in change of concentration were experienced from twenty-one to the lowest at thirty metres. From figures 1-3, it has shown the rate of both theoretical values comparing faviourably well. The expression from figure [1-3] shows that the concentration are influenced by the rate formation stratification in the study location, the rate of porosity in the formation determine the rate of increase in concentration as observed in this study. The rate migration in figure one are different from other concentration due to porosity influences from other location, this implies that the degree of porosity establishing different level in deposition also influences the variation of concentration without substrate utilization. both theoretical values has expressed the level authenticity of the model for application in monitoring and prevention of further migration in the soil formation , comparing both results implies that both parameters values can be applied for monitoring and prevention including further studies in the research area.

4. Conclusion

Evaluating the models that will monitor the depositions of uranium and salmonellae in soil and water environment has been expressed, this is to ensure the finest predictive and assessed fit model are applied in monitoring and prediction of uranium and salmonellae in the study area. Two different theoretical values were generated from different conditions within the same study location, the values generated were compared to monitor the best fit model from the various developed equations, comparing both parameters it generate best fit showing that both expressed model from various developed equation can be applied for monitoring and evaluation in the study area. The expressed figures from migration of uranium and salmonellae are base on the variations of porosity in the soil structural deposition in the study area, such condition influences the deposition including the behaviour of the contaminant in the system as it is reflected in the figures. The progressive condition in figure one shows the rate of high degree of porosity, including the deposition of substrate utilization. While that of other varies in migration base of low degree of porosity including decrease in substrate, but the major influences of migration in the study location investigated are determined by degree of porosity as it is expressed from the figures, the study is imperative because it has establish different governing equation in analytical and experimental method, so both methods can be applied to achieve results for the study area.

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