Available online www.jsaer.com

Journal of Scientific and Engineering Research, 2018, 5(3):78-88

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Modelling and Simulation of Franciseilla Accumulation on Effective Stress of Deltaic Clay in Wetland Area Ofahoada East, Rivers State

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Abstract Franciseilla deposit was monitored in predominated wetland location. The study area was found to develop high effective stress in its deposition due the predominance of deltaic clay in the environment. Such deposition in natural wetland location were monitored by applying this modelling approach in order to determine the rate of accumulation and transport of franciseilla due to predominant impermeable deposition in natural wet land. The contaminants experienced high to low concentration; the results range from 6.40E-01-1.85E-08, 1.74E-00-2.10E-02 at distances ranging from 3-42m times ranging from 10-140 days. This implies that there is the tendency of inhibition from impermeable deltaic clay predominant in the formation. Other causes of low deposited concentration are base on some minerals that were found in the formation inhibiting the migration process of the microbes. The developed mathematical model were applied to generate simulation values and compared with experimental results. Both parameters express favorable fits validating the developed model.

Keywords modelling and simulation, franciseilla accumulation, deltaic clay

1. Introduction

Microbes control large amount, assortment and metabolic activity of the ocean and control important biogeochemical pathways that engross the widespread carbon cycle [1]. As a result, microbial progressions are symbolized in mathematical applications used to study global carbon cycle– archetypal weather feedbacks and how aquatic eco - systems act in response to ecological gradients in e.g. temperature, stratification, and nutrient regimes [2-6]. The depositions of Groundwater chemistry are one of the purposes for mineral composition of the aquifer through which it flows. The Hydrochemical procedure and hydro geochemistry of the groundwater fluctuates spatially and temporally, depending on the geology and chemical characteristics of the aquifer. Apodaca, *et al*., [7] have inferred that Hydrogeochemical procedures such as dissolution, precipitation, ion-exchange methods including residence time along the flow path control geochemical composition of groundwater. Abimbola, *et al*., [8]; Olatunji, *et al*., [9], furthermore, instituted the important roles geology plays in the chemistry of subsurface water. More so, the importance of mineral digenesis in the geochemical evolution of groundwater has been clarified by (Back, *et al*., [10]; Plummer, [11]; Bredehoeft *et al*., [5]; Hendry & Schwartz, [13]). Studies by (Goldenberg *et al*., [14]; Jones *et al*., [15]; Drever, [16]; and Keller *et al*., [17], Eluozo, [18]) have also express some soluble conditions minerals undergo in digenetic reactions. They provide a medium for cations exchange reactions as well as present an important influence on the geochemistry of an aquifer system. Preceding studies carried out in the area have tended to emphasize only the general water supply issues [19-20]. Amadi, *et al*., [21] assessed the hydro geochemistry of groundwater in parts of the Niger Delta. Etu-Efeotor, [22]; Udom, *et al*., [23]; Nwankwoala, *et al*., [24], recognized that the groundwater quality in the area is rapidly deteriorating. Increase in population and speedy urbanization has made groundwater the main foundation of water supply, therefore, it is very important to understand the hydrogeochemical processes that take position in the aquifer system [8-9]; it also exhibits sound component of geology that played a significant role in the chemistry of subsurface water. More so, the effect of mineral diagenesis in the geochemical evolution of groundwater has been clarified by (Back, *et al.*, [10]; Plummer, [11]; Bredehoeft *et al.*, [5]; Hendry & Schwartz, [13]). Studies by Goldenberg *et al.*, [14]; Jones *et al.*, [15]; Drever, [16]; and Keller *et al.*, [17], Eluozo, [18] have reported that when soluble minerals react digenetic ally they make accessible intermediate cations exchange reactions as well as present a significant pressure on the geochemistry of an aquifer system. Previous studies carried out in the area of geochemistry emphasize only the general water supply issues [19-20]. Amadi, *et al.*, [11] assessed the hydro geochemistry of groundwater in parts of the Niger Delta. Etu-Efeotor, [22]; Udom, *et al.*, [23]; Nwankwoala, *et al.*, [24], recognized that the groundwater quality in the area is speedily declining. Increase in population and rapid urbanization has made groundwater the major source of water supply, hence, it is very essential to understand the hydrogeochemical processes that take place in the aquifer system.

2. Governing Equation

$$\Delta\tau^1 \frac{d^2c}{dx^2} - V_x \frac{dc}{dx} + \phi_t \frac{dc}{dx} = 0 \qquad \text{…………………..} \qquad (1)$$

Where,

V = velocity of transport

C = concentration of contaminant

ϕ Porosity of the formation

Δ = Effective stress

X = Depth

$$\Delta\tau^1 \frac{d^2c}{dx^2} - \left(V_x - \phi_t\right)\frac{dc}{dx} = 0 \qquad \text{…………………..} \qquad (2)$$

Let $C = \sum_{n=0}^{\infty} a_n x^n$

$$C^1 = \sum_{n=1}^{\infty} n a_n x^{n-1}$$

$$C^{11} = \sum_{n=2}^{\infty} n(n-1) a_n x^{n-2}$$

$$\Delta\tau^1 \sum_{n=2}^{\infty} (n-1) a_n x^{n-2} - \left(V_x - \phi_t\right) \sum_{n=1}^{\infty} n a_n x^{n-1} = 0 \qquad \text{…………………..} \qquad (3)$$

Replace *n* in the 1st term by *n+2* and in the 2nd term by *n+1*, so that we have;

$$\Delta\tau^1 \sum_{n=2}^{\infty} n(n+2)(n+1) a_{n+2} x^n - \left(V_x + \phi_t\right) \sum_{n=0}^{\infty} (n+1) a_{n+1} x^n = 0 \qquad \text{……………} \qquad (4)$$

i.e. $\Delta\tau^1 (n+2)(n+1) a_{n+2} = \left(V_x - \phi_t\right)(n-1) a_{n+1}$ ………………….. (5)

$$a_{n+2} = \frac{\left(V_x - \phi_t\right)(n+1) a_{n+1}}{\Delta\tau^1 (n+2)(n+1)} \qquad \text{…………………..} \qquad (6)$$

$$a_{n+2} = \frac{\left(V_x - \phi_t\right) a_{n+1}}{\Delta\tau^1 (n+2)} \qquad \text{…………………..} \qquad (7)$$

for $n = 0,\ a_2 = \frac{(V_x - \phi_t)a_1}{2\Delta\tau^1}$ ………………….. (8)

for $n = 1,\ a_3 = \frac{(V_x - \phi_t)a_2}{3\Delta\tau^1} = \frac{(V_x - \phi_t)^2 a_1}{2\Delta\tau^1 \bullet 3\Delta\tau^1}$ ………………….. (9)

for $n = 2;\ a_4 = \frac{(V_x - \phi_t)a_3}{\Delta\tau^1} = \frac{(V_x - \phi_t)}{4\Delta\tau^1} \bullet \frac{(V_x - \phi_t)a_1}{3\Delta\tau^1 \bullet 2\Delta\tau^1} = \frac{(V_x - \phi_t)^3 a_1}{4\Delta\tau^1 \bullet 3\Delta\tau^1}$ … (10)

for $n = 3;\ a_5 = \frac{(V_x - \phi_t)}{5\Delta\tau^1} = \frac{(\phi - V_t)^4 a_1}{5\Delta\tau^1 \bullet 4\Delta\tau^1 \bullet 3\Delta\tau^1 \bullet 2\Delta\tau^1}$ …………… (11)

for $n;\ a_n - \frac{(V_x - \phi_t)^{n-1} a_1}{\Delta\tau^{1^{n-1}} n!}$ ………………….. (12)

$$C(x) = a_0 + a_1 x + a_2 x^2 + a_3 x^3 + a_4 x^4 + a_5 x^5 + \ldots\ldots a_n x_n \quad \text{…………..} \quad (13)$$

$$= a_0 + a_1 x + \frac{(V_x - \phi_t)a_1 x^2}{2!\Delta\tau^1} + \frac{(V_x - \phi_t)a_1 x^3}{3!\Delta\tau^2} + \frac{(V_x - \phi_t)x^4}{4!\Delta\tau^3} + \frac{(V_x - \phi_t)^5}{5!\Delta\tau^4} \quad (14)$$

$$C(x) = a_0 + a_1\left[x + \frac{(V_x - \phi_t)x^2}{2!\Delta\tau^1} + \frac{(V_x - \phi_t)^2 x^3}{3!\Delta\tau^2} + \frac{(V_x - \phi_t)^3 x^4}{4!\Delta\tau^3} + \frac{(V_x - \phi_t)x^5}{5!\Delta\tau^4} + \ldots\right] \quad (15)$$

$$\boxed{C(x) = a_0 + a_1 \ell^{\frac{(V_x - \phi_t)}{\Delta\tau^1}x}}$$ ………………….. (16)

Applying the following boundary condition to equation(16),we have

$C(o) = 0$ *and* $C(o) = H$

$$C(x) = a_0 + a_1 \ell^{\frac{(\phi - V_t)}{K}x}$$

$$C(o) = a_0 + a_1 = 0$$

i.e. $a_0 + a_1 = 0$ ………………….. (17)

$$C^1(x) = \frac{(\phi - V_t)}{2!K} a_1 \ell^{\frac{(\phi - V_t)}{K}x}$$

$$C^1(o) = \frac{(\phi - V_t)}{2!K} a_1 = H$$

$$a_1 = \frac{HK}{\phi - V_t} \quad \text{…………………..} \quad (18)$$

Substituting (18) into equation (17), gives

$$a_1 = a_0$$

$$\Rightarrow a_0 = \frac{-HK}{\phi - V_t} \quad \text{…………………..} \quad (19)$$

Hence, solution of equation (16) is of the form:

$$C(x) = -\frac{HK}{\phi - V_t} + \frac{HK}{\phi - V_t} \ell^{\frac{(\phi - V_t)}{K}x}$$

$$\Rightarrow C(x) = \frac{HK}{\phi - V_t}\left[\ell^{\frac{(\phi - V_t)}{K}x} - 1\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (20)$$

If $x = V \bullet t$

$$\therefore \quad C(x) = \frac{HK}{\phi - V_t}\left[\ell^{\frac{(\phi - V_t)}{K}V \bullet t} - 1\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (21)$$

If $H = \dfrac{d}{V}$

$$C(x) = \frac{HK}{\phi - V_t}\left[\ell^{\frac{(\phi - V_t)}{K}\frac{d}{V}} - 1\right]$$

3. Materials and Method

Standard laboratory experiments were performed to monitor franciseilla using the standard method for the experiment at different formation. The soil deposition of the strata was collected in sequences base on the structural deposition of the lithology at different locations. The samples collected at different locations generated variations at different depths producing different franciseilla concentration through column experiment. From the pressure flow at different strata, the experimental results were compared with the theoretical values for the validation of the model.

4. Results and Discussion

Results of the experiments are presented in tables including graphical representation for franciseilla concentration

Table 1: Concentration of franciseilla at Different Depth

Depth [M]	Predicted Values Conc. [Mg/L]
3	6.40E-01
6	2.70E-01
9	8.90E-02
12	2.55E-02
15	6.84E-03
18	1.76E-03
21	4.41E-04
24	1.08E-04
27	2.94E-05
30	6.24E-06
33	1.47E-06
36	3.45E-07
39	8.03E-08
42	1.85E-08

Table 2: Predicted and Validate Concentration of franciseilla at Different Depth

Depth [M]	Predicted Values Conc. [Mg/L]	Validated Concentration [Mg/L]
3	6.40E-01	6.66E-01
6	2.70E-01	2.88E-01
9	8.90E-02	8.98E-02
12	2.55E-02	2.66E-02
15	6.84E-03	6.99E-03

18	1.76E-03	1.87E-03
21	4.41E-04	4.55E-04
24	1.08E-04	1.12E-04
27	2.94E-05	2.98E-05
30	6.24E-06	6.33E-06
33	1.47E-06	1.55E-06
36	3.45E-07	3.55E-07
39	8.03E-08	8.21E-08
42	1.85E-08	1.89E-08

Table 3: Concentration of franciseilla at Different Times

Time [T]	Predicted Values Conc. [Mg/L]
10	6.40E-01
20	2.70E-01
30	8.90E-02
40	2.55E-02
50	6.84E-03
60	1.76E-03
70	4.41E-04
80	1.08E-04
90	2.94E-05
100	6.24E-06
110	1.47E-06
120	3.45E-07
130	8.03E-08
140	1.85E-08

Table 4: Predicted and Validate Concentration of franciseilla at Different Time

Time [T]	Predicted Values Conc. [Mg/L]	Validated Concentration [Mg/L]
10	6.40E-01	6.66E-01
20	2.70E-01	2.88E-01
30	8.90E-02	8.98E-02
40	2.55E-02	2.66E-02
50	6.84E-03	6.99E-03
60	1.76E-03	1.87E-03
70	4.41E-04	4.55E-04
80	1.08E-04	1.12E-04
90	2.94E-05	2.98E-05
100	6.24E-06	6.33E-06
110	1.47E-06	1.55E-06
120	3.45E-07	3.55E-07
130	8.03E-08	8.21E-08
140	1.85E-08	1.89E-08

Table 5: Concentration of franciseilla at Different Depths

Depth [M]	Predicted Values Conc. [Mg/L]
3	1.74E+00
6	2.03E+00
9	1.78E+00

12	1.38E+00
15	1.00E+00
18	7.00E-01
21	4.70E-01
24	3.10E-01
27	2.00E-01
30	1.30E-01
33	8.00E-02
36	5.50E-02
39	3.40E-02
42	2.10E-02

Table 6: Predicted and Validated Concentration of franciseilla at Different Depths

Depth [M]	Predicted Values Conc. [Mg/L]	Validated Concentration [Mg/L]
3	1.74E+00	1.87
6	2.03E+00	2.11
9	1.78E+00	1.88
12	1.38E+00	1.42
15	1.00E+00	1.11
18	7.00E-01	7.11E-01
21	4.70E-01	4.85E-01
24	3.10E-01	3.22E-01
27	2.00E-01	2.14E-01
30	1.30E-01	1.36E-01
33	8.00E-02	8.24E-02
36	5.50E-02	5.66E-02
39	3.40E-02	3.47E-02
42	2.10E-02	2.24E-02

Table 7: Concentration of franciseilla at Different Times

Time [T]	Predicted Values Conc. [Mg/L]
10	1.74E+00
20	2.03E+00
30	1.78E+00
40	1.38E+00
50	1.00E+00
60	7.00E-01
70	4.70E-01
80	3.10E-01
90	2.00E-01
100	1.30E-01
110	8.00E-02
120	5.50E-02
130	3.40E-02
140	2.10E-02

Table 8: Predicted and Validated Concentration of franciseilla at Different Times

Time [T]	Predicted Values Conc. [Mg/L]	Validated Concentration [Mg/L]
10	1.74E+00	1.87
20	2.03E+00	2.11

30	1.78E+00	1.88
40	1.38E+00	1.42
50	1.00E+00	1.11
60	7.00E-01	7.11E-01
70	4.70E-01	4.85E-01
80	3.10E-01	3.22E-01
90	2.00E-01	2.14E-01
100	1.30E-01	1.36E-01
110	8.00E-02	8.24E-02
120	5.50E-02	5.66E-02
130	3.40E-02	3.47E-02
140	2.10E-02	2.24E-02

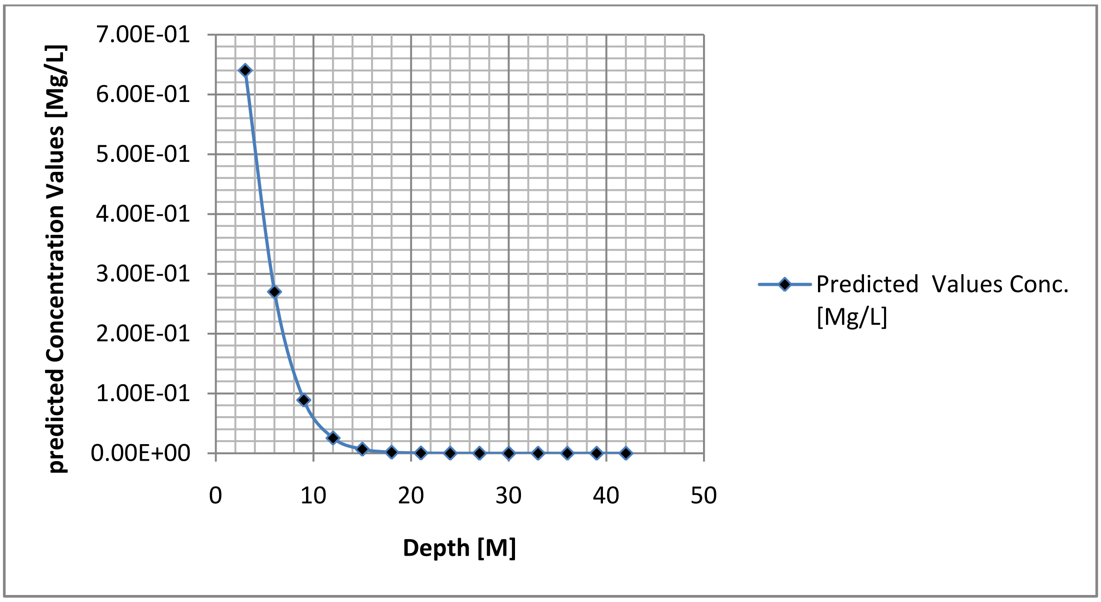

Figure 1: Concentration of franciseilla at Different Times

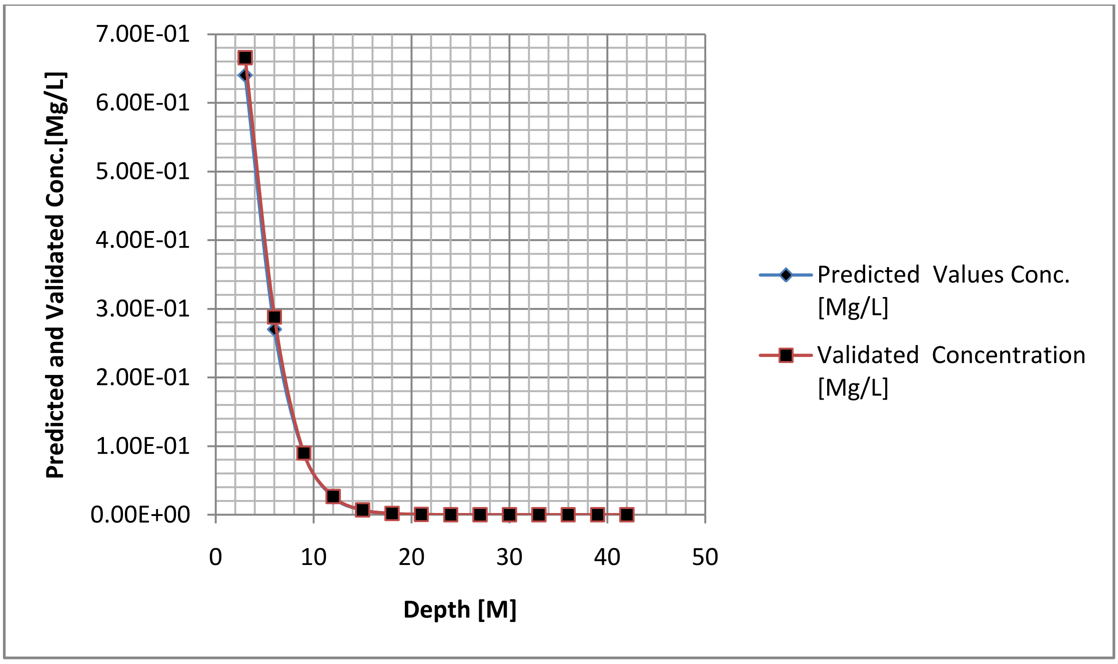

Figure 2: Predicted and Validated Concentration of franciseilla at Different Times

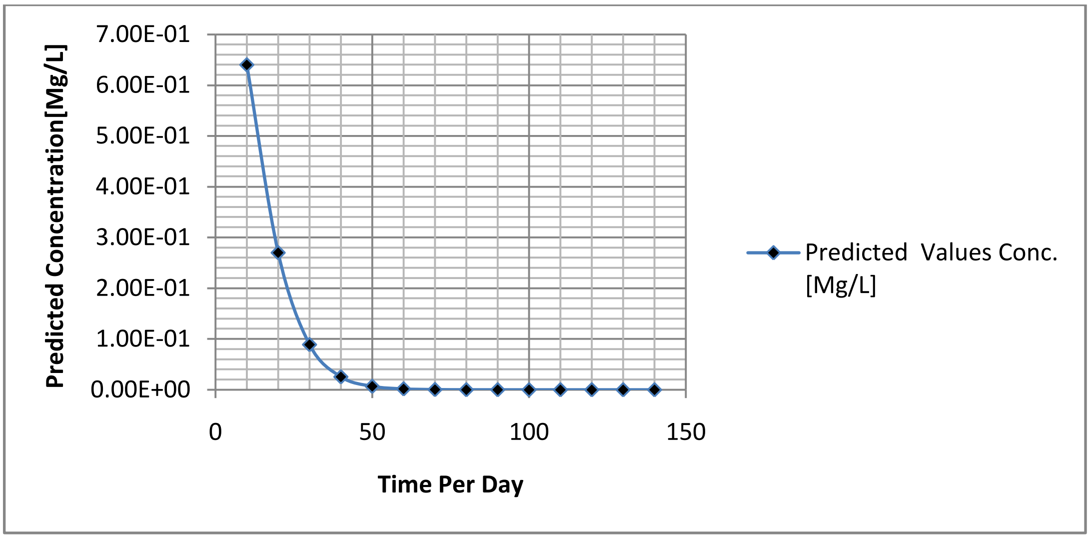

Figure 3: Concentration of franciseilla at Different Times

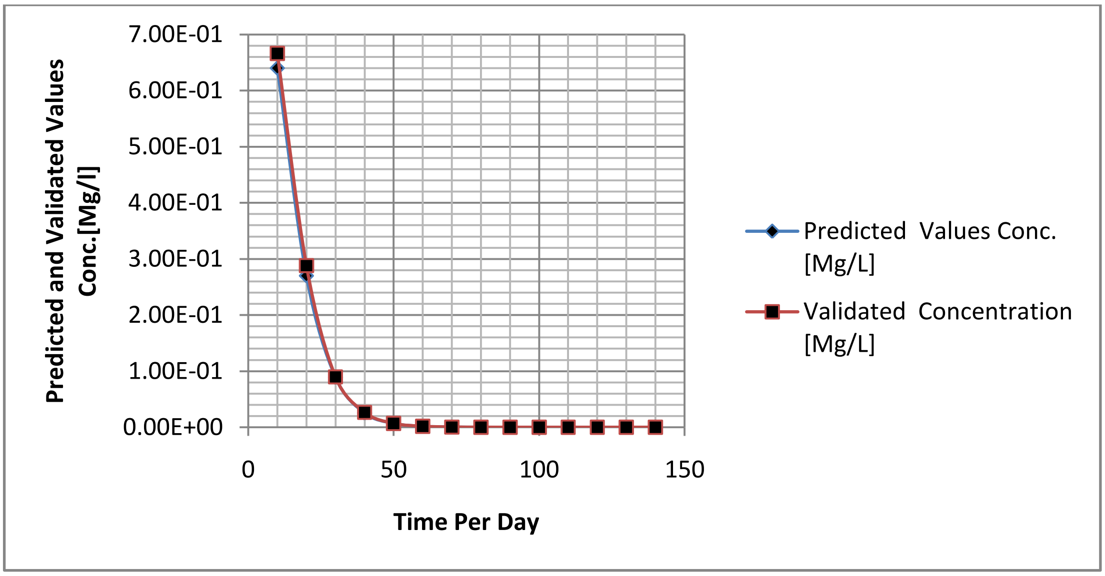

Figure 4: Predicted and Validated Concentration of franciseilla at Different Times

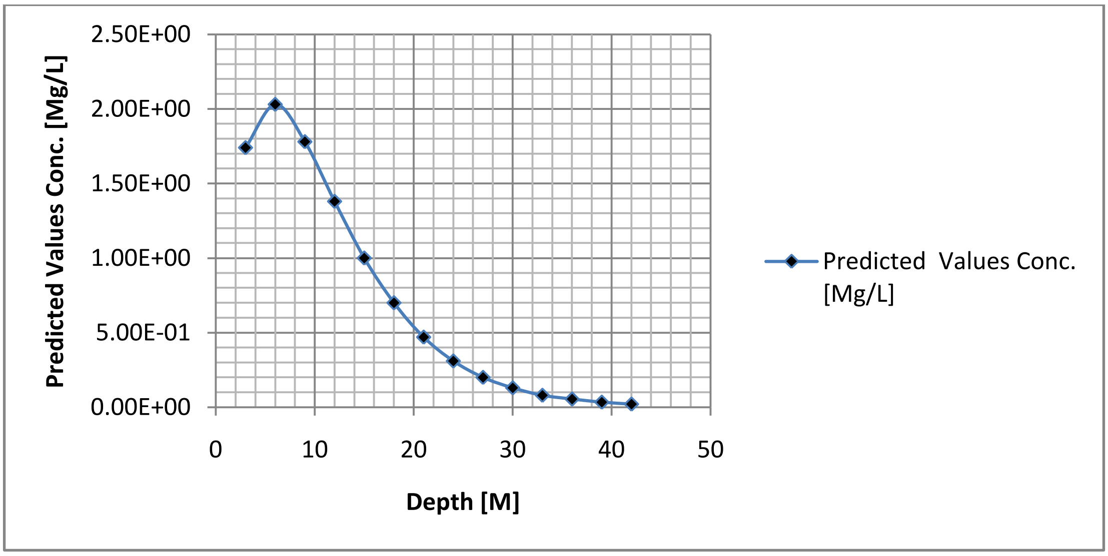

Figure 5: Concentration of franciseilla at Different Times

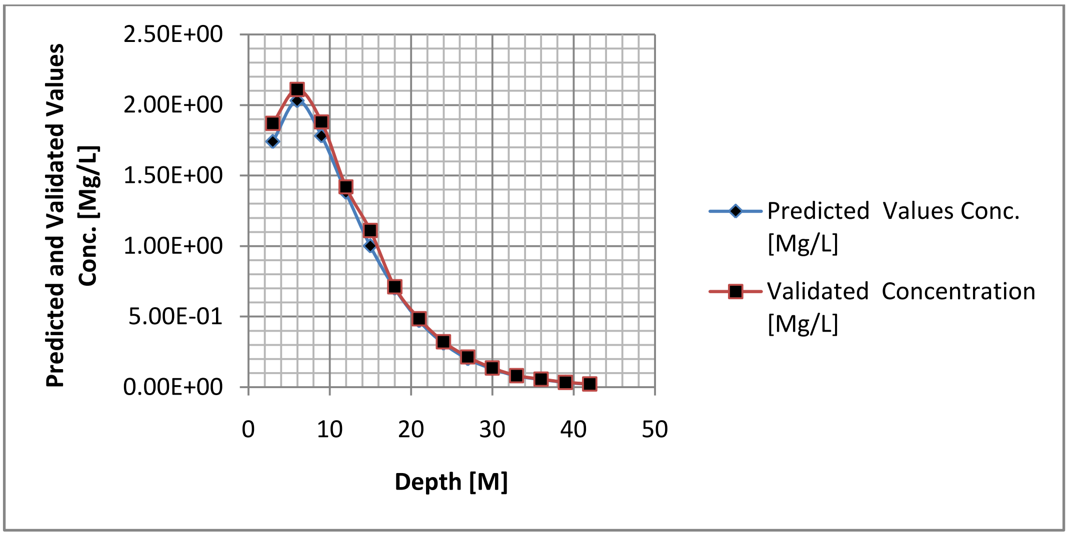

Figure 6: Predicted and Validated Concentration of franciseilla at Different Times

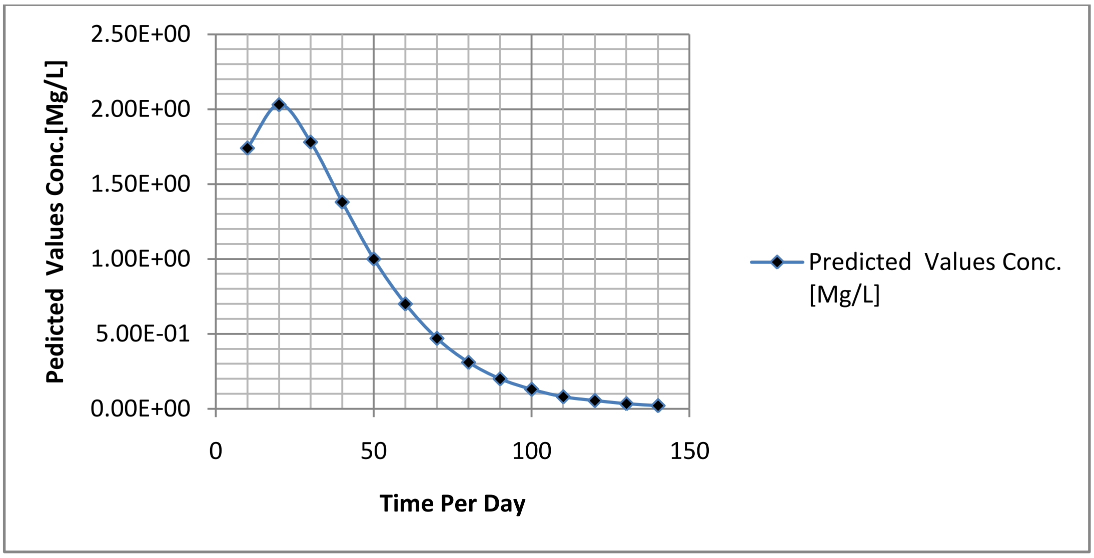

Figure 7: Concentration of franciseilla at Different Times

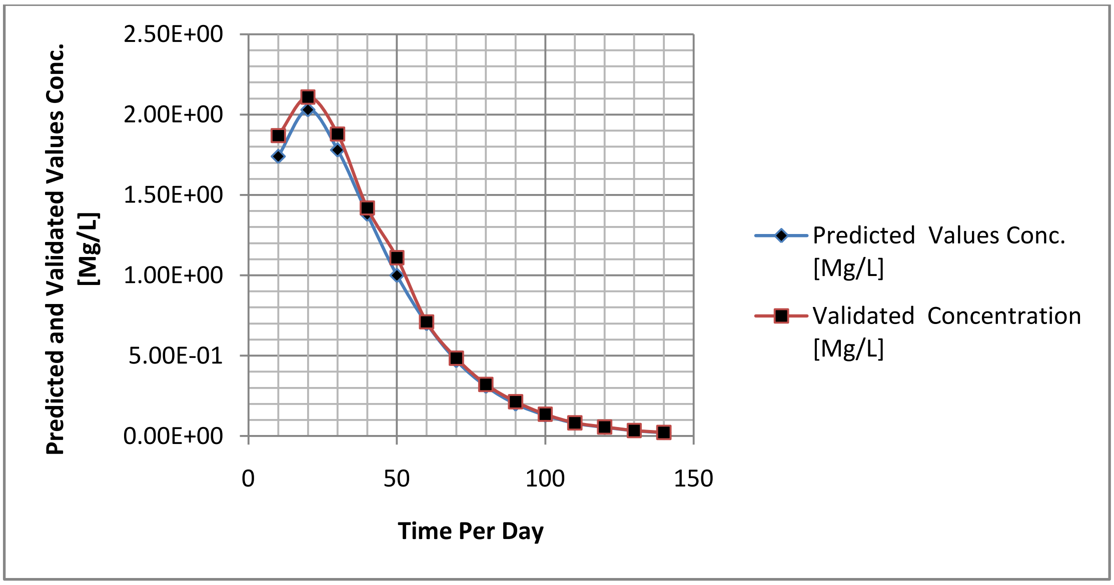

Figure 8: Predicted and Validated Concentration of franciseilla at Different Times

The figures presented express the rates of concentration at different depths. Clay depositions were found to be predominant in the study location. Such impermeable formations were monitored in the study area to analyze the rate of franciseilla deposition in the environment. The deposition of these formations are predominant in wetland area, the rate of such impermeable formation determine the transport level of the microbes in the formation. The deposition of this predominant deltaic clay formation has some variation to where there is transition to silty clay deposition. In figure one, it is observed that the rate of impermeability were experienced decreasing the migration process of the contaminant in some location. Based on these factors, figure three and four experienced the migration process and also high to low concentration due to these observations in the formation. There is some slight variation based on porosity rate that expresses slight fluctuation in its deposition reflecting on the depositional rate of the microbes. While figures five to eight maintained similar conditions by decreasing with respect to change in concentration based on the slight deposition of silty clay, increasing the rate of porosity in the environment. All the figures showed higher concentration at shallow depth, decreasing with respect to change in depth. There should be several cause of such degradation in all these figures to experience franciseilla concentration in such state. These observations implies that the decrease in concentration are based on several factors, but precisely, the decrease in concentrations can be attributed to impermeable deposition including the rate of inhibition from other deposited minerals in the formation. The rate of concentration in silty deposition has developed several stresses causing phreatic bed deposit, the lowest concentration that might be insignificant in water quality. These figures has definitely expressed the behaviour of the microbes pressured by the formation as well as other deposited minerals

5. Conclusion

The deposition of this franciseilla has been expressed in the system through the developed model for the study. It has explained the transport system under the influences of accumulations in some deposited formation predominantly observed in the study location. High to lowest concentration were experienced from all the figures in different locations, the simulation developed best fits with the experimental values, but the concentration at different locations varies. These were observed through the developed predicted values that express the same with experimental results. The rate of impermeable formation expressed variation at different strata, predomination of deltaic clay were experienced, but the rate of impermeability were not homogeneous as there is slight variation on their depositions. The silty clay formation expresses decrease in impermeable phase, and there were inhibitions from the deposition of deltaic clay. As shown from the rate of concentration, the deposition on the lowest region is less harmless at those formations with phreatic depositions.

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