ISSN: 2456 - 1819

EIJO: Journal of Civil Engineering, Architecture, Interior Design and Innovative Research (EIJO–CEAIDIR)

Einstein International Journal Organization (EIJO)

Available Online at: www.eijo.in

Volume – 1, Issue – 1, May – June 2016, Page No. 06-17

Model Prediction to Monitor Porosity Influence on Clostridium Transport in Homogenous Sity Formation, Patani, Delta State of Nigeria

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ABSTRACT

The behaviour of clostridium transport were observed not to be shown concern in the study area, the migration process were observed through most physiochemical analysis that find out the rate of concentration in water supply around the community, the alarming rate of its contamination are seriously causing hundred of ill health in the study location , most settlers in the study area does not know their cause of ill health thus the sources of this disease, there is need for thorough evaluation of ground water supply in the study location. Lots of evaluation made previously could not produced detailed results, the application of this modelling techniques generated detailed sources of contaminant and their various rate of concentration at different depth and time, the migration process and causes of exponential and vacillation were determined from the derived model simulation values, the study is imperative because it has generated the sources thoroughly and predicted their rate of concentration under the influences of predominated porosity in the study area.

Keywords: Modelling, Simulation, Permeability, Clostridium, Transport, Coarse Formation.

1. Introduction

Soil and groundwater contamination by pesticides from agricultural activities is a worldwide environmental problem. Although pesticide and other contaminant concentrations can be monitored, such monitoring is quite expensive and time consuming. Various simulation models have been developed for assessment of groundwater vulnerability to contamination, resource management, and design of monitoring programs. The BPS (Kozák and Vacek 1996) and HYDRUS-1D (Simunek et al. 1998) models have been developed recently, among many others, to simulate water movement and solute transport in soils. The chlorotoluron transport in several soil types of the Czech Republic was studied experimentally and described with the BPS code (Kocarek et al. 2005). Streck et al. (1995) presented apparent inconsistency between sorption isotherms determined from laboratory and field lysimeter experimental data. Poletika et al. (1995) used linear and nonlinear one- and two-stage sorption models to fit the sorption and desorption isotherms. Kamra et al. (2001) studied pesticides transport in small soil columns applying non-equilibrium two-region/mobile-immobile model. Flury et al. (1995) investigated preferential flow in the field. In this study herbicide was only partly sorbed by the soil matrix. A fraction of chemicals was transported with or without minor adsorption along cracks or fissures. Kocarek et al. (2005) observed chlorotoluron transport affected by preferential flow in 3 soil profiles from 5 studied soil types. Jorgensen et al. (2002) experimentally studied pesticides transport through preferential paths. (Therrien and Sudicky 1996) that simulated water and solute flow in fractured porous system. Gerke and van Genuchten (1993, 1996) proposed the dual-permeability model that solves flow and transport equations in both matrix and fracture pore systems used for one scenario in the EU risk assessment The Macro model for simulation of water and solute transport in a dual-permeability system was developed by Jarvis (1994). Macro was used for instance to simulate water and isoproturon behavior in a heavy clay soil by Besien et al. (1997). The Macro model was also program (Focus 2000). Furthermore the behaviour of the contaminant through preferential flow on chlorotoluron transport in the soil profile. Experimental field data presented in Kodesova et al. (2004) that involved the chlorotoluron transport in the soil profile were simulated using the modified HYDRUS-1D software package (Simunek et al. 1998, 2003). Preferential flow was evaluated by comparing results of the single-porosity and dual-permeability models (Gerke and van Genuchten 1993, 1996, Kodešová1, 2005).

2. Governing Equation

$$K\frac{d^2c}{dx^2} - \phi\frac{dc}{dx} + V_t\frac{dc}{dx} = 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \qquad (1)$$

$$K\frac{d^2c}{dx^2} - (\phi - V_t)\frac{dc}{dx} = 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \qquad (2)$$

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

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

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

$$K\sum_{n=2}^{\infty} n(n-1) a_n x^{n-2} - (\phi - V_t)\sum_{n=1}^{\infty} n a_n x^{n-1} = 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (3)$$

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

$$K\sum_{n=2}^{\infty} n(n+2)(n+1) a_{n+2} x^n - (\phi - V_t)\sum_{n=0}^{\infty} (n+1) a_{n+1} x^n = 0 \qquad \ldots\ldots\ldots\ldots\ldots \qquad (4)$$

i.e. $K(n+2)(n+1)a_{n+2} = (\phi - V_t)(n+1)a_{n+1} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (5)$

$$a_{n+2} = \frac{(\phi - V_t)(n+1)a_{n+1}}{K(n+2)(n+1)} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (6)$$

$$a_{n+2} = \frac{(\phi - V_t)a_{n+1}}{K(n+2)} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (7)$$

for $n = 0,\ a_2 = \frac{(\phi - V_t)a_1}{2K} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (8)$

for $n = 1,\ a_3 = \frac{(\phi - V_t)a_2}{3K} = \frac{(\phi - V_t)^2 a_1}{2K \bullet 3K} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (9)$

for $n = 2;\ a_4 = \frac{(\phi - V_t)a_3}{4K} = \frac{(\phi - V_t)}{4K} \bullet \frac{(\phi - V_t)a_1}{3K \bullet 2K} = \frac{(\phi - V_t)^3 a_1}{4K \bullet 3K \bullet 2K} \quad \ldots \qquad (10)$

for $n = 3;\ a_5 = \frac{(\phi - V_t)}{5K} = \frac{(\phi - V_t)^4 a_1}{5K \bullet 4K \bullet 3K \bullet 2K} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (11)$

for $n;\ a_n - \frac{(\phi - V_t)^{n-1} a_1}{K^{n-1} n!} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (12)$

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

$$= a_0 + a_1 x + \frac{(\phi - V_t)a_1 x^2}{2!K} + \frac{(\phi - V_t)a_1 x^3}{3!K^2} + \frac{(\phi - V_t)x^4}{4!K^3} + \frac{(\phi - V_t)^4}{5!K^4} \ldots \qquad \ldots\ldots.. \quad (14)$$

$$C(x) = a_0 + a_1\left[\frac{(\phi - V_t)x}{2!K} + \frac{(\phi - V_t)^2 x^3}{3!K^2} + \frac{(\phi - V_t)^3}{4!K^3} + \frac{(\phi - V_t)^4}{5!K^4}\right] \ldots\ldots\ldots \qquad (15)$$

$$C(x) = a_0 + a_1 \ell^{\frac{(\phi - V_t)}{K}x} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (16)$$

Subject equation (16) to the following boundary condition

$$C(o) = 0 \; and \; C(o) = H$$

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

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

i.e. $a_0 + a_1 = 0$ ………………….. (17)

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

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

$$a_1 = \frac{HK}{\phi - V_t} \ldots\ldots\ldots\ldots\ldots \qquad (18)$$

Substitute (18) into equation (17)

$$a_1 = a_0$$

$$\Rightarrow \; a_0 = \frac{-HK}{\phi - V_t} \ldots\ldots\ldots\ldots\ldots \qquad (19)$$

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

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

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

If $x = V \bullet t$

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

If $T = \frac{d}{V}$

$$C(x) = \frac{HK}{\phi - V_t}\left[\ell^{\frac{(\phi - V_t)}{K}\frac{d}{V}} - 1\right] \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \qquad (22)$$

3. Materials and Method

Standard laboratory experiment where performed to monitor clostridium concentration at different formation, the soil deposition of the strata were collected in sequences base on the structural deposition at different locations, this samples collected at different location it generated variation at different depth producing different migration of clostridium concentration through pressure flow at different strata, the experimental result are applied to compare with the theoretical values to determined the validation of the model.

4. Result and Discussion

Results and discussion are presented in tables including graphical representation of salmonella concentration

Table: 1 concentration of clostridium concentration at Different Depth

Depth [M]	Predicted Values Conc. [Mg/L]
3	7.30E-01
6	1.46E+00
9	2.23E+00
12	2.97E+00
15	3.71E+00
18	4.46E+00
21	5.20E+00
24	5.95E+00
27	6.69E+00
30	7.43E+00
33	8.18E+00
36	8.92E+00
39	9.66E+00

Table: 2 Predicted and Validate clostridium Concentration at Different Depth

Depth [M]	Predicted LP]	Validated [P]
3	7.30E-01	0.75
6	1.46E+00	1.47
9	2.23E+00	2.22
12	2.97E+00	2.96
15	3.71E+00	3.71
18	4.46E+00	4.45
21	5.20E+00	5.19
24	5.95E+00	5.94
27	6.69E+00	6.68
30	7.43E+00	7.43
33	8.18E+00	8.17
36	8.92E+00	8.91
39	9.66E+00	9.66

Table: 3 concentration of clostridium concentration at Different Depth

Time [T]	Predicted Values Conc. [Mg/L]
10	1.04E-01
20	2.08E-01
30	3.12E-01
40	4.16E-01
50	5.20E-01
60	6.24E-01
70	7.28E-01
80	8.33E-01
90	9.37E-01
100	1.04E+00
110	1.15E+00
120	1.24E+00
130	1.35E+00
140	1.46E+00

Table: 4 Predicted and Validate clostridium Concentration at Different Depth

Time [T]	Predicted Values Conc. [Mg/L]	Validated Concentration [Mg/L]
10	1.04E-01	0.114
20	2.08E-01	0.214
30	3.12E-01	0.319
40	4.16E-01	0.424
50	5.20E-01	0.532
60	6.24E-01	0.633
70	7.28E-01	0.744
80	8.33E-01	0.844
90	9.37E-01	0.945
100	1.04E+00	1.09
110	1.15E+00	1.19
120	1.24E+00	1.3
130	1.35E+00	1.38
140	1.46E+00	1.49

Table: 5 concentration of clostridium concentration at Different Depth

Depth [M]	Predicted Values Conc. [Mg/L]
3	1.77E-03
6	3.54E-03
9	5.31E-03
12	7.08E-03
15	8.85E-03
18	1.06E-02
21	1.23E-02
24	1.41E-02

27	1.59E-02
30	1.77E-02
33	1.94E-02
36	2.12E-02
39	2.30E-02

Table: 6 Predicted and Validate clostridium Concentration at Different Depth

Depth [M]	Predicted Values Conc. [Mg/L]	Validated Concentration [Mg/L]
3	1.77E-03	1.88E-03
6	3.54E-03	3.66E-03
9	5.31E-03	5.44E-03
12	7.08E-03	7.15E-03
15	8.85E-03	8.98E-03
18	1.06E-02	1.18E-02
21	1.23E-02	1.32E-02
24	1.41E-02	1.51E-02
27	1.59E-02	1.66E-02
30	1.77E-02	1.84E-02
33	1.94E-02	1.99E-02
36	2.12E-02	2.24E-02
39	2.30E-02	2.40E-02

Table: 7 concentration of clostridium concentration at Different Depth

Depth [M]	Predicted Values Conc. [Mg/L]
3	1.69E-05
6	2.01E-05
9	2.93E-04
12	5.50E-05
15	3.80E-02
18	5.18E-02
21	1.18E-03
24	1.41E-03
27	1.52E-02
30	1.95E-02
33	2.55E-02
36	2.97E-02
39	2.05E-04
42	1.19E-04
45	1.86E-04

Table: 8 Predicted and Validate clostridium Concentration at Different Depth

Depth [M]	Predicted Values Conc. [Mg/L]	Validated Concentration [Mg/L]
3	1.69E-05	1.70E-03
6	2.01E-05	2.22E-05
9	2.93E-04	3.04E-04
12	5.50E-05	5.57E-05
15	3.80E-02	3.95E-02
18	5.18E-02	5.22E-02
21	1.18E-03	1.24E-03
24	1.41E-03	1.48E-03
27	1.52E-02	1.61E-02
30	1.95E-02	2.05E-02
33	2.55E-02	2.66E-02
36	2.97E-02	3.09E-02
39	2.05E-04	2.15E-04
42	1.19E-04	1.23E-04
45	1.86E-04	1.94E-04

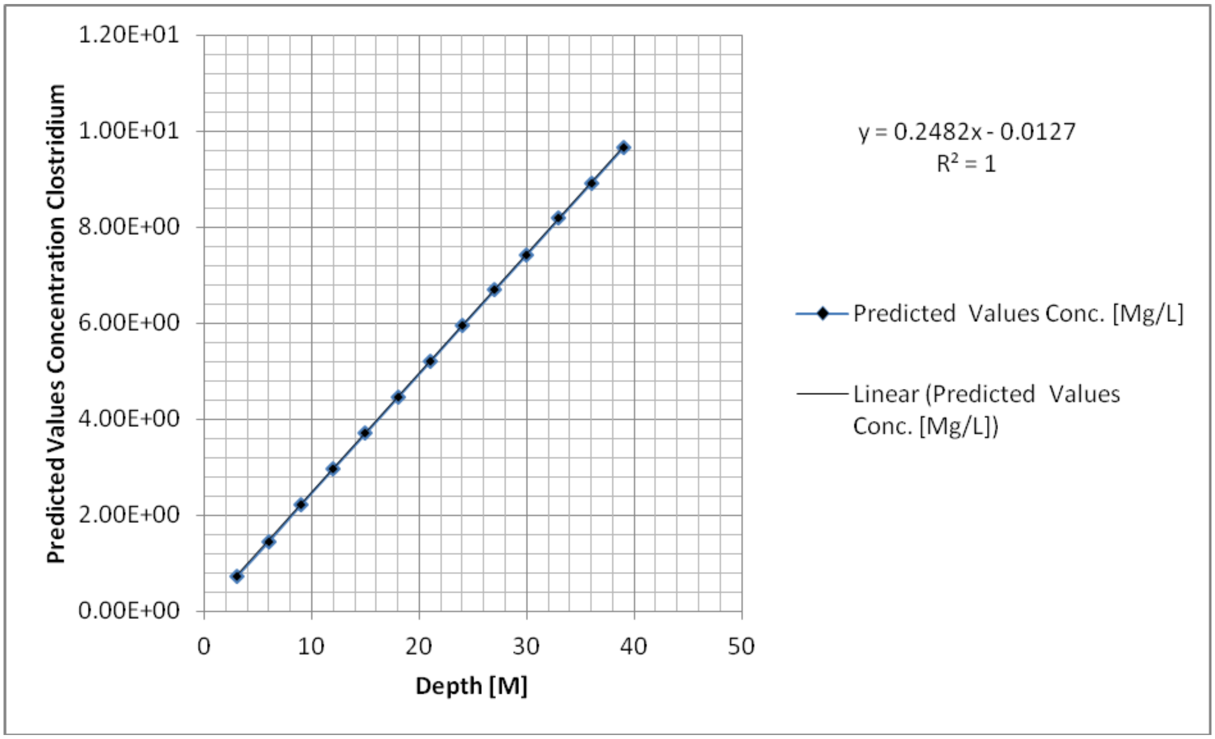

Figure 1: Concentration of clostridium concentration at Different Depth

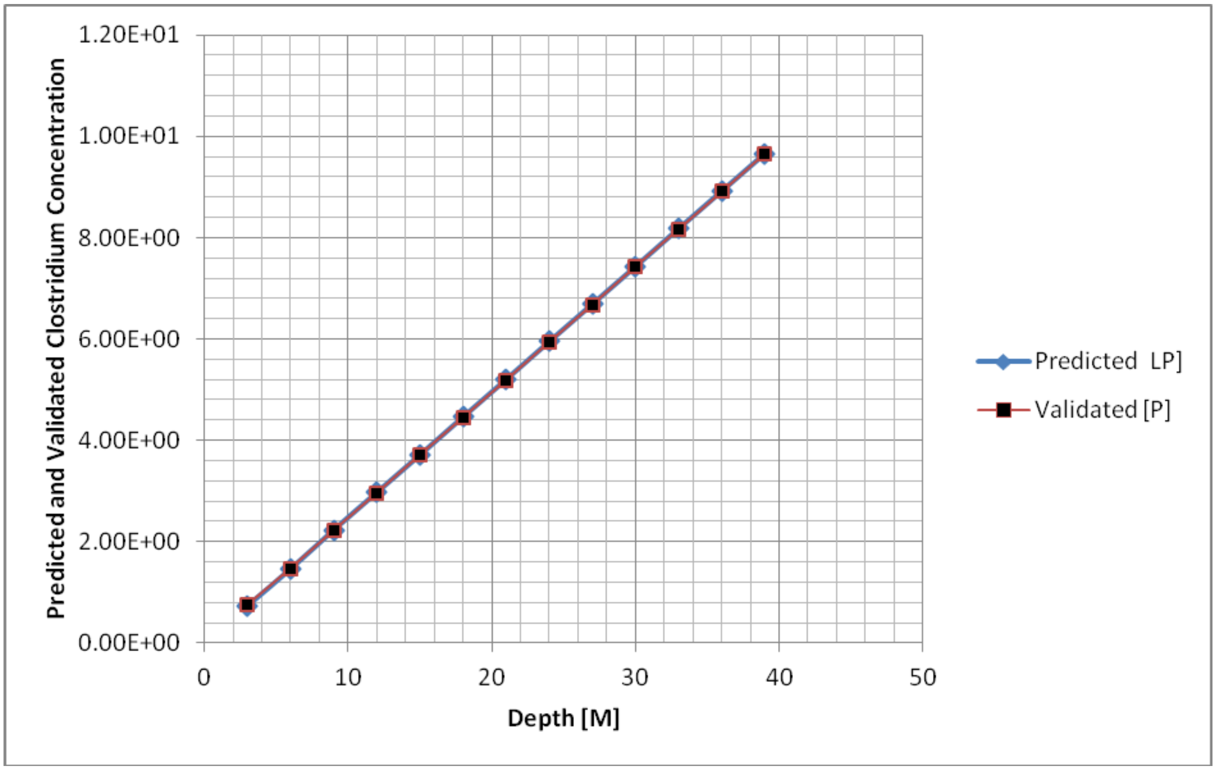

Figure 2: Predicted and Validate clostridium Concentration at Different Depth

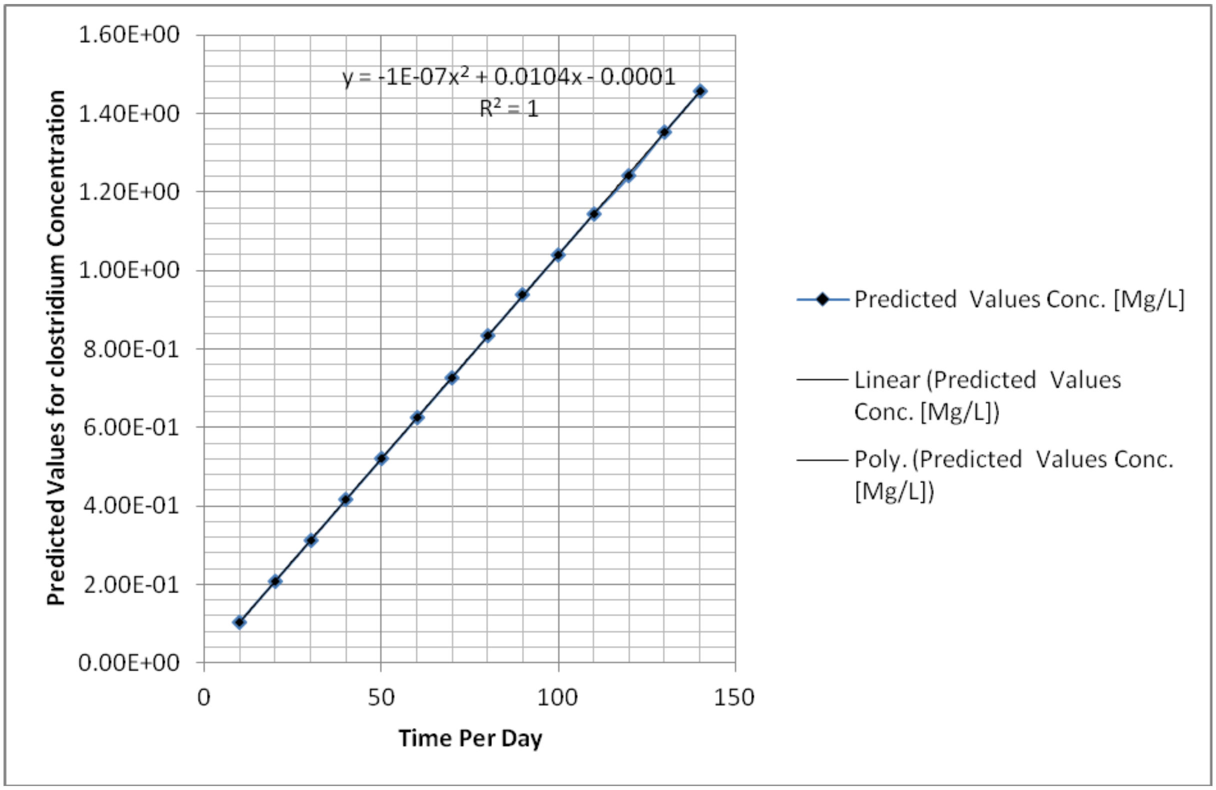

Figure 3: concentration of clostridium concentration at Different Depth

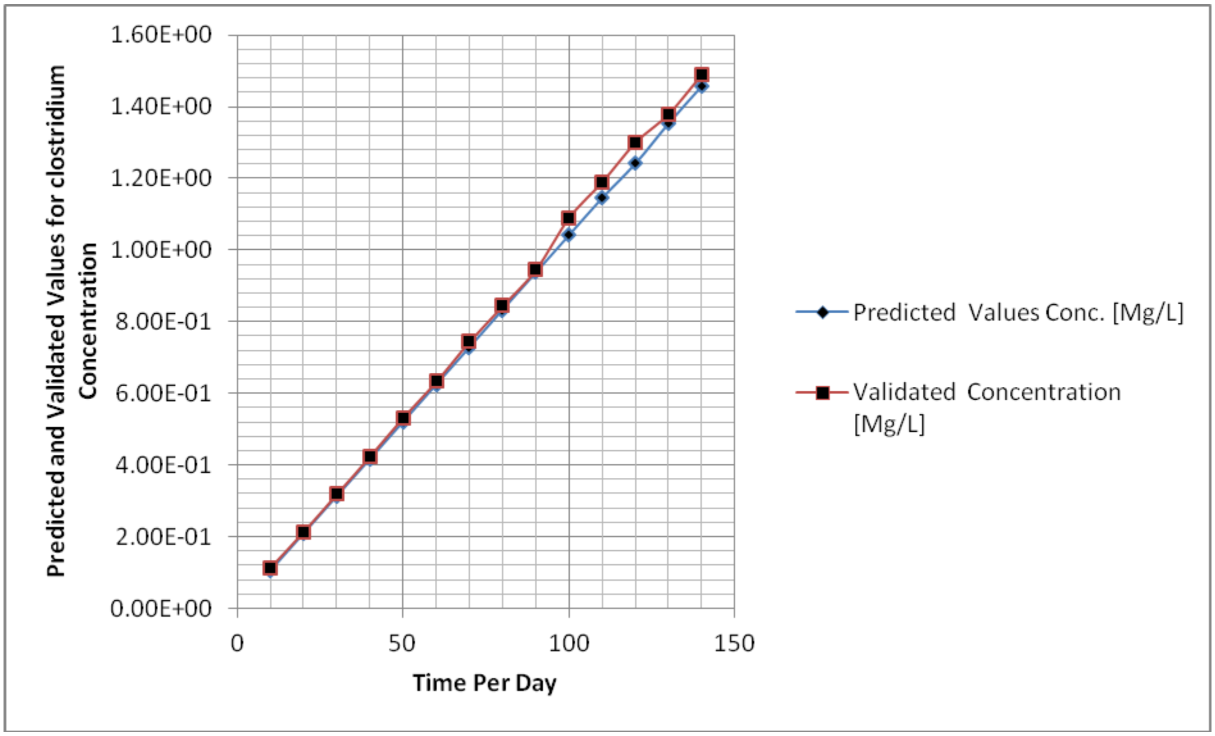

Figure 4: Predicted and Validate clostridium Concentration at Different Depth

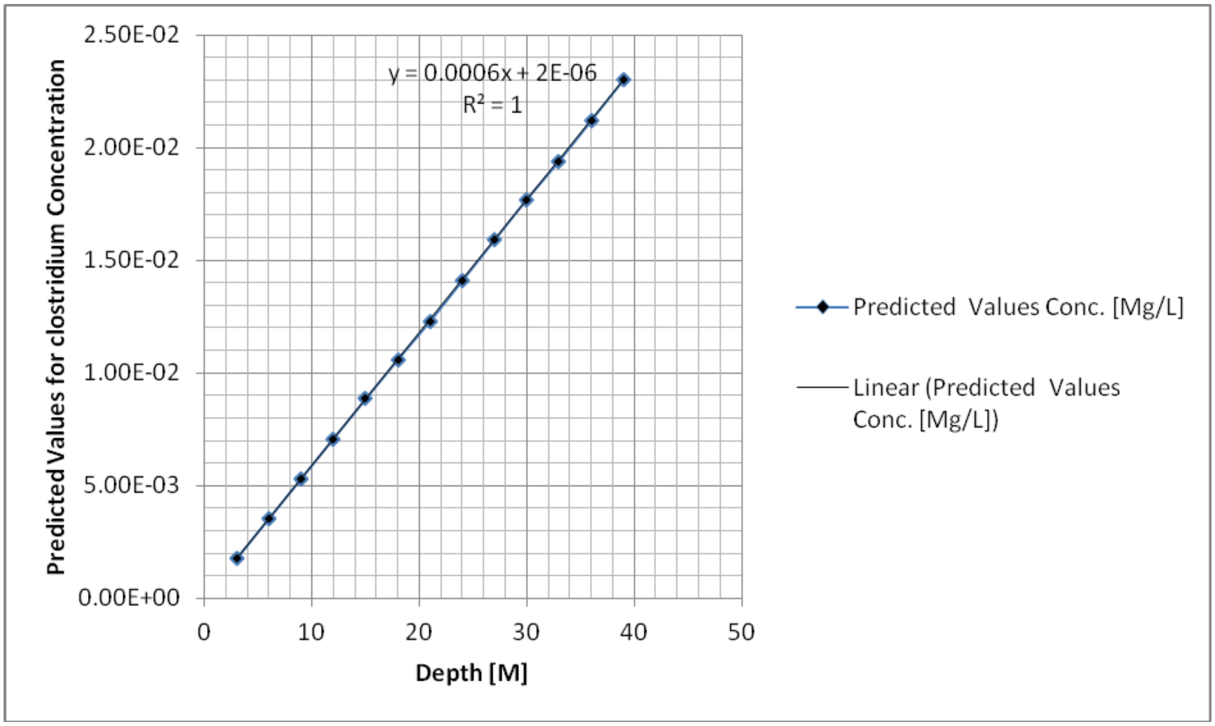

Figure 5: concentration of clostridium concentration at Different Depth

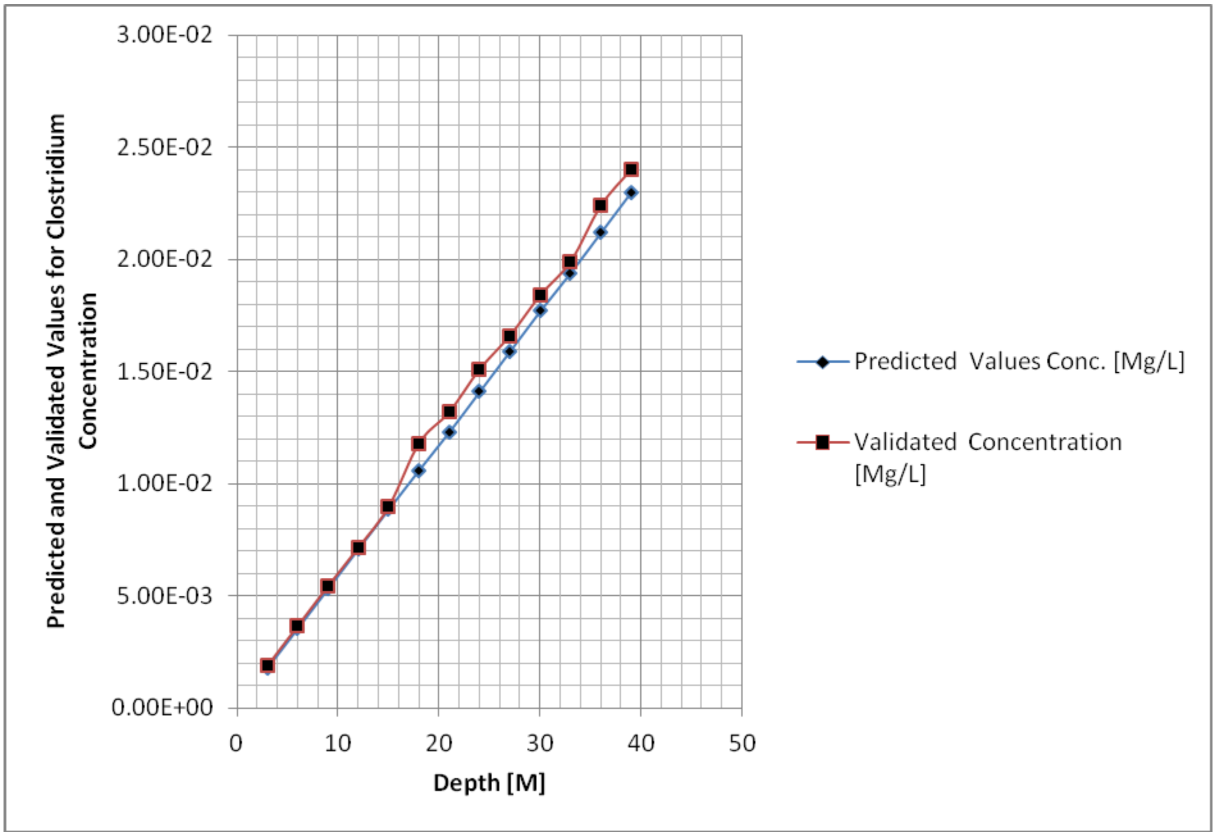

Figure 6: Predicted and Validate clostridium Concentration at Different Depth

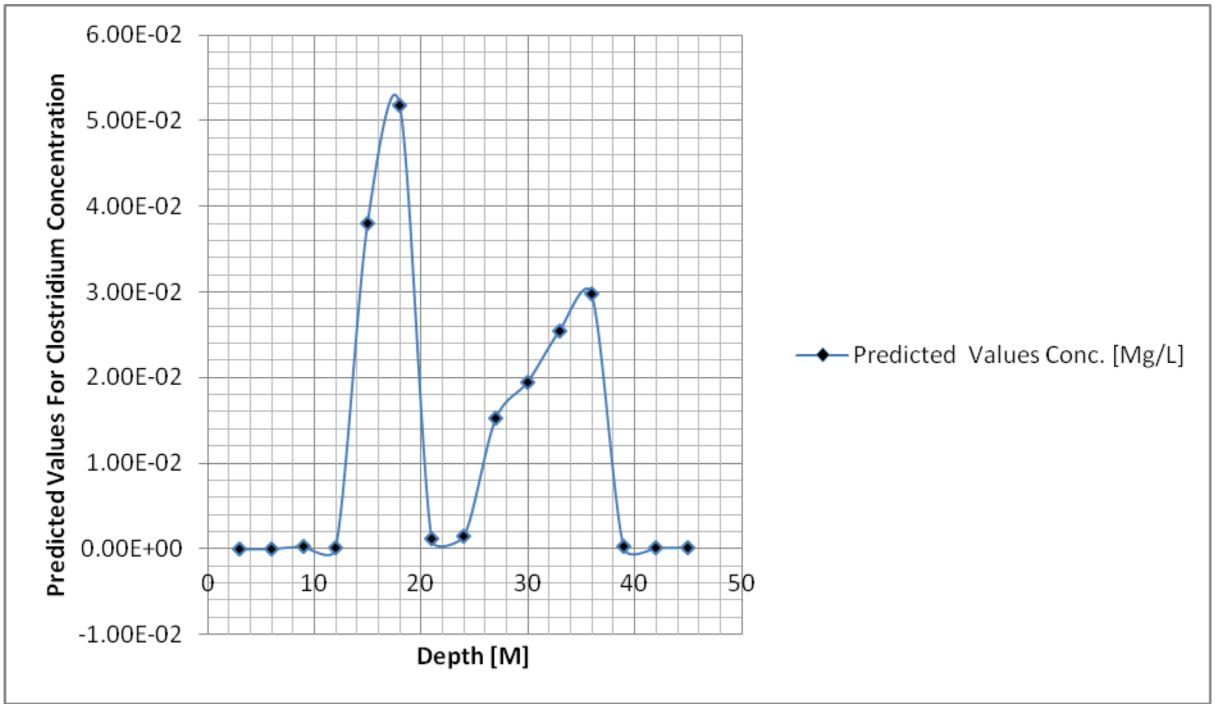

Figure 7: concentration of clostridium concentration at Different Depth

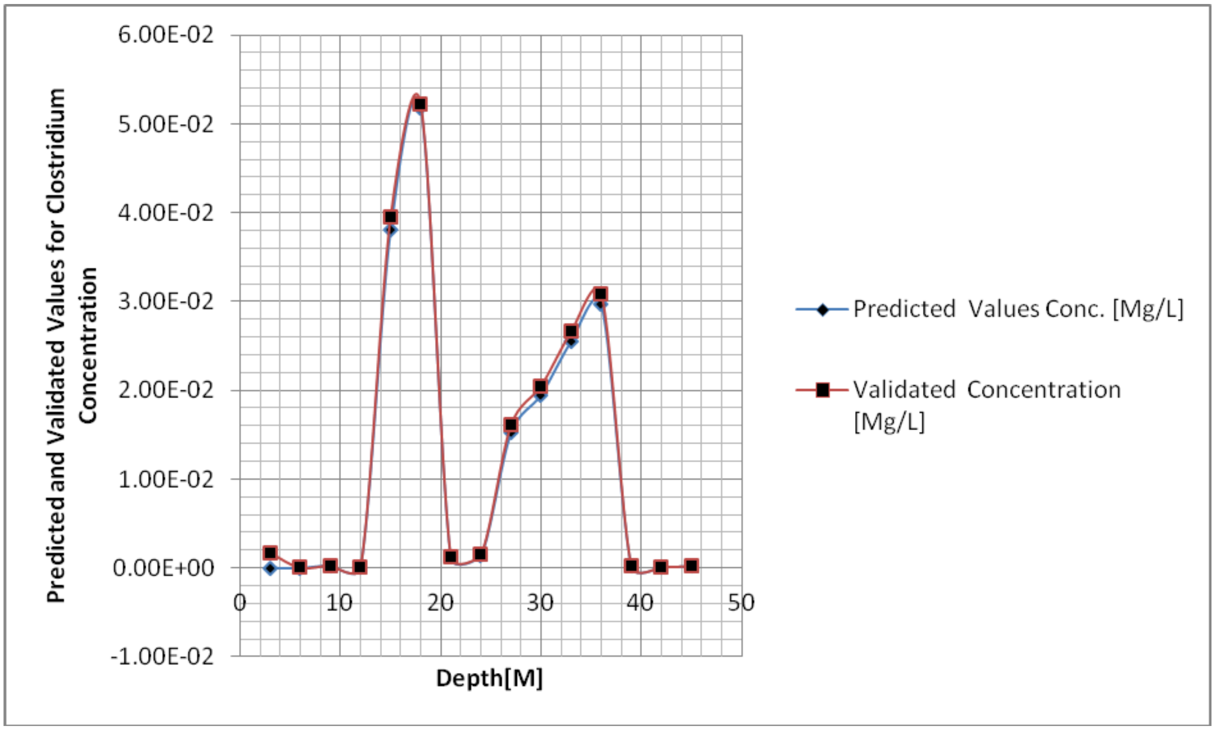

Figure 8 : Predicted and Validate clostridium Concentration at Different Depth

The figures from one to four express on variation of time and depth showing various rate of concentration, this implies that the contaminant were uniform at different time and depth, the structures of the formation pressure the deposition and transport system of the contaminant as it express in figure one to four. Exponential deposition were observed on these figures at various time and depth, these conditions can be attributed to the variation of deposited porosity of the formation, this is through the structural disintegration of the porous rocks developing unconsolidated strata in the deltaic formation, the ability of penetrations within the micropoles at various intercedes of the strata generated the migration of the contaminant developing variation of concentration thus exponential deposition in those figures. Similar experienced were found in figure five and six, they also maintained exponential migration with respect to time and depth, but with more linear compared to other previous expressed figures, and it is observed that some deposited homogeneous strata may have express higher concentration. While figure seven and eight were different from other figures, fluctuation were observed in these figures, the lowest concentration were experienced between three and twelve, suddenly, rapid increase were observed between fifteen and twenty one including areas another vacillation were observed, the lowest similar to three and twelve were experienced, more so the same rapid increase were observed between twenty seven and thirty nine, thus homogeneous concentration were finally experienced between forty three and forty nine, these theoretical values were compared with experimental data, both parameters generated best fit validating the model.

5. Conclusion

The study of clostridium deposition and its migration in various time and depth has been expressed, these concentration were observed to deposited different concentration base on several factors, but the predominant influences is the variations of porosity at different time and depth, the pressure from the strata porosity predominantly pressured the variation of concentration in exponential and vacillation phase in the formation, the study experience some formation that its concentration are very high which can be due to accumulation of the contaminant from stratum that experience lower hydraulic conductivity, the contaminant may accumulate base on these factors observed in the system, while other figures observed lower concentration base on higher hydraulic conductivity in those formation thus express lower concentration, these condition were observed in various figures of the transport system in the study location, the study is imperative because the deposition of clostridium transport has been evaluated through modelling approach, validation of these model through experimental values has express the authenticity of the developed model that can monitor the clostridium in homogeneous coarse formation.

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