DISPERSION AND STORAGE COEFFICIENT INFLUENCE ON ACCUMULATION OF FRANKIA TRANSPORT IN HETEROGENEOUS SILTY AND FINE SAND FORMATION, WARRI, DELTA STATE OF NIGERIA

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Abstract

The study of frankia transport pressured by dispersion and storage coefficient has been thoroughly expressed. The study has monitored the deposition of frankia in silty and fine sand formation. The developed model has express the behaviour of frankia in the study location, storage coefficient and dispersions were observed to pressure the behaviour of the contaminant as expressed in graphical representation, the fluctuation of concentration reflect the influences from porosity variation thus dispersion and storage coefficient, this generated slight accumulation of frankia in silty and fine sand formation, this condition were examined through the rate of its deposition base on some fluctuation experienced that could not monitor the detail deposition of frankia transport in silty and fine sand formation, slight heterogeneous setting in the formation were also observed, the developed model were compared with other experimental values, and both parameters expressed favourable fits validating the model.

Keywords: Dispersion, storage coefficients frankia and heterogeneous formation

1. Introduction

With over a billion individual cells and estimates of 104–105 distinct genomes per gram of soil (Gans et al., 2005; Tringe et al., 2005; Fierer et al., 2007 b Katherine, 2011; Eluozo and Afiibor, 2013), bacteria in soil are the reservoirs for much of Earth's genetic biodiversity. This vast phylogenetic and functional diversity can be attributed in part to the dynamic physical and chemical heterogeneity of soil, which results in spatial and temporal separation of microorganisms (Papke and Ward, 2004). Given the high diversity of carbon (C) – rich compounds in soils, the ability of each taxon to compete for only a subset of resources could also contribute to the high diversity of bacteria in soils through resource partitioning (Zhou et al., 2002 Katherine et al 2011). Indeed, Waldrop and Firestone (2004) have demonstrated distinct

substrate preferences by broad microbial groups in grassland soils and C resource partitioning has been demonstrated to be a key contributor to patterns of bacterial co-existence in model communities on plant surfaces (Wilson and Lindow, 1994). The development of high-throughput tools to assess the composition of soil bacterial communities is rapidly contributing to an improved understanding of bacterial diversity and biogeographically distribution (Drenovsky et al., 2009; Lauber et al., 2009; Chu et al., 2010 Katherine et al 2011). However, our ability to assess the functions of different bacterial taxa has not kept pace (Green et al., 2008). This limits our ability to interpret the functional consequences of shifts in community composition in response to environmental changes (Stein and Nicol, 2011). There several concept applied to monitor the trace of the bacteria for this reason, the use of tracer molecules such as stable-isotopes and the thymidineanalog, 3-bromodeoxyuridine (BrdU), have been widely adopted in an effort to connect phylogeny to function. Stable-isotopes, particularly the heavy carbon isotope 13C, have been frequently used to identify microbial community members capable of catabolizing particular substrates (Radajewski et al., 2000; Griffiths et al., 2004; Buckley et al., 2007; Feth El Zahar et al., 2007; Schwartz, 2007). This technique requires separation of nucleic acids based on buoyant density, so high concentrations of isotopically labeled substrate are needed. Thus, this approach is costly and impractical for many complex organic compounds that are not commercially available. An alternative is the use of BrdU to monitor cell division following substrate addition. This approach was first applied to the study of bacterial populations over a decade ago (Urbach et al., 1999) and it has since been used to identify soil bacterial taxa that respond to various environmental stimuli (Borneman, 1999; Yin et al., 2000; Artursson and Jansson, 2003; Artursson et al., 2005). Recently, BrdU incorporation has been shown to detect a broad diversity of bacterial phyla in marine systems (Edlund et al., 2008) and fungal taxa in temperate (Hanson et al., 2008) and boreal forest soils (Allison et al., 2008).

2. Theoretical background

The behaviour of contaminant in the soil has been observed by experts in different dimension, the rate of contaminant migration in soil and water environment are monitored through various way under the influences of flow in the soil through various formation characteristics, the study of storage coefficient in the phreatic bed influencing contaminant has not been thoroughly expressed, this implies that the migration of the contaminant through these sources has not been

evaluated, the rate of dispersions of the contaminant are through these flows, these are base on the permeation of the formation between the lithology in the study area.

3. Governing Equation

$$D\frac{d^2c}{dx^2} - ST\frac{dc}{dx} + V_t\frac{dc}{dx} = 0 \quad \text{……..} \quad (1)$$

$$D\frac{d^2c}{dx^2} - (ST - V_t)\frac{dc}{dx} = 0 \quad \text{……..} \quad (2)$$

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

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

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

$$D\sum_{n=2}^{\infty} n(n-1) a_n x^{n-2} - (ST - V_t)\sum_{n=1}^{\infty} n a_n x^{n-1} = 0 \quad \text{……..} \quad (3)$$

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

$$D\sum_{n=2}^{\infty} (n+2)(n+1) a_{n+2} x^n - (ST - V_t)\sum_{n=0}^{\infty} (n+1) a_{n+1} x^n = 0 \quad \text{……} \quad (4)$$

i.e. $D(n+2)(n+1)a_{n+2} = (ST - V_t)(n+1)a_{n+1}$ …….. (5)

$$a_{n+2} = \frac{(ST - V_t)(n+1)a_{n+1}}{D(n+2)(n+1)} \quad \text{……..} \quad (6)$$

$$a_{n+2} = \frac{(ST - V_t)a_{n+1}}{D(n+2)} \quad \text{……..} \quad (7)$$

for $n = 0$, $a_2 = \frac{(ST - V_t)a_1}{2D}$ …….. (8)

for $n = 1$, $a_3 = \frac{(ST - V_t)a_2}{3D} = \frac{(ST - V_t)^2 a_1}{2D \bullet 3D}$ …….. (9)

for $n = 2$; $a_4 = \frac{(ST - V_t)a_3}{4D} = \frac{(ST - V_t)}{4D} \bullet \frac{(ST - V_t)a_1}{3D \bullet 2D} = \frac{(ST - V_t)^3 a_1}{4D \bullet 3D \bullet 2D}$ … (10)

for $n = 3;\ a_5 = \dfrac{(ST - V_t)a_4}{5D} = \dfrac{(ST - V_t)}{5D \bullet 4D \bullet 3D \bullet 2D}$ …… (11)

for $n;\ a_n - \dfrac{(ST - V_t)^{n-1} a_1}{D^{n-1} n!}$ …….. (12)

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

$= a_0 + a_1 x + \dfrac{(ST - V_t)a_1 x^2}{2!D} + \dfrac{(ST - V_t)a_2 x^3}{3!D^2} + \dfrac{(ST - V_t)a_1 x^4}{4!D^3} + \dfrac{(ST - V_t)a_1 x^5}{5!D^4} + \ldots$ (14)

$C(x) = a_0 + a_1 \left[x + \dfrac{(ST - V_t)x^2}{2!D} + \dfrac{(ST - V_t)x^3}{3!D^2} + \dfrac{(ST - V_t)x^4}{4!D^3} + \dfrac{(ST - V_t)x^5}{5!D^4} \right] \ldots$ (15)

$C(x) = a_0 + a_1 \ell^{\frac{(ST - V)}{D}x}$ …….. (16)

Subject equation (16) to the following boundary conditions
$C(o) = 0\ and\ C(o) = H$

$C(x) = a_0 + a_1 \ell^{\frac{(ST - V)}{D}x}$

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

i.e. $a_0 + a_1 = 0$ …….. (17)

$C^1(x) = \dfrac{(ST - V_t)}{2!D} a_1 \ell^{\frac{(ST - V_t)}{D}x}$

$C^1(o) = \dfrac{(ST - V_t)}{2!D} a_1 = H$

$$a_1 = \frac{HD}{ST - V_t}$$ …….. (18)

Substitute (18) into equation (17)

$$a_1 = a_0$$

$$\Rightarrow\ a_0 = \frac{-HD}{ST - V_t}$$ …….. (19)

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

$$C(x) = -\frac{HD}{ST - V_t} + \frac{HD}{ST - V_t}\ell^{\frac{(ST - V_t)}{D}x}$$

$$\Rightarrow C(x) = \frac{HD}{ST - V_t}\left[\ell^{\frac{(ST - V_t)}{D}x} - 1\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (20)$$

4. Materials and method

Standard laboratory experiments were performed to monitor the concentration of frankia at depositions in different formation. The soil strata were collected in sequences base on the structural deposition at different locations. The samples collected at different locations generated variation at different depths producing different migration of frankia concentration through pressure flow at different strata. The experimental results are applied and compared with the theoretical values to determine the validation of the model.

5 .Result and Discussion

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

Table: 1 Concentration of Frankia at Different Depths

Depth [M]	Frankia Concentration
3	**1.10E-08**
6	**2.20E-08**
9	**3.31E-08**
12	**4.41E-08**
15	**5.51E-08**
18	**6.62E-08**
21	**7.72E-08**
24	**8.82E-08**
27	**9.93E-08**
30	**1.10E-07**
33	**1.21E-07**
36	**1.32E-07**
39	**1.43E-07**

Table: 2 Predicted and Validated Concentration of Frankia at Different Depths

Depth [M]	Predictive Values	Experimental Values
3	1.10E-08	1.10E-08
6	2.20E-08	2.21E-08
9	3.31E-08	3.34E-08
12	4.41E-08	4.48E-08
15	5.51E-08	5.66E-08
18	6.62E-08	6.74E-08
21	7.72E-08	7.44E-08
24	8.82E-08	8.85E-08
27	9.93E-08	9.88E-08
30	1.10E-07	1.21E-07
33	1.21E-07	1.31E-07
36	1.32E-07	1.42E-07
39	1.43E-07	1.52E-07

Table: 3 Concentration of Frankia at Different Depths

Time Per Day	Frankia Concentration
10	1.54E-09
20	3.00E-09
30	4.41E-09
40	6.18E-09
50	7.72E-09
60	9.27E-09
70	1.01E-08
80	1.24E-08
90	1.39E-08
100	1.54E-08
110	1.69E-08
120	1.85E-08
130	2.00E-08
140	2.16E-08

Table: 4 Predicted and Validated Concentration of Frankia at Different Depths

Time Per Day	Predictive Values	Experimental Values
10	1.54E-09	1.64E-09
20	3.00E-09	3.04E-09
30	4.41E-09	4.24E-09
40	6.18E-09	6.09E-09
50	7.72E-09	7.54E-09
60	9.27E-09	9.54E-09
70	1.01E-08	1.12E-08
80	1.24E-08	1.31E-08
90	1.39E-08	1.45E-08
100	1.54E-08	1.66E-08
110	1.69E-08	1.74E-08
120	1.85E-08	1.78E-08
130	2.00E-08	2.05E-08
140	2.16E-08	2.21E-08

Table: 5 Concentration of Frankia at Different Depths

Depth [M]	Frankia Concentration
3	2.62E-11
6	5.25E-11
9	7.88E-11
12	1.05E-10
15	1.31E-10
18	1.51E-10
21	1.83E-10
24	2.10E-10
27	2.36E-10
30	2.62E-10
33	2.89E-10
36	3.15E-10
39	3.41E-10
42	3.67E-10

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

Depth [M]	Predictive Values	Experimental Values
3	2.62E-11	2.62E-11
6	5.25E-11	5.32E-11
9	7.88E-11	8.02E-11
12	1.05E-10	1.07E-10
15	1.31E-10	1.34E-10
18	1.51E-10	1.61E-10
21	1.83E-10	1.90E-10
24	2.10E-10	2.15E-10
27	2.36E-10	2.42E-10
30	2.62E-10	2.69E-10
33	2.89E-10	2.96E-10
36	3.15E-10	3.23E-10
39	3.41E-10	3.50E-10
42	3.67E-10	3.77E-10

Table: 7 Concentration of Frankia at Different Depths

Depth [M]	Frankia Concentration
3	7.65E-07
6	1.53E-06
9	2.30E-06
12	3.06E-06
15	3.83E-06
18	4.59E-06
21	5.31E-06
24	6.12E-06
27	6.89E-06
30	7.65E-06
33	8.45E-06
36	9.19E-06
39	9.96E-06
42	1.07E-05
45	1.15E-05

Table: 8 Predicted and Validated Concentration of Frankia at Different Depths

Depth [M]	Predictive Values	Experimental Values
3	7.65E-07	8.96E-07
6	1.53E-06	1.80E-06
9	2.30E-06	2.70E-06
12	3.06E-06	3.60E-06
15	3.83E-06	4.50E-06
18	4.59E-06	5.40E-06
21	5.31E-06	6.30E-06
24	6.12E-06	7.20E-06
27	6.89E-06	8.10E-06
30	7.65E-06	9.00E-06
33	8.45E-06	9.90E-06
36	9.19E-06	1.07E-05
39	9.96E-06	1.17E-05
42	1.07E-05	1.26E-05
45	1.15E-05	1.35E-05

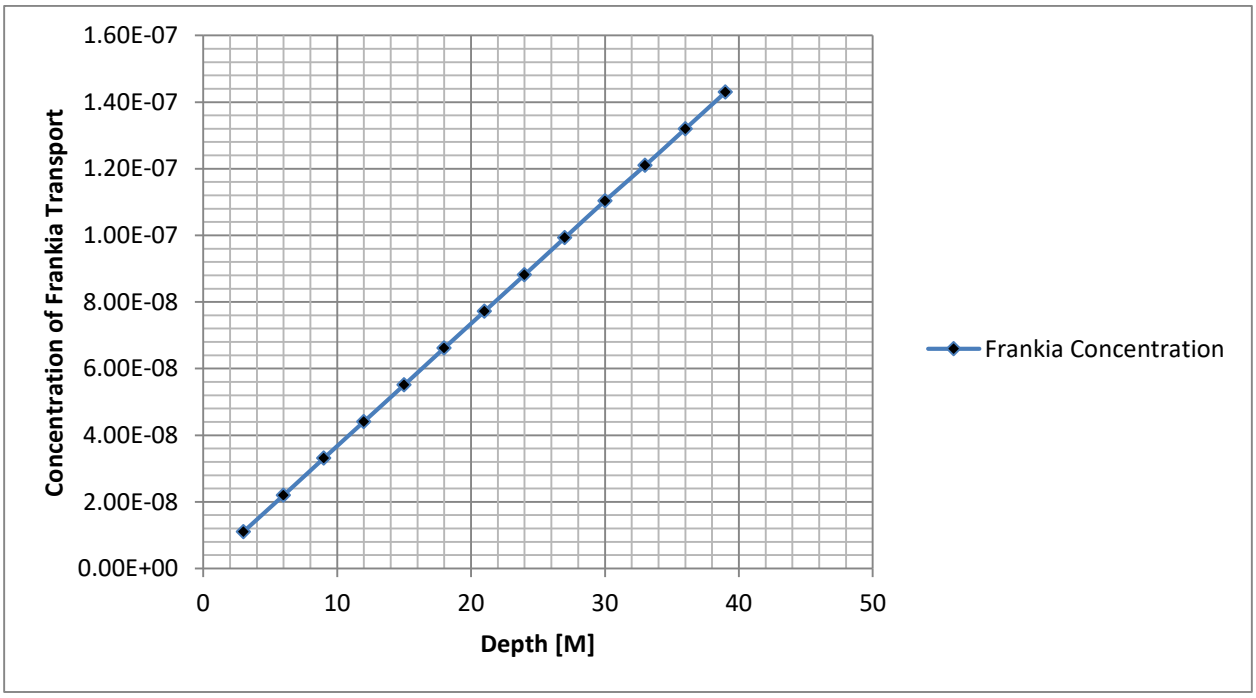

Figure: 1 Concentration of Frankia at Different Depths

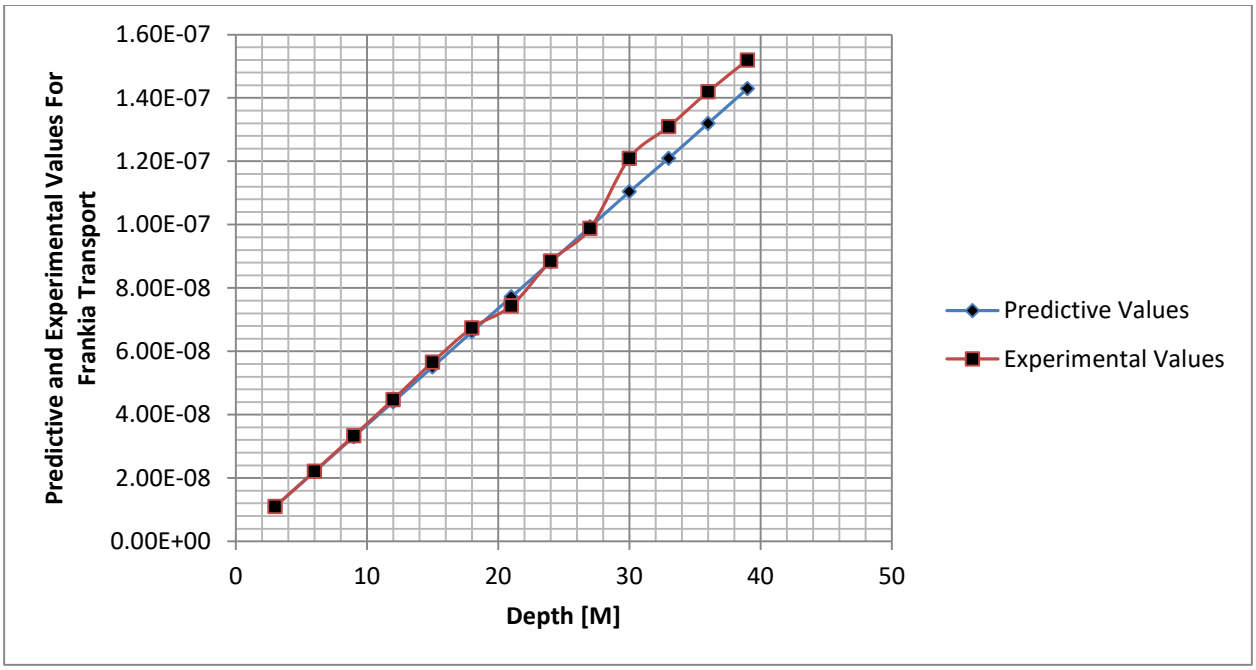

Figure: 2 Predicted and Validated Concentration of Frankia at Different Depths

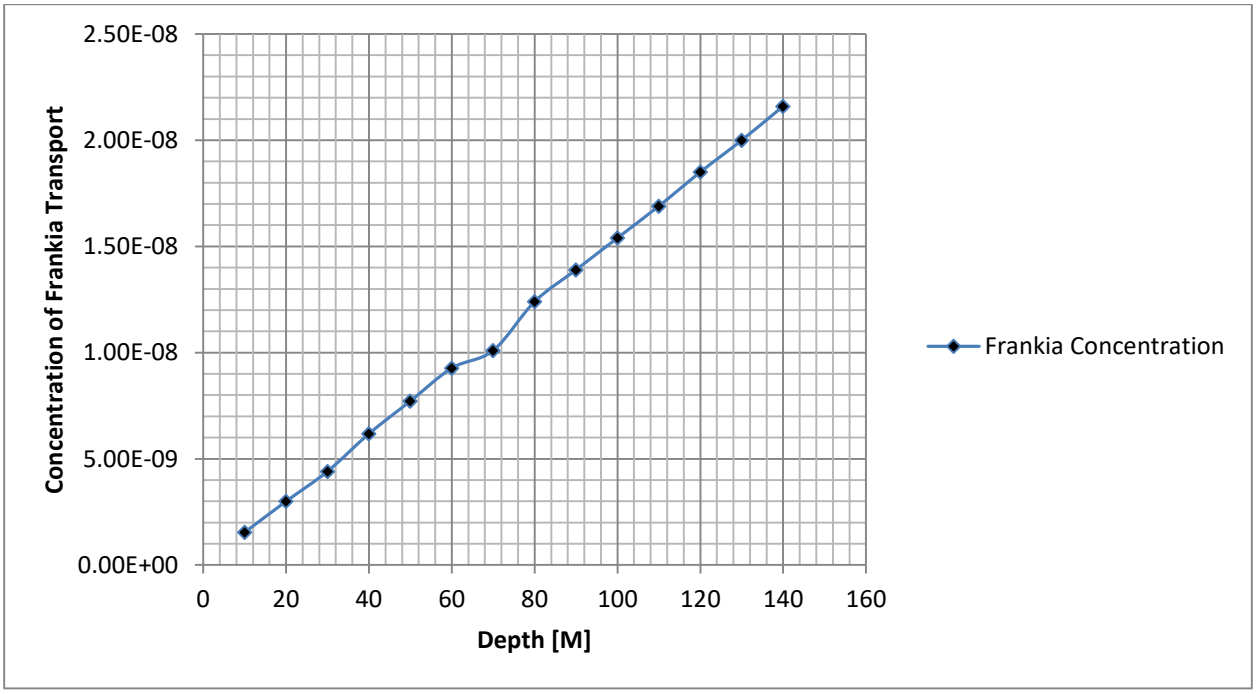

Figure: 3 Concentration of Frankia at Different Depths

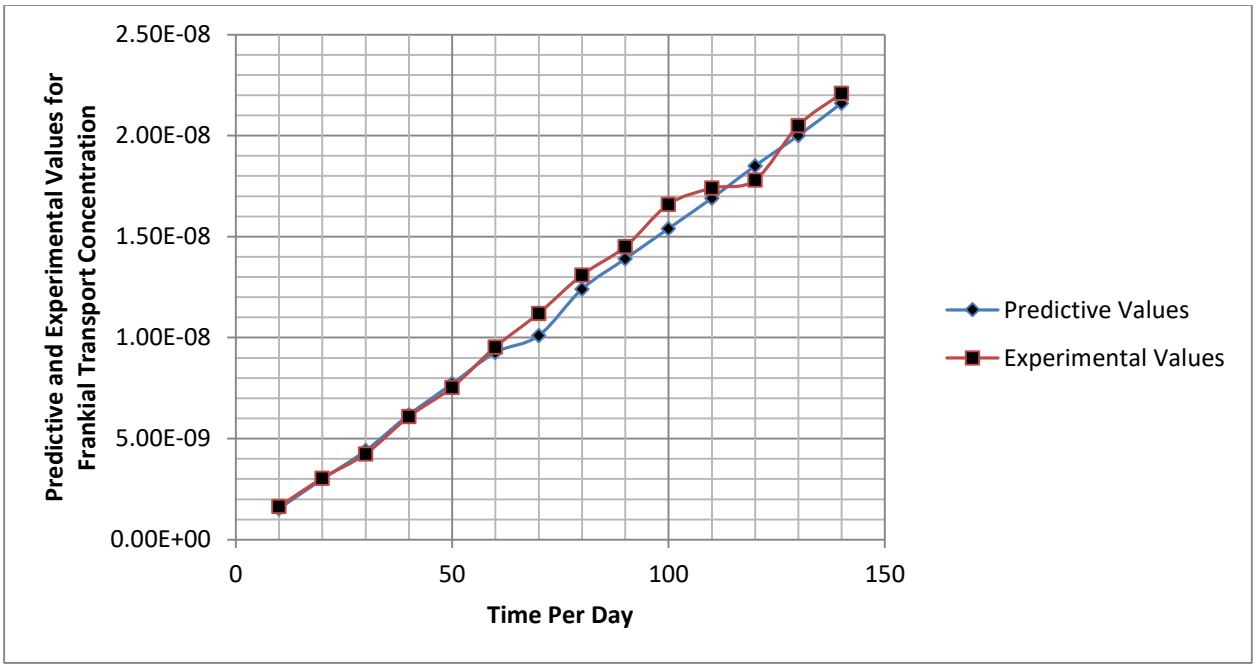

Figure: 4 Predicted and Validated Concentration of Frankia at Different Depths

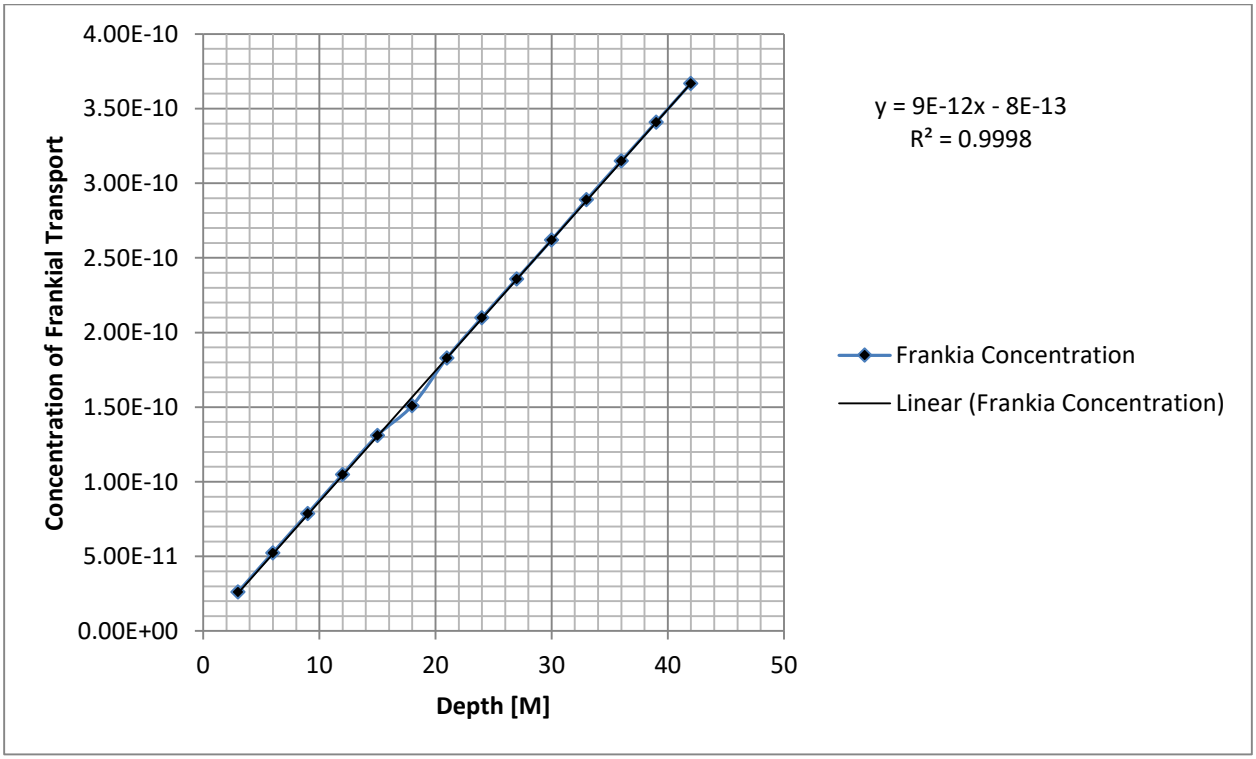

Figure: 5 Concentration of Frankia at Different Depths

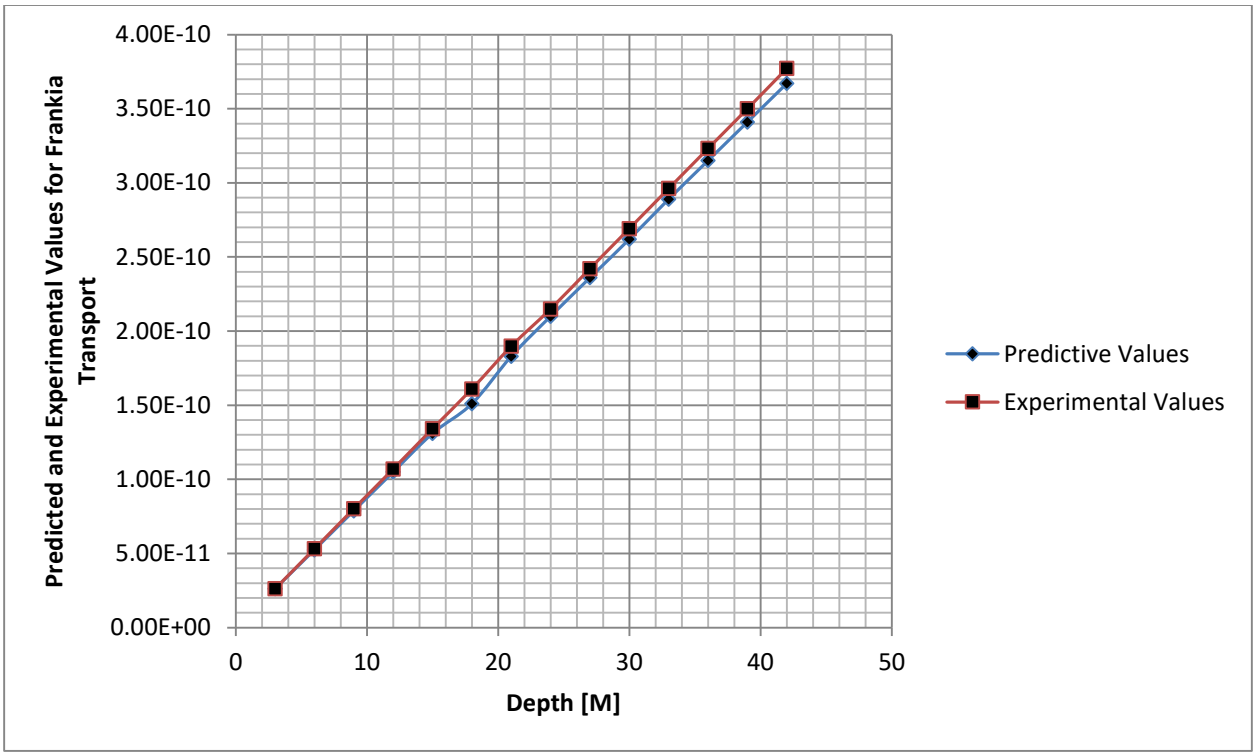

Figure: 6 Predicted and Validated Concentration of Frankia at Different Depths

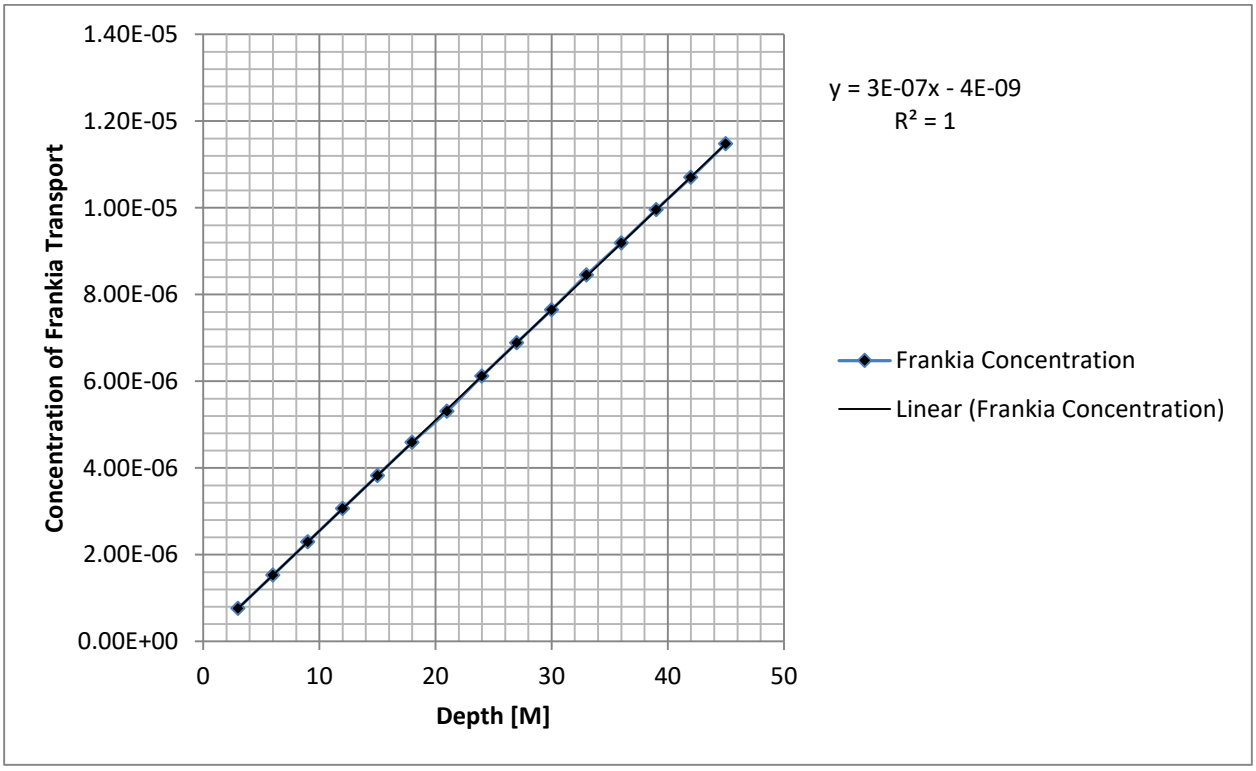

Figure: 7 Concentration of Frankia at Different Depths

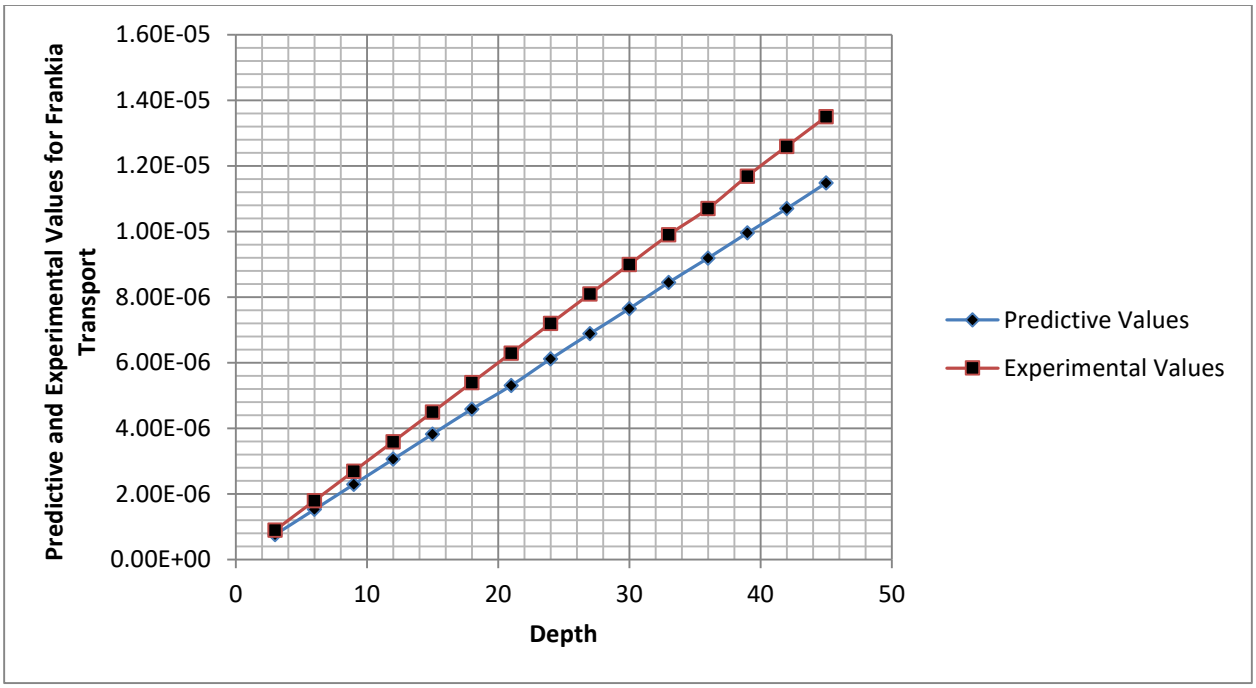

Figure: 8 Predicted and Validated Concentration of Frankia at Different Depths

The study has express the behaviour of the system through graphical representation expressing the behaviour of the contaminant, the figures show the level of migration at different concentration, figure one to four expresses the migration system normally in exponential phase but the rate of concentration, these determined the rate of depositions in various strata structured in the study area, the concentration of frankia were found to develop rapid migration within figure one and two, increase with respect to change in depth base on the transport system were observed, it is influenced by the variation of the porosity, such porous medium were observed to influences the migration rate of frankia concentration in the study area, while figure three and four shows that the system considering time express the migration rate of fluid velocity carrying the solute experiences similar rate of migration but with lower concentration. These developments increase the rate of concentration because if the fluid velocity decreases accumulation will occur thus increase concentration; these conditions were experiences from figure one to four. While figure five and six maintained experiences similar migration process but with different rate of concentration in the formation, figure six and seven express low rate of concentration, that can be attributed to slight deposition of inhibitors including rate of porosity between those strata. But slight increment of concentration were observed in seven and eight, the variation from porosity level and deposition of inhibitors were found to reflect on the

concentration rate of frankia in these figures, their migration rate maintained linear phase with increase in concentration from change in depth, their behaviour observed this condition base on the rate of inhibition and variations observed from increase rate of porosity in the formation, the transport of frankia were found through these developed simulated values, the comparative analysis between predictive and experimental values generated best fits validating the developed model for frankia transport.

6. Conclusion

The study has express the migration rate of frankia in silty and fine sand formation, the study express various rate of concentration under the influences of deposition rate of porosity and inhibitors that were observed in the formation to have reflect the deposition of frankia in the study area, the migration rate of this contaminant has expresses its behaviour in the deposition on silty and fine sand formation, the development of these model were to monitor the rate of it fluctuation on the its concentration even on linear phase express in graphical representation, the vacillation of the contaminant in the strata shows the rate of influences from the stated parameters, the developed model were compared with experimental values, both parameters meet faviourable fits, the behaviour of the contaminant has been express through the developed model simulation values, the transport system in silty and fine sand formation has express the refection of slight immobile velocity generating slight accumulation in the study area.

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