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Research article

PREDICTIVE MODEL TO MONITOR STATIONARY PHASE IN VERTICAL AND DISPERSION DEPOSITION OF THERMOTOLERANT TRANSPORT IN FINE AND SLTY SOIL COLUMN , RUMUOKORO DISTRICT OF PORT HARCOURT METROPOLIS

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Abstract

Stationary phase of thermotolerant deposited in the study area has been expressed, the model results were plotted in figures, the behaviour of the microbes were expressed under stationary phase condition from the presented figures, the expressed parameters are from developed mathematical model that generated the simulated values for validation, the generated theoretical values expressed model equations that were resolved to produced another theoretical values, through least square concept in the study locations, the values were compared with column experimental values, both parameters established a best fit. the developed theoretical model are from the best fit, it expressed the behaviuor of the microbes in term of rapid migration in soil and water environments, the study is imperative because it will monitor the behaviour of the microbes in terms of transport influences in the formation, experts will apply this method to monitor the behavior thermotolerant concentration under stationary phase condition in the study area.

Keywords: Predictive model, stationary phase thermotolerant transport, fine and column soil

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1. Introduction

Modeling microbial processes in porous media is essential to improving our understanding of the biodegradation of contaminants and the movement of pathogens. Microbial processes incorporate physicochemical processes and biological processes. Microorganisms and their transport in the environment is a complex issue of growing concern. Most reactive transport models only consider physicochemical processes. The impact of biological processes in a flowing groundwater system can only be evaluated within this physicochemical framework (Murphy and Ginn, 2000). The physicochemical processes are primarily based on the physical structure and chemical properties of the subsurface flow system and porous media. Microbial mobility dominated by physicochemical interaction with the porous media is mainly described with the colloid infiltration model (Li, 2006, Eluozo). The transport behavior of microorganisms in the subsurface environment is of great significance with respect to the fate of pathogens associated with wastewater recharge, riverbank filtration, septic systems, feedlots, and land application of biosolids. A common element to most of these applications is that the associated aqueous solutions typically have relatively high concentrations of dissolved organic carbon. Thus, the potential influence of DOC on pathogen transport is of interest. The factors affecting the transport and fate of viruses and bacteria in the subsurface have received significant attention (e.g., Yates and Yates, 1988; Schijven and Hassanizadeh, 2000; Ginn et al., 2002, Eluozo 2013). Bacteriophages are often used as a surrogate to evaluate the transport and fate of pathogenic viruses. They serve as useful models because they are similar in size and structure to many enteric viruses in some condition, do not pose a human-health hazard, and are relatively inexpensive. MS-2 Bacteriophages was used in this study, and is considered a model virus for use in transport studies because it is relatively persistent during transport (e.g., Schijven, et al. 1999). MS-2 has been classified as a group I virus, which are those whose transport is considered to be influenced by soil characteristics such as pH, exchangeable iron, and organic matter content (Gerba and Keswick., 1981). Several prior studies have examined the transport of MS-2 in porous media (Hurst et al. 1980; Bales et al. 1993; 1997; Schijven, et al. 1999, 2002, 2003; Jin et al. 2000; Hijnen et al. 2005). The objective of this study was to investigate the influence of dissolved organic carbon on MS-2 Bacteriophages transport in a sandy soil. Miscible-displacement experiments were conducted to examine the retention and transport of MS-2, at two influent concentrations, in the absence and presence of DOC. The experiments were conducted by Alexandra Chetochine. The results of the experiments were analyzed with a mathematical model that incorporated inactivation and rate-limited attachment/detachment.

2. Materials and method

Soil samples from several different borehole locations, were collected at intervals of three metres each (3m). 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 soil formation, the result were analysed to determine the rate of thermotolerant concentration between fine and silty formation through column experiment in the study area.

3. Theoretical Background

Theoretical background for 3rd degree polynomial curve fitting

General: $y = a_0 + a_1 x + a_2 x^2 + a_3 x^3 + \dots\dots\dots + a_n x^n$

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

Thus; $y_1 = a_0 + a_1 x_1 + a_2 x_1^2 + a_3 x_1^3 + \dots\dots\dots + a_n x_1^n$ ………… (1)

$$y_2 = a_0 + a_1 x_2 + a_2 x_2^2 + a_3 x_2^2 + \dots\dots\dots + a_n x_2^n \dots \qquad \dots\dots\dots\dots \qquad (2)$$

$$y_3 = a_0 + a_1 x_3 + a_2 x_3^2 + a_3 x_2^2 + \dots\dots\dots + a_n x_2^n \qquad \dots\dots\dots\dots \qquad (3)$$

$$y_4 = a_0 + a_1 x_4 + a_2 x_n^2 + a_3 x_n^2 + \dots\dots\dots + a_n x_4^n \qquad \dots\dots\dots\dots \qquad (4)$$

Summing all the equations will yield (1 n) →

$$\sum_{i=1}^{i=n} y_i = \sum a_0 + \sum_{i=1}^{i=n} a_1 x_i + \sum_{i=1}^{i=n} a_2 x_i^2 + \sum_{i=1}^{i=n} a_3 x_i^3 + \sum_{i=1}^{i=n} a_4 x_i^4 + \dots\dots + \sum_{i=1}^{i=n} a_n x_i^n$$

$$\boxed{\sum_{i=1}^{i=n} y_i = n a_0 + a_1 \sum_{i=1}^{n} x_i + a_2 \sum_{i=1}^{n} x_i^2 + a_3 \sum_{i=1}^{n} x_i^3 + \dots\dots + \sum_{i=1}^{n} x_i^n} \qquad \dots\dots\dots\dots \qquad (5)$$

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

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

$$\sum_{i=1}^{1} y_i = n a_0 + a_1 \sum x_i + a_2 \sum x_i^2 + a_3 \sum x_i^3 + \dots\dots + a_n \sum x_i^n \qquad \dots\dots\dots \qquad (6)$$

Multiply equation (6) by x_i

$$x_i \sum y_i = n a_0 x_i + a_1 x_i \sum x_i + a_2 x_i \sum x_i^2 + a_3 x_i \sum x_1^3 + \dots\dots\dots + a_n x_i \sum x_i^n$$

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

Multiply equation (6) by x_i^2

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

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

Multiply equation (3.85) by x_i^3

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

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

Multiply equation (6) by x_i^n

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

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

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 $a_0, a_1, a_2, a_3, \ldots\ldots a_n$ 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:

$$y = a_0 + a_1 x + a_2 x^2 + a_3 x^3 \qquad (11)$$

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

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

4. Results and Discussion

Table 1: Comparisons of predictive and experimental values of thermotolerant at different Depths

Depths [m]	Predictive Values	Experimental values
3	0.15	0.16
6	0.48	0.72
9	6.31	6.22
12	10.17	11.77
15	14.77	14.23
18	20.27	15.99
21	26.83	27.43
24	34.61	30.21
27	43.79	44.1
30	54.51	53.23

Table 2: Comparisons of predictive and experimental values of thermotolerant at different Depths

Depths [m]	Predictive Values	Experimental values
3	0.98	0.96
6	0.91	0.92
9	1.08	1.13
12	1.39	1.77
15	1.82	1.73
18	2.37	2.79
21	3.1	3.43
24	3.85	3.61
27	4.79	4.66
30	5.85	5.23

Table 3: Comparisons of predictive and experimental values of thermotolerant at different Depths

Depths [m]	Predictive Values	Experimental values
3	0.18	0.21
6	3.48	3.55
9	7.14	7.55
12	11.37	12.22
15	16.51	16.45
18	22.87	23.11
21	30.78	31.22
24	40.56	41.45
27	52.53	53.44
30	67.03	68.11

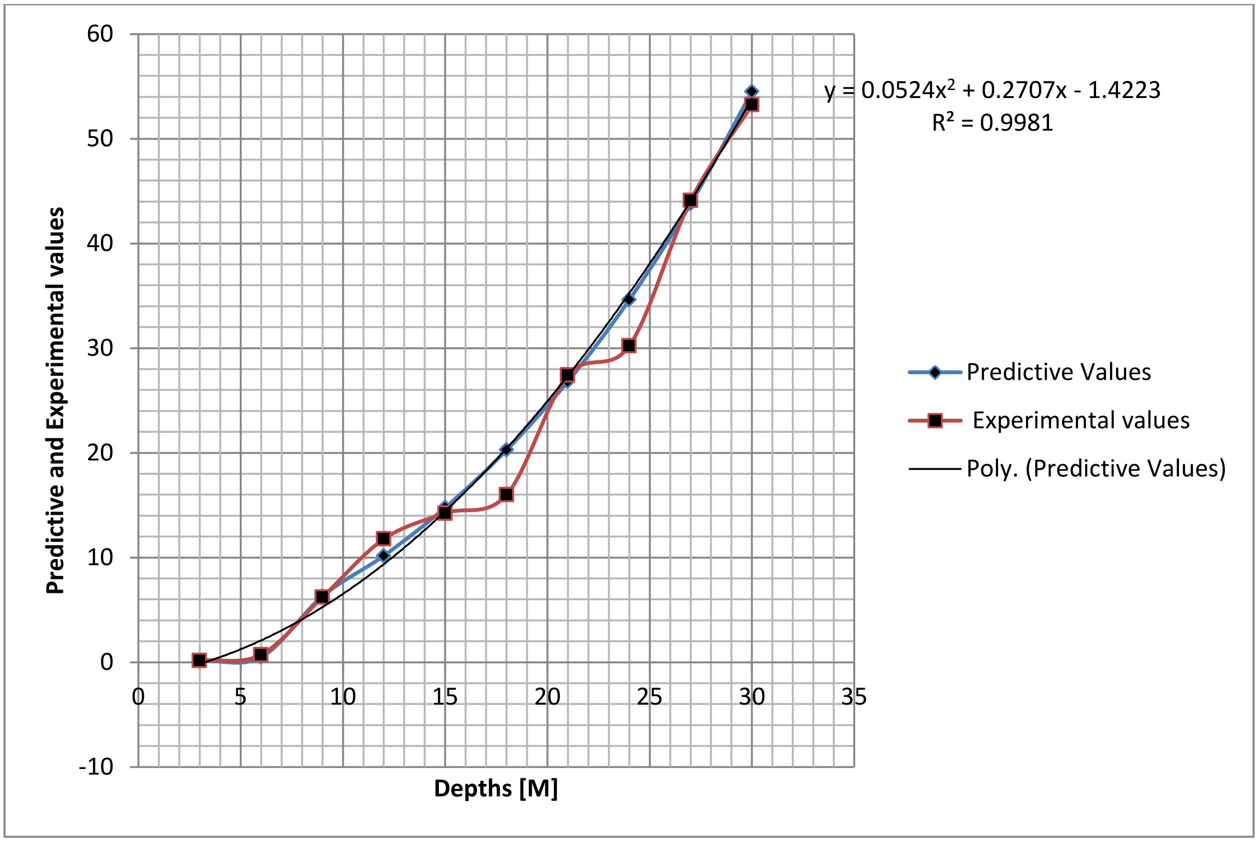

Table 2: Comparisons of predictive and experimental values of thermotolerant at different Depths

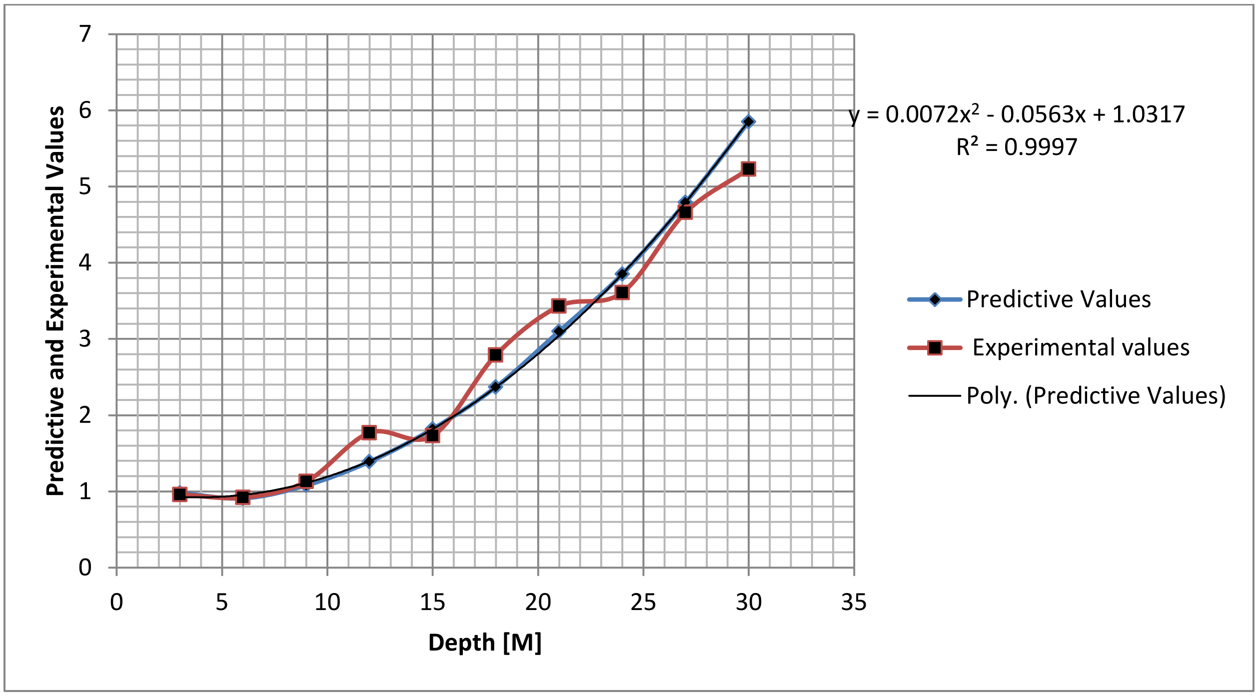

Table 2: Comparisons of predictive and experimental values of thermotolerant at different Depths

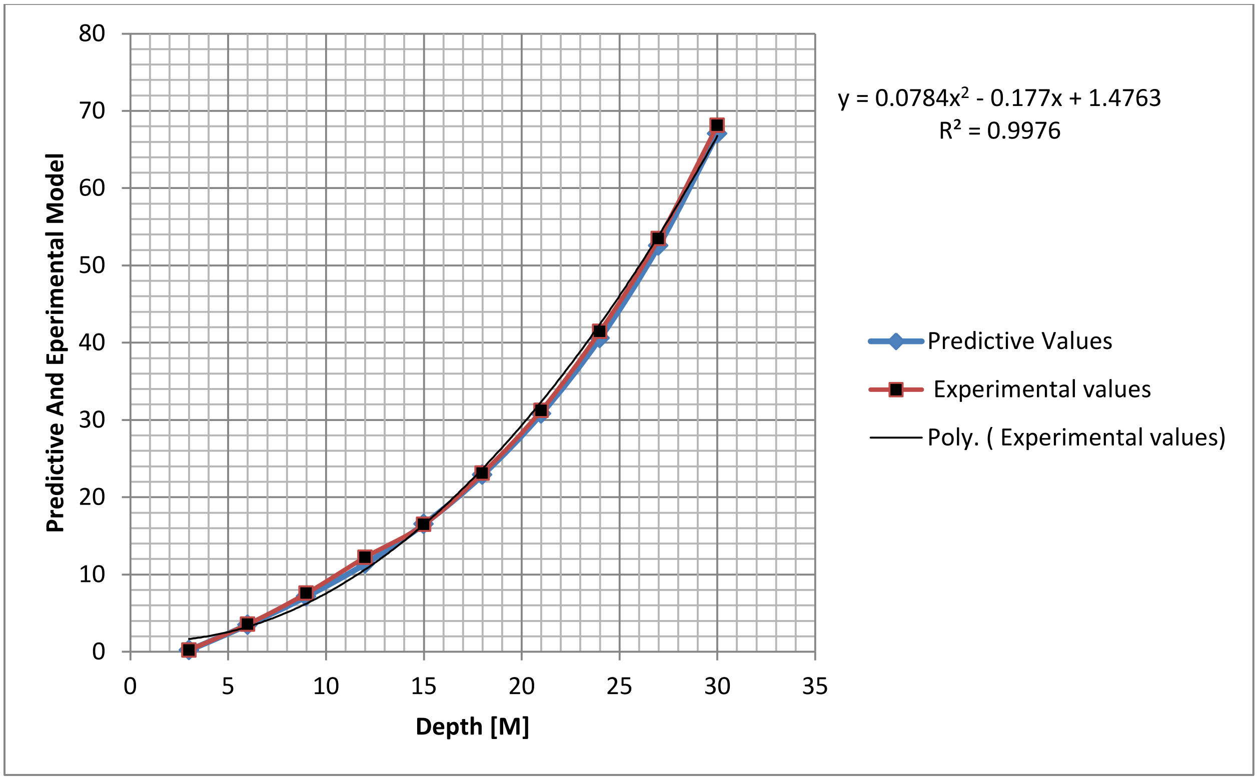

Table 3: Comparisons of predictive and experimental values of thermotolerant at different Depths

Figures shows one to three shows that the microbes deposited in stationary phase by rapidly increasing with change in concentration with respect to depth in the formation, the deposition of thermotolerant were found to be influenced by regeneration of the contaminant in the study area, such biological waste were predominant due high deposition from waste dump site around the study area, dispersion of the microbes were found to generate high degree of spread in the formation, the study developed the values through developed model that produced resolved equations from the figures, such predictive values were compare with column experimental values, both parameters generated best fit for validation of the predictive model, the rate of thermotolerant spread were from high deposited degree of pollution sources influenced by high degree of soil porosity in study area, the study is imperative because expert in the field will use this application to monitor the rate of spread and migration through the predictive model and its values in the study location.

4. Conclusion

Predictive values on thermotolerant deposition was through the expressed figures, the behaviour of this microbes was expressed in the figures, the growth rate were found to deposit on rapid increase of the transport process, the behaviour of the microbes are base on the deposition of the formation under the influences of high degree of porosity in the study area, the deposition of porosity expressed lots of variation at different formation with respect to change in concentration and depth, such condition were found to influences the behaviour of thermotolerant deposition, the exponential condition in the transport system are base on the homogeneous stetting of the formation, this are reflected on the deposition and behaviour of the microbes, such influences were found on the deposition of thermotolerant in the formations as the homogeneous stratification generated rapid increase of the concentration in the transport system, these expressed theoretical values were compared with experimental values, both parameters compared faviourably well, such parameters developed best fit expressing validation of the generated model in the study area.

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