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Hydraulic Conductivity and Velocity Influences on Partial Deposition of Caulobacter in Homogeneous Gravel Formation, Eleme, River State of Nigeria

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Abstract: This paper evaluates partial deposition of Caulobacter and its rate of transport in soil and water environment. The study monitored the migration process in homogeneous gravel formation. The study area predominantly deposits homogeneous gravel formation where it partially deposits Caulobacter in sequence through the lithology to phreatic bed within a short period. The rate of transport has not been monitored to determined there rate of porosity through hydraulic conductivity influences, these condition were found to pressured the contaminant fast to Phreatic bed in the study location, the transport process were integrated in the developed system that generated derived model to predict the transport process to unconfined bed. The developed model expresses various rate of concentration through simulation were partial deposition of Caulobacter in fluctuation were observed, Such theoretical values were compared with other experimental results for model validation; both parameters compared faviourably well expressing validation rate for the study, experts will definitely use these tools in monitoring the transport rate of Caulobacter in gravel formation.

Keywords: Hydraulic Conductivity, Permeability, Caulobacter and Gravel Formation

1. Introduction

Various scientific breakthroughs on the behaviuor of major scaling on organisms processes at the ecosystem and global levels have been express by [7, 17, 18, 19, and 20]. The respiration has particular importance in the environment thus global scales, [1, 2, 3, and 4]. The influences from climatic condition definitely effects on soil microbial communities which will definitely develop metabolic activities thus create potentially devastating feedbacks to the Earth's biosphere [4, 5, 6, and 9]. Biomass has been express as fast growing species, these condition develop (biomass that produced substrate consumed per unit) it normally convert larger fraction of substrate into CO_2 during growth, thus respire faster than efficiently growing organisms. It has been investigated that there is an unavoidable thermodynamic trade-off between growth rate and yield among heterotrophic organisms [10, 11, 12. and 25]. Previous researcher proposed that two opposing environmental strategies survive at either end of this spectrum: [12, 13, 14, and 15]. Microbes are observed to develop the cooperative, slow, capable growth approach that is more successful in spatially structured environments like biofilms [8, 9, and 10]. Examined billion of individual cells estimated from 104–105 distinct genomes per gram of soil 21, 22, 23, and 25], express bacteria in soil known to generate reservoirs for several Earth's genetic biodiversity. This development of phylogenetic thus functional diversity can be attributed to dynamic physical and chemical heterogeneity of soil, which results in spatial and temporal separation of microorganisms [5, and 16]. It noted by experts that the ability of each taxon to compete for only a subset of resources can lead to contribute to the high diversity of bacteria in soils through resource partitioning [2, 3 and 4]. Indeed, the ability to demonstrated distinct substrate preferences by broad microbial groups in grassland soils and resource partitioning has been examined to be a key contributor to patterns of Bacterial co-existence in model communities on plant surfaces [6 7, 8 18, 19, and 25].

2. Governing Equation

$$\frac{\varphi}{A}\frac{d^2c}{dL^2} = Ko\frac{dc}{dL} + Vh\frac{dc}{dL} \tag{1}$$

$$\frac{\varphi}{A}\frac{d^2c}{dL^2} = \left(Ko - Vh\right)\frac{dc}{dL} \tag{2}$$

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

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

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

$$\frac{\varphi}{A}\sum_{n=2}^{\infty} n\left(n-1\right) a_n x^{n-2} - \left(Ko + Vh\right)\sum_{n=1}^{\infty} n a_n x^{n-1} \tag{3}$$

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

$$\frac{\varphi}{A}\sum_{n=0}^{\infty}\left(n+2\right)\left(n+1\right) a_{n+2} x^n - \left(Ko + Vh\right)\sum_{n=0}^{\infty}\left(n+1\right) a_{n+1} x^n \tag{4}$$

$$\text{i.e. } \frac{\varphi}{A}\left(n+2\right)\left(n+1\right) a_{n+2} = \left(Ko + Vh\right)\left(n+1\right) a_{n+1} \tag{5}$$

$$a_{n+2} = \frac{\left(Ko + Vh\right)\left(n+1\right) a_{n+1}}{\frac{\varphi}{A}\left(n+2\right)\left(n+1\right)} \tag{6}$$

$$a_{n+2} = \frac{\left(Ko + Vh\right) a_{n+1}}{\frac{\varphi}{A}\left(n+2\right)} \tag{7}$$

$$\text{for } n = 0,\ a_2 = \frac{\left(Ko + Vh\right) a_1}{2\frac{\varphi}{A}} \tag{8}$$

$$\text{for } n = 1,\ a_3 = \frac{\left(Ko + Vh\right) a_2}{2\frac{\varphi}{A}} = \frac{\left(Ko + Vh\right)^2 a_2}{2\frac{\varphi}{A}} \tag{9}$$

$$\text{for } n = 2;\ a_4 = \frac{\left(Ko + Vh\right) a_3}{4\frac{\varphi}{A}} = \frac{\left(Ko + Vh\right)}{4\frac{\varphi}{A}} \bullet \frac{\left(Ko + Vh\right) a_1}{3\frac{\varphi}{A} \bullet 2\frac{\varphi}{A}} = \frac{\left(Ko + Vh\right)^3 a_1}{4\frac{\varphi}{A} \bullet 3\frac{\varphi}{A} \bullet 2\frac{\varphi}{A}} \tag{10}$$

$$\text{for } n = 3;\ a_5 = \frac{\left(Ko + Vh\right)^4}{5\frac{\varphi}{A}} = \frac{\left(Ko + Vh\right)^4 a_1}{5\frac{\varphi}{A} \bullet 4\frac{\varphi}{A} \bullet 3\frac{\varphi}{A} \bullet 2\frac{\varphi}{A}} \tag{11}$$

$$\text{for } n;\ a_n - \frac{\left(Ko + Vh\right)^{n-1} a_1}{\frac{\varphi}{A}^{n-1} n!} \tag{12}$$

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

$$= a_0 + a_1 x + \frac{\left(Ko + Vh\right) a_1 x^2}{2!\frac{\varphi}{A}} + \frac{\left(Ko + Vh\right) a_1 x^3}{3!\frac{\varphi}{A}^2} + \frac{\left(Ko + Vh\right) a_1 x^4}{4!\frac{\varphi}{A}^3} + \frac{\left(Ko + Vh\right) a_1 x^5}{5!\frac{\varphi}{A}^4} + \ldots \tag{14}$$

$$C(x) = a_0 + a_1\left[x + \frac{(Ko+Vh)x^2}{2!\frac{\varphi}{A}} + \frac{(Ko+Vh)^2 x^3}{3!\frac{\varphi}{A}^2} + \frac{(Ko+Vh)x^4}{4!\frac{\varphi}{A}^3} + \frac{(Ko+Vh)^4 x^5}{5!\frac{\varphi}{A}^4}\right] \quad (15)$$

$$C(x) = a_0 + a_1 \ell^{\frac{(Ko+Vh)}{\frac{\varphi}{A}}x} \quad (16)$$

Subject equation (16) to the following boundary conditions,

$$C(o) = 0 \; and \; C^1(o) = H$$

$$C(x) = a_0 + a_1 \ell^{\frac{(Ko+Vh)}{\frac{\varphi}{A}}x}$$

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

$$\text{i.e. } a_0 + a_1 = 0 \quad (17)$$

$$C^1(x) = \frac{(Ko+Vh)}{\frac{\varphi}{A}} a_1 \ell^{\frac{(Ko+Vh)}{\frac{\varphi}{A}}x}$$

$$C^1(o) = \frac{(Ko+Vh)}{\frac{\varphi}{A}} a_1 = H$$

$$a_1 = \frac{H\frac{\varphi}{A}}{Ko+Vh} \quad (18)$$

Substitute (18) into equation (17)

$$a_1 = -a_0$$

$$\Rightarrow a_0 = \frac{H\frac{\varphi}{A}}{Ko+Vh} \quad (19)$$

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

$$C(x) = -\frac{H\frac{\varphi}{A}}{Ko+Vh} + \frac{H\frac{\varphi}{A}}{Ko+Vh}\ell^{\frac{(Ko+Vh)}{\frac{\varphi}{A}}x}$$

$$\Rightarrow C(x) = \frac{H\frac{\varphi}{A}}{Ko+Vh}\left[\ell^{\frac{(Ko+Vh)}{\frac{\varphi}{A}}x} - 1\right] \quad (20)$$

3. Materials and Method

Standard laboratory experiment where performed to monitor Caulobacter using the standard method for the experiment 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 generated variations at different depths producing different Caulobacter concentration through column experiment from the pressure flow out at different strata, the experimental result were compared with the theoretical values for the validation of the model.

4. Results and Discussion

Results and discussion are presented in tables including graphical representation for Caulobacter in gravel formation.

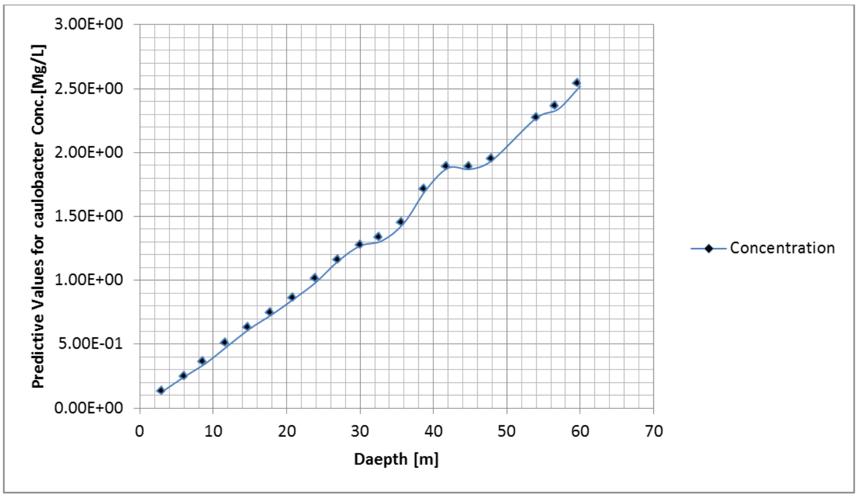

Figure 1. *Concentration of Caulobacter of flow at Different Depth.*

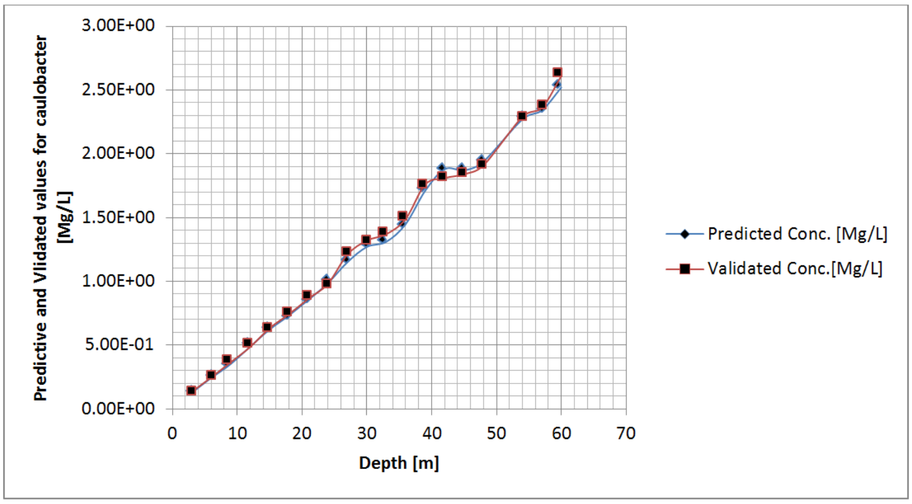

Figure 2. *Predicted and Validate Concentration of Caulobacter at Different Depth.*

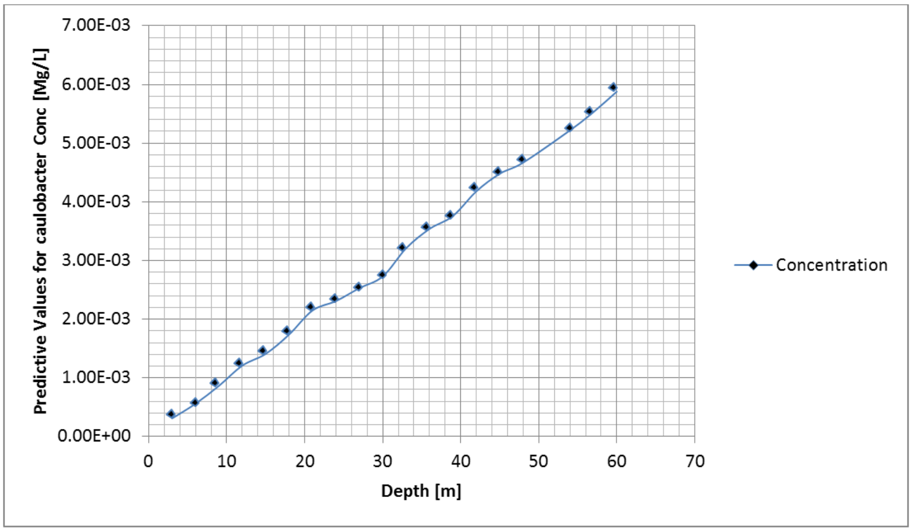

Figure 3. *Concentration of Caulobacter of flow at Different Depth.*

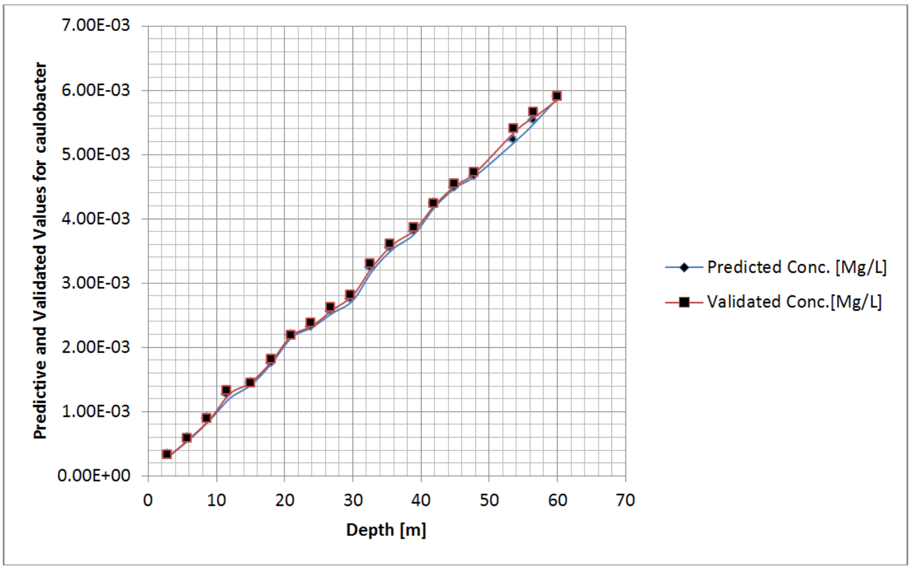

Figure 4. *Predicted and Validate Concentration of Caulobacter at Different Depth.*

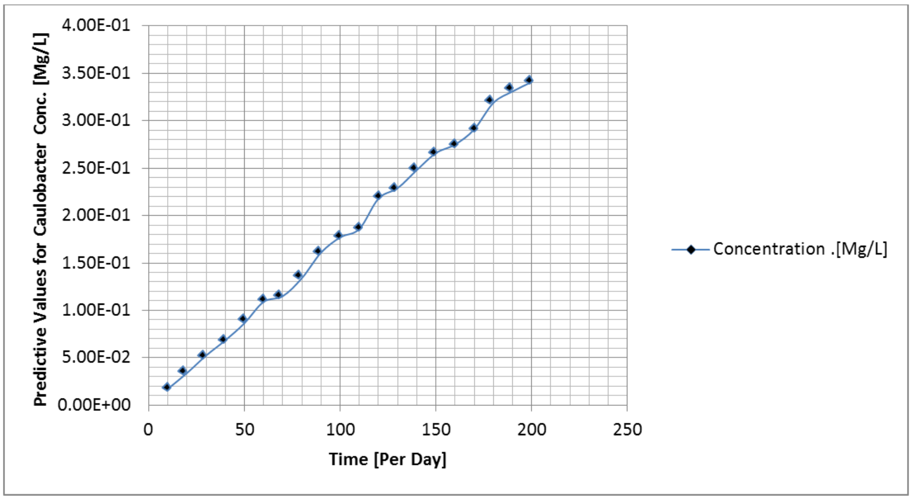

Figure 5. *Concentration of Caulobacter of flow at Different Time Per day.*

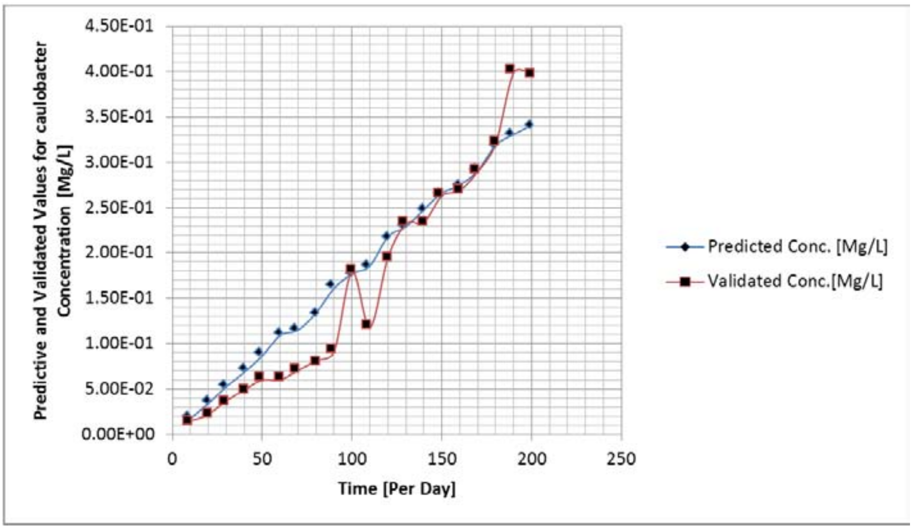

Figure 6. *Predicted and Validate Concentration of Caulobacter at Different Time Per day.*

Table 1. *Concentration of Caulobacter flow at Different Depth.*

Depth [M]	Concentration.[Mg/L]
3	1.27E-01
6	2.43E-01
9	3.52E-01
12	4.88E-01
15	6.22E-01
18	7.33E-01
21	8.55E-01
24	9.86E-01
27	1.15E+00
30	1.27E+00
33	1.31E+00
36	1.45E+00
39	1.71E+00
42	1.88E+00
45	1.87E+00
48	1.94E+00
54	2.27E+00
57	2.34E+00
60	2.52E+00

Table 2. *Predicted and Validate Concentration of Caulobacter at Different Depth.*

Depth [M]	Predicted Conc. [Mg/L]	Validated Conc.[Mg/L]
3	1.27E-01	1.35E-01
6	2.43E-01	2.47E-01
9	3.52E-01	3.66E-01
12	4.88E-01	4.85E-01
15	6.22E-01	6.33E-01
18	7.33E-01	7.43E-01
21	8.55E-01	8.65E-01
24	9.86E-01	9.81E-01
27	1.15E+00	1.21E+00
30	1.27E+00	1.32E+00
33	1.31E+00	1.37E+00
36	1.45E+00	1.49E+00
39	1.71E+00	1.76E+00
42	1.88E+00	1.81E+00
45	1.87E+00	1.84E+00
48	1.94E+00	1.91E+00
54	2.27E+00	2.29E+00
57	2.34E+00	2.36E+00
60	2.52E+00	2.61E+00

Table 3. *Concentration of Caulobacter of flow at Different Depth.*

Depth [M]	Concentration [Mg/l]
3	3.11E-04
6	5.60E-04
9	8.65E-04
12	1.21E-03
15	1.41E-03
18	1.74E-03
21	2.15E-03
24	2.31E-03
27	2.53E-03
30	2.73E-03
33	3.21E-03
36	3.54E-03
39	3.76E-03
42	4.18E-03
45	4.48E-03
48	4.67E-03
54	5.22E-03
57	5.53E-03
60	5.88E-03

Table 4. *Predicted and Validate Concentration of Caulobacter at Different Depth.*

Depth [M]	Predicted Conc. [Mg/L]	Validated Conc.[Mg/L]
3	3.11E-04	2.98E-04
6	5.60E-04	5.76E-04
9	8.65E-04	8.77E-04
12	1.21E-03	1.28E-03
15	1.41E-03	1.45E-03
18	1.74E-03	1.77E-03
21	2.15E-03	2.18E-03
24	2.31E-03	2.33E-03
27	2.53E-03	2.58E-03
30	2.73E-03	2.81E-03
33	3.21E-03	3.27E-03
36	3.54E-03	3.61E-03
39	3.76E-03	3.82E-03
42	4.18E-03	4.21E-03
45	4.48E-03	4.51E-03
48	4.67E-03	4.72E-03
54	5.22E-03	5.38E-03
57	5.53E-03	5.61E-03
60	5.88E-03	5.85E-03

Table 5. *Concentration of Caulobacter flow at Different Depth.*

Time per day	Concentration.[Mg/L]
10	1.72E-02
20	3.39E-02
30	5.24E-02
40	6.84E-02
50	8.65E-02
60	1.09E-01
70	1.15E-01
80	1.34E-01
90	1.61E-01
100	1.77E-01
110	1.86E-01
120	2.18E-01
130	2.29E-01
140	2.48E-01
150	2.66E-01
160	2.75E-01
170	2.91E-01
180	3.19E-01
190	3.31E-01
200	3.41E-01

Table 6. *Predicted and Validate Concentration of Caulobacter at Different Depth.*

Time per day	Predicted Conc. [Mg/L]	Validated Conc.[Mg/L]
10	1.72E-02	1.44E-02
20	3.39E-02	2.19E-02
30	5.24E-02	3.68E-02
40	6.84E-02	4.89E-02
50	8.65E-02	5.98E-02
60	1.09E-01	6.01E-02
70	1.15E-01	7.04E-02
80	1.34E-01	8.11E-02
90	1.61E-01	9.12E-02
100	1.77E-01	1.79E-01
110	1.86E-01	1.18E-01
120	2.18E-01	1.95E-01
130	2.29E-01	2.32E-01
140	2.48E-01	2.34E-01
150	2.66E-01	2.63E-01
160	2.75E-01	2.69E-01
170	2.91E-01	2.90E-01
180	3.19E-01	3.21E-01
190	3.31E-01	3.99E-01
200	3.41E-01	3.98E-01

Figure one and two explain the fluctuation of the Caulobacter transport under exponential deposition in the study location, the transport of the Caulobacter under the transport process expresses the rate of structural influence reflected on variation of porosity, these has definitely influences the transport process of Caulobacter in the formation. Such condition express the rate of pressure on fluctuation of the contaminant from the structured strata, but under the exponential phase of deposition, the concentration express variation compared to previous figures, the rate of concentration are higher than the concentration in one and two, but they are all migrating under exponential phase base on the homogeneous porous gravel deposition, the rate of migration in such alluvium depositions observed slight low permeability, partial deposition of Caulobacter are observed under the influences of these condition found in the migration rate as observed in the transport process of the system. but in this three and four there is increase in porosity and permeability coefficient where by the concentration are lower compared to previous figures, these also express the rates of its partial deposition under these formation characteristics, while in figure five and six experiences increase in permeation in the strata as it influences the concentration stabilizing the partial deposition, observing the rate of partial deposition with respect to time per day monitored the system under the rate of migration with respect to time. The highest was observed at two hundred days, these implies that the transport can migrate to Phreatic bed within this period from surface, the study through the developed model generated these theoretical values from simulations and was compared with experimental values, both parameters expressed best fits validating the model for the study.

5. Conclusion

The behaviuor of Caulobacter has been thoroughly developed through this application. The developed model expresses the migration process of Caulobacter from the surface to Phreatic bed, the rate of concentration where evaluated at various strata in other to monitor various rate of partial deposition of Caulobacter in the study area. The study has definitely express the rate of concentration under the partial deposition of Caulobacter transport observed applying this type of mathematical method. The rate of concentration at different depth and time from the simulation are base on the formation effect through the rate of porosity in various strata. Predicted values were compared with experimental result, both parameters express best fits validating the developed model. The study has definitely streamlined the behaviour of Caulobacter under the pressure of porosity in the study area.

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