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Modelling Alluvia Structural Deposition Influences on Campylobacter Accumulation in Silty Formation

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Abstract:

This paper monitors the behavior of campylobacter in silty depositions, the study observed accumulation of campylobacter base on the pressured from lower formation characteristics observed in the deltaic depositions, these conditions were experienced from the deltaic environment were soil porosity and permeability experiences low degree thus developed slow migration of the contaminant, the study observed an accumulation of the contaminant in the study location. Such condition implies the system predict the contaminant base on the structural setting of the litho units in deltaic environment, validation from the simulation values were carried out, both parameters developed favorable fits, the study is imperative because accumulation of campylobacter has caused lots of ill health in deltaic environment, the developed model will be useful to experts in monitoring and evaluation of the contaminant in silty deposited area.

Key Words: Modelling, alluvia, structural deposition and campylobacter

Introduction:

The significant tendency of adequate and consistent geotechnical classification of sub-soils is granted. Based on these conditions, the impact of the imposed load is worsening by the thickness and consistency of the compressible layer. This, in addition to other intrinsic factors contributes to the failure of civil engineering structures (Youdeowei & Nwankwoala, 2013; Amadi *et al*,2012). Nigeria is very attractive to foreign investors; these generate design and construction of foundation, and thus civil engineering structures in order to reduce unfavorable effects and prevention of post construction crisis. Generally, in the Niger Delta geotechnical information on the underlying soils are desired for the design of appropriate foundation for structures (Ngah &Nwankwoala, 2013; Nwankwoala & Warmate, 2014, Eluozo and Ode 2015a, 2015b, 2015c).The deposition of soil in several deltaic formation varies, such condition should be monitored to express their various behavior in terms of compressibility consolidation, there formation characteristics determined there deposition; there strength of soil types locations express various depositions thus generate different settlement factors that constitutes an extensive plain exposed to periodical inundation by flooding when the rivers and creeks overflow their banks. A prominent feature of the rivers and creeks is the occurrence of natural levees on both banks, behind which occur vast areas of back-swamps and lagoons/lakes where surface flow is negligible (Youdeowei and Nwankwoala, 2010). Looking from the present knowledge, the geology of the Niger Delta is derived from the works of Reyment (1965), Short and Stauble (1967), Murat (1970), Merki (1970), thus the exploration activities from oil and gas companies. It has been observed that the formation of the so-called proto-Niger Delta occurred during the second depositional cycle (Campanian-Maastrichtian) of the southern Nigerian basin. However, modern Niger Delta was formed during the third and last depositional cycle of the southern Nigerian basin which started in the Paleocene (Nwankwoala1et al 2015).

Theoretical Background:

The study expresses the behavior of homogeneous structure predominant in alluvia location of the Niger delta environment, this study mathematically relate this problem, by modelling the behavior of the system based on the deposited structures, the system monitored the behavior of campylobacter depositions in alluvia depositions, the study applying mathematical model is to ensure the behavior of campylobacter migration are thoroughly observed in silty depositions, the derived model were done through the developed system thus generating the governing equation. Simulation of the model will definitely generate values that represent different concentration as it migrates in various silty depositions.

Governing Equation:

$$K\frac{hA}{L}\frac{\partial c}{\partial t} = \Delta V\frac{\partial^2 c}{\partial z^2} + h_{(x)}\frac{\partial c}{\partial z} + \Delta\phi\frac{\partial^2 c}{\partial z^2} \quad \ldots\ldots\ldots\ldots\ldots \quad (1)$$

Nomenclature

h = Fluid flow at vertical level
K = Permeability
A = Cross sectional area
L = Length
T = Time
Q = Porosity
c = Concentration
V = Velocity
z = Depth
$h_{(x)}$ = Fluid at short distance

$$K\frac{hA}{L}\frac{\partial c}{\partial t} = [\Delta V + \Delta\phi]\frac{\partial^2 c}{\partial z^2} + h\frac{\partial c}{\partial z} \quad \ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$K\frac{hA}{L}\frac{\partial c}{\partial t} = [\Delta V + \Delta\phi]\frac{\partial^2 c}{\partial z} \quad \ldots\ldots\ldots\ldots\ldots \quad (3)$$

$$K\frac{hA}{L}\frac{\partial c_1}{\partial t} = h\frac{\partial c}{\partial z} \quad \ldots\ldots\ldots\ldots\ldots \quad (4)$$

$$[\Delta V + \Delta\phi]\frac{\partial^2 c_3}{\partial z^2} = -h\frac{\partial c_3}{\partial z} \quad \ldots\ldots\ldots\ldots\ldots \quad (5)$$

The solution is of the form $c = (t,z) = c_1(t,z) + c_2(t,z) + c_3(t,z)$

Let $c = T, Z$ .... (6)

$$\frac{\partial c_1}{\partial t} = T^1 Z \quad \ldots\ldots\ldots\ldots\ldots \quad (7)$$

$$\frac{\partial c}{\partial z} = TZ^1 \quad \ldots\ldots\ldots\ldots\ldots \quad (8)$$

$$\frac{\partial^2 c}{\partial z^2} = TZ^{11} \quad \ldots\ldots\ldots\ldots\ldots \quad (9)$$

Consider (3)

$$K\frac{hA}{L}T^1 Z = [\Delta V + \Delta\phi]TZ^{11} = \beta^2 \quad \ldots\ldots\ldots\ldots\ldots \quad (10)$$

$$K\frac{hA}{L} = \beta^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (11)$$

$$\int \frac{dT}{T} = \int \frac{\beta^2}{K\frac{hA}{L}} dt \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (12)$$

$$Ln\,T = \frac{\beta^2}{K\frac{hA}{L}} + c \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (13)$$

$$\boxed{T = A\ell^{\frac{\beta}{K\frac{hA}{L}}t}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (14)$$

Considering this expression again $[\Delta V + \Delta\phi] = \beta^2$

$$[\Delta V + \Delta\phi]Z^{11} = \beta^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (15)$$

$$c = B\ell^{\frac{\beta^2}{\Delta V + \Delta\phi}Z} + D\ell^{\frac{\beta^2}{\Delta V + \Delta\phi}Z} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (16)$$

Combine (14) and (16) gives

$$c_1(t, z) = \left(B\ell^{\frac{\beta}{\Delta V + \Delta\phi}Z} + D\ell^{\frac{\beta}{\Delta V + \Delta\phi}Z} \right) A\ell^{\frac{\beta^2}{K\frac{hA}{L}}t} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (17)$$

Consider equation (4)

$$K\frac{hA}{L}\frac{\partial c_2}{\partial t} = h\frac{\partial c_2}{\partial z}$$

$$K\frac{hA}{L}T^1 Z = hZ^1 T$$

$$K\frac{hA}{L}\frac{T^1}{T} = h\frac{Z^1}{Z} = \gamma \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (18)$$

$$h\frac{Z^1}{Z} = \gamma \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (19)$$

$$\int \frac{dT}{T} = \frac{\gamma}{K\frac{hA}{L}} \int dt \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (20)$$

$$Ln\,T = \frac{\gamma}{K\frac{hA}{L}} + \varphi \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (21)$$

$$T = C\ell^{\frac{\gamma}{K\frac{hA}{L}}t} \qquad \text{.............................} \qquad (22)$$

Considering $h\dfrac{Z^1}{Z} = \gamma$

$$\int \frac{dz}{z} = \int \gamma v dz \qquad \text{.............................} \qquad (23)$$

$$Ln\, z = \gamma hz + b \qquad \text{.............................} \qquad (24)$$

$$z = \Delta\ell^{\gamma h} \qquad \text{.............................} \qquad (25)$$

Combine (22) and (25), gives;

$$c_2 = (t, z) = ab\ell^{\left(\frac{1}{K\frac{hA}{L}} + h\right)t} \qquad \text{.............................} \qquad (26)$$

Consider equation (5)

$$[\Delta V + \Delta\phi]Z^{11}T = -hZ^1T$$

$$[\Delta V + \Delta\phi]\frac{Z^{11}}{Z} = -h\frac{dz}{dz} = \theta^2 \qquad \text{.............................} \qquad (27)$$

$$[\Delta V + \Delta\phi]\frac{d^2z}{dz^2} = \theta^2 \qquad \text{.............................} \qquad (28)$$

$$Z = E\,Cos\frac{\theta}{\sqrt{\Delta V + \Delta\phi}}z + F\,Sin\frac{\theta}{\sqrt{\Delta V + \Delta\phi}}z \qquad \text{.............................} \qquad (29)$$

Also $h\dfrac{dz}{dz} = +\theta^2$

$$\int \frac{dz}{dz} = h\theta^2 \int dz \qquad \text{.............................} \qquad (30)$$

$$Ln\, z = h\theta^2 z + d \qquad \text{............................} \qquad (31)$$

$$z = D\ell^{h\theta^2} \qquad \text{............................} \qquad (32)$$

Combining (29) and (30) yield

$$c_3 = (t, z) = \left(E\,Cos\frac{\theta}{\sqrt{\Delta V + \Delta\phi}}z + F\,Sin\frac{\theta}{\sqrt{\Delta V + \Delta\phi}}z\right)G\ell^{h\theta^2} \qquad \text{......................} \qquad (33)$$

Therefore, combined equations (17), (26) and (33) give

$$c(t, z) = c_1(t, z) + c_2(t, z) + c_3(t, z)$$

$$c_1(t,z) = \left(B\ell^{\frac{\beta}{\Delta V + \Delta\phi}Z} + D\ell^{-\frac{\beta}{\Delta V + \Delta\phi}Z} \right) A\ell^{\frac{\theta^2}{K\frac{hA}{L}}t} +$$

$$ab\ell^{\left(\frac{1}{K\frac{hA}{L}}+h\right)}\gamma + \left(E\,Cos\frac{\theta}{\sqrt{\Delta V + \Delta\phi}}z + F\,Sin\frac{\theta}{\sqrt{\Delta V + \Delta\phi}} \right) G\ell^{h\theta^2}z \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (34)$$

Materials and Method:

Standard laboratory experiment where performed to monitor the rate of campylobacter at different formation, the soil deposition of the strata were collected in sequences base on the structural deposition at different study area, this samples collected at different location generating variation of campylobacter concentration at different depth through its pressure flow at the lower end of the column, the experimental result are applied to compared with theoretical values for model validation.

Results and Discussion:

Results and discussion are presented in tables including graphical representation of campylobacter at different Depth.

Table 1: Predictive values of campylobacter concentration at Time

Time Per Day	Predictive Concentration [Mg/L]
10	6.23E-04
20	1.41E-03
30	2.36E-03
40	3.47E-03
50	4.75E-03
60	6.49E-03
70	7.80E-03
80	9.57E-03
90	1.15E-02
100	1.36E-02
110	1.58E-02
120	1.83E-02

Table 2: Predictive and Experimental Values for Campylobacter at different Depth

Time Per Day	Predictive Campylobacter Concentration [Mg/L]	Experimental Campylobacter Concentration [Mg/L]
10	6.23E-04	6.34E-04
20	1.41E-03	1.17E-03
30	2.36E-03	2.47E-03
40	3.47E-03	3.63E-03
50	4.75E-03	4.95E-03
60	6.49E-03	6.43E-03
70	7.80E-03	8.07E-03
80	9.57E-03	9.87E-03
90	1.15E-02	1.18E-02
100	1.36E-02	1.39E-02
110	1.58E-02	1.62E-02
120	1.83E-02	1.87E-02

Table 3: Predictive values of campylobacter concentration at Time

Time Per Day	Predictive Concentration [Mg/L]
10	4.38E-05
20	8.86E-05
30	1.34E-04
40	1.81E-04
50	2.29E-04
60	2.78E-04
70	3.28E-04
80	3.79E-04
90	4.32E-04
100	4.85E-04
110	5.39E-04
120	5.95E-04

Table 4: Predictive and Experimental Values for Campylobacter at different Depth [m]

Time Per Day	Predictive Campylobacter Concentration [Mg/L]	Experimental Campylobacter Concentration [Mg/L]
10	4.38E-05	4.07E-05
20	8.86E-05	8.22E-05
30	1.34E-04	1.25E-04
40	1.81E-04	1.68E-04
50	2.29E-04	2.13E-04
60	2.78E-04	2.58E-04
70	3.28E-04	3.00E-04
80	3.79E-04	3.25E-04
90	4.32E-04	4.00E-04
100	4.85E-04	4.50E-04
110	5.39E-04	5.00E-04
120	5.95E-04	5.52E-04

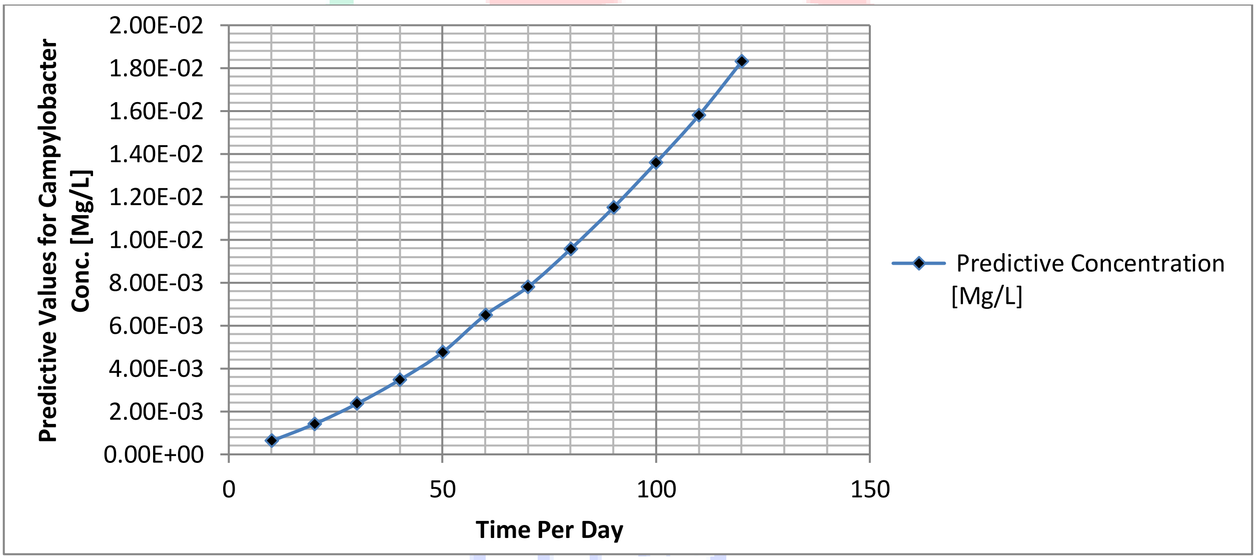

Figure 1: Predictive values of campylobacter concentration at Time

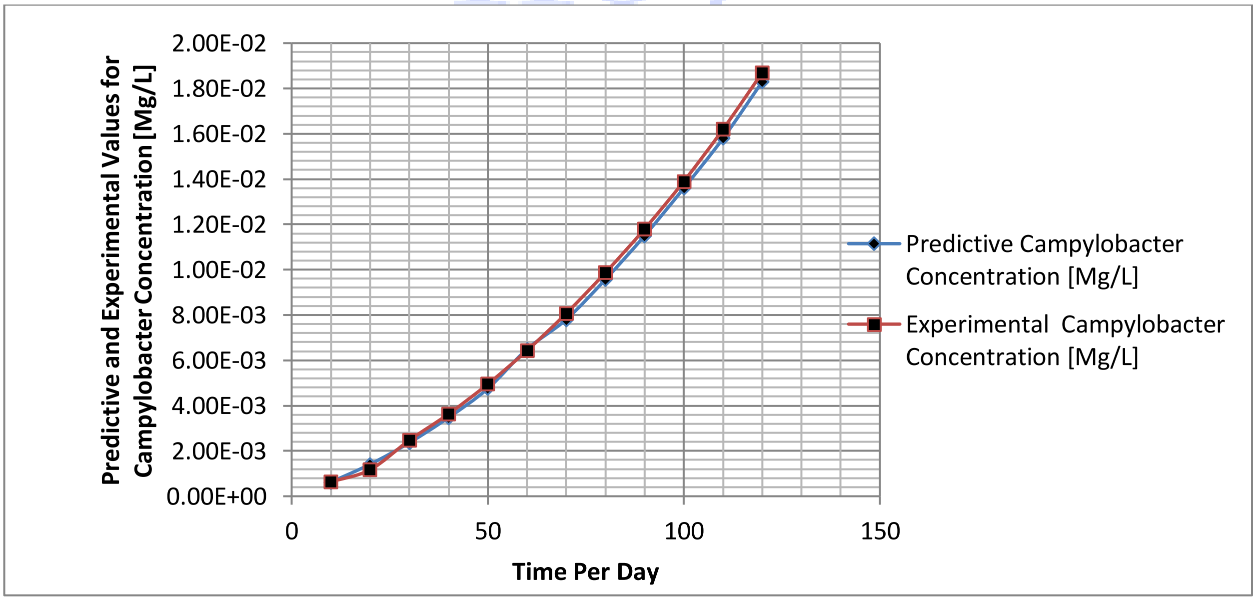

Figure 2: Predictive and Experimental Values for Campylobacter at different Depth [m]

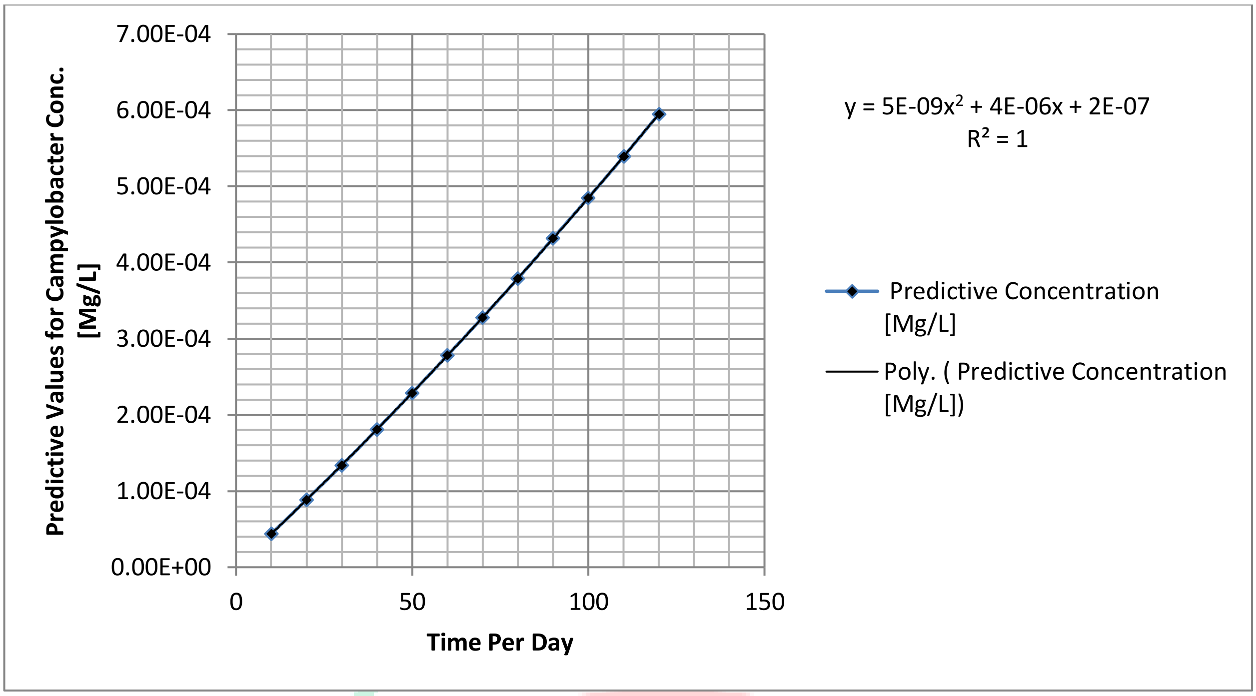

Figure 3: Predictive values of campylobacter concentration at Time

The figure presented shows the linearization of the campylobacter deposition in silty formation, the study observed exponential level base on the rate of low permeation of silty deposition, these condition implies that the behavior of the contaminant in terms of migration experienced low migration thus generated accumulation in predominant environment within the depth of study, all the figures from the simulation developed exponential phase in the study area, these expression shows the rate at which low formation characteristics influences the behavior of the contaminant in terms of migration at different depth, model validation were carried out and both parameter experienced favorable fits.

Conclusion:

The accumulation of the campylobacter in silty deposition were observed in some deltaic locations, the study experiences higher rates of accumulation in silty deposition, linear migration of campylobacter was observed from the simulation values, while model validation were carried to express the authenticity of the developed derived solution, comparison done within both parameters experienced favorable fits, the study observed the rate at which low formation characteristics pressured the migration rate of the contaminant thus developed high accumulation of the concentration in the study area.

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