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Research article

MATHEMATICAL MODEL TO PREDICT THE MIGRATION OF CRYPTOSPORIDIUM IN HOMOGENEOUS FORMATION IN OBIO/AKPOR, RIVERS STATE OF NIGERIA

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Abstract

Modeling of bacteria transport process has been expressed by different researchers on a particular formation, on the application batch system. Their results can only be determined from the behavior of the microbes at a particular soil formation. Previous studies have not provided a platform to monitor the behavior of the microbes sequentially from the made/organic soil to the formation where auriferous zones are deposited. The behavior of the microbes at porous medium cannot give an explicit result on microbial behavior in soil and water environment. This expression from previous studies cannot solve or monitor the behavior of the microbes determined by formation characteristics that can solve the problem of preventing bacterial transport to groundwater aquifers. The deltaic nature of the study area are influenced by several formation characteristics, where porosity play the role of independent variables that influence the bacterial behavior at different stratum, under the influence of the deltaic nature of the soil. The model expression will definitely monitor the bacterial behavior sequentially as considered in the system to express various concentrations of the bacteria to groundwater aquifers. Finally, the developed model derived will definitely conquer the bacterial transport on designing of water wells in the study location.

Keywords: mathematical model to predict cryptosporidium and homogeneous formation

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1. Introduction

Bacterial adhesion is imperative in a variety of ecological applications together with microbial biofouling and *in-situ* bioremediation. When situation permit, attached bacterial cells may survive for lingering periods and biofilms, i.e., powerless microbial cell colonization on a surface, can be formed. Biofilms have been familiar as a potential source of pollution, though biofilms arrangement may also be valuable for biofouling [Momba et al 2000] and biodeterioration [Chavant, et al 2000]. Bacterial adhesion and surface colonization are interrelated with bacterial surface physicochemical properties [Sinet et al, 2002 Flint,et al 1997 Rosenberg,1991, Bornaet and Rouxhxt, 2000], which ascribes to the surface molecular composition in terms of proteins, polysaccharides and hydrocarbon-like compounds [Barker et al, 2002]. Bacterial strains with diverse cell surface properties show diverse adhesion kinetics and affinity for substrate [Gottenbos et al, 2002]. Bacterial surface physicochemical properties and as a result their adhesion can be influenced by growth situation (Briandet et al. 1999). For example, [Gottenbos et al, 2002] it is found that incubation temperature impacted the hydrophobicity of *C. parapsilosis* strain 294 through contact angle measurements of strains deposited on lawns of yeasts [Busalmen and Sanchez, 2001]. [Doyle et al, 1980] It observed a low adhesion density of cells grown in the logarithmic state and a high adhesion density of cells grown in the stationary state by examining the adhesion of *Lactococcus lactis* on polystyrene [Doyle et al, 1980]. Bacterial adherence to substrate is also influenced by pH and ionic strength of the electrolyte solution [Doyle et al 1980, Pelletier et al,.1997 Vander et al,2001]. Bacterial surface physico-chemical properties can be chemically modified to stimulate bacterial adhesion to substrate [, Whitetle 1991, Bornaet, et al 2001]. Besides, several extracellular structures (lipopolysaccharides, flagella and membrane proteins) also impact the modulation of the adhesion of bacteria to substrate [Bornaet et al 2001, Gomez et al 2002, Whitetle 1991and Pelletier et al,.1997]. The United States Environmental Protection Agency [Arnold et al 1998] estimated that 45 percent of the rivers, 54 percent of the lakes, and 54 percent of the estuaries, among 32 percent of U.S. waters assessed, are threatened or polluted [Arnold et al 1998]. The nation's waters are still threatened by pollutants such as sediment, bacteria, nutrients, and metals in spite of more than 30 years cleanup efforts. Non-point source (NPS) pollution transported by precipitation and runoff from both urban and agricultural areas is the most significant source of water quality problem in the United States [USEPA, 2000]. NPS pollution is difficult to monitor and control because the pollutants are generated over an extensive area of land and enter receiving water bodies in a diffused manner. NPS pollution is low in concentration and high in total load, while point source pollution generally high in concentration and low in total load. Therefore, NPS pollution abatement is usually focused on land and runoff management practices. Agricultural activities may introduce sediments, nutrients, pesticides, and other organic matter to the water bodies. It is reported that agriculture is the most widespread source of pollution in impaired rivers and lakes [USEPA, 2000,]. Pesticides mainly originate from agricultural activities. Over 76% of the 1.2 billion pounds of pesticides' active ingredients used in the United States during the 90s were used in agricultural areas [Arnold et al 1998]. It is estimated that the annual amount of pesticide (active ingredient) used in the U.S. is about 20% of the total amount used in the world [Arnold et al 1998]. Growing evidence shows that pesticides exist in the environment, such as atmosphere, surface, and ground water, far from the areas of their application. About 50% of the U.S. population, primarily in urban areas, relies on streams and reservoirs for drinking water. Surface waters are vulnerable to pesticide contamination because runoff from source areas, including agricultural and urban areas, can carry pesticides into streams. Although surface water problems by pesticides have been investigated because of their acute effects, more attention has been given to soil and ground water contamination by pesticides because ground water is a major source of drinking water in Western Europe and the United States [Arnold et al 1998,and Van den and Va Denlinden,1994]. Furthermore, continued contamination of surface water resources has increased our dependence on ground water to meet growing water needs. Contamination of soil and ground water by NPS pollutants is serious, because areal extent of contamination is usually large and effective Remediation is very difficult [4]. Ground water and surface water quality were examined as part of the National Water Quality Assessment (NAWQA) Program by the U.S. Geological Survey in 1991. The results of the NAWQA study of pesticides in surface water indicated that more than 95% of the samples collected from 58 rivers and streams across the U.S. contained at least one pesticide or pesticide byproduct (Larson et al., 1999). Results from the first set of ground water/land use studies conducted in the first 20 NAWQA study units during 1993-1995 indicated that the concentration and frequency of pesticide detection was closely related to the use and properties of pesticides and land use categories [Woolheriser, et al 1990, Kolpin, et al 1998]. Overall, the results of the national study demonstrated that pesticides were commonly detected in shallow ground water of both agricultural and urban areas, with about 54% of 1034 sites sampled containing one or more pesticide compounds. However, agricultural areas showed higher frequency of pesticide detection in ground water than urban areas (Kolpin et al., 1998).

2. Theoretical background

The transport of bacterial at different formation is a serious pollution problem soil and water environment ,some of the bacteria's pose serious threat to ground water aquifers, the behavior of the contaminant are base on the influence of deposition between the transport zone, the developed system at various condition were considered, the behavior of the bacterial at different formation characteristics were not left behind, geological history of the study location were expressed, base on these variables, it is imperative to sequentially denote all the parameters with mathematical tools ,the condition of the bacterial and the geological formation were one of the major parameters that were express in the system, this is to relate other variable in terms of generating there function in the system, by expressing their relationship with other parameters in the context , mathematical equation were developed thus these equation are formulated with all the variables that were considered to monitor the migration of bacterial from on formation to another under the application plug flow system.

Various mathematical method were considered, but the most accepted method that were found to generate a models at various condition are slit method techniques, and Bernoulli's method of separation of variables, the application of the concept were found to monitor the transport of bacterial at different soil formation to ground water aquifers, since the bacterial are to be influenced by several soil characteristics including environmental conditions, the derived mathematical equation considered all these condition before formulation of the equation, the derived mathematical model will be able to monitor the transport of bacterial at different formation

$$\frac{1+fP_bK_d}{\theta}\frac{\partial C}{\partial t}=D\frac{\partial^2 C_1}{\partial x^2}-V\frac{\partial C}{\partial x} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (1)$$

Nomenclature

C	=	Bacterial Concentration (cell/m^3)
S_k	=	Bacterial concentration on kinetic adsorption (cell/g)
P_b	=	Bulk Density (g/m^2)
K_d	=	Partitioning coefficient of bacteria (m^3/g)
θ	=	Porosity (m^3/m^3)
D	=	Longitudinal Dispersion coefficient (m^2/sec)
X	=	Co-ordinate parallel to the flow (m)
V	=	Pore velocity (m/sec)
α	=	First order mass transfer coefficient (sec^{-1})
μ_{sk}	=	First order bacterial deposition coefficient (sec^{-1})

Applying physical splitting techniques on equation (1) we have

The equation expresses the bacterial concentration considering their behavior under the influence of some considered variables that may influence the system. The parameters are considered to monitor their behavior at every phase, the stated nomenclature are the influential parameters that express the dynamic behavior of the bacterial at any phase on the transport process.

$$1+\frac{fpbkd}{\theta}\frac{\partial^2 C_1}{\partial x^2} = D\frac{\partial^2 C_1}{\partial x^2} \quad \text{.......................................} \quad (2)$$

$$\left.\begin{array}{l} x = 0 \\ C_{(o)} = C_o \\ \left.\frac{\partial C_1}{\partial x}\right|_{x=0} = 0 \end{array}\right\} \quad \text{...................................} \quad (3)$$

$$\frac{1+fP_bK_d}{\theta}\frac{\partial C_2}{\partial t} = V\frac{\partial C_2}{\partial x} - \frac{\alpha P_b}{\theta}1-f\,K_dC-S_k \quad \text{..............................} \quad (4)$$

$$\left.\begin{array}{l} t = 0 \\ x = 0 \\ C_{(o)} = 0 \\ \left.\frac{\partial C_2}{\partial t}\right|_{t=0,\ B} \end{array}\right\} \quad \text{.......................................} \quad (5)$$

$$D\frac{\partial^2 C_3}{\partial x^2} = -V\frac{\partial C_3}{\partial x} - \frac{\alpha P_b}{\theta}1-f\,K_d \quad \text{.......................................} \quad (6)$$

$$\left.\begin{aligned} x &= 0 \\ C_{(o)} &= 0 \end{aligned}\right\} \qquad \text{.......................................} \qquad (7)$$

The method applied is to split the parameters denoted with mathematical equation in terms of expressing their relationship to each other in the system, these conditions are developed through the understanding of various functions of all the variables and their roles in the system, the variables are denoted with mathematical tools, boundary conditions were expressed, base on various parameters role on the transport system to ground water aquifers, and there relationship in the system design to solve the bacterial concentration at every phase. The split parameters are derived in accordance with the behavior of the bacterial, including the expressed formation variables in soil and fluid behavior as denoted in mathematical expression on the system.

Applying direct integration on (2)

$$\frac{1+fP_bK_d}{\theta}\frac{\partial C}{\partial t} = DC + K_1 \qquad \text{.......................................} \qquad (8)$$

Again, integrate equation (8) directly, yields

$$\frac{1+fP_bK_d}{\theta} = DCx + K_1x + K_2 \qquad \text{.......................................} \qquad (9)$$

Subject to equation (3), we have

$$\frac{1+fP_bK_d}{\theta}Co = K_2 \qquad \text{.......................................} \qquad (10)$$

And subjecting equation (8) to (3)

$$\text{at} \quad \left.\frac{\partial C_1}{\partial t}\right|_{x = 0,\ C_{(o)} = C_o} = 0$$

Yield

O = DCo K2

$$\Rightarrow \quad K_1 = -DC_o \qquad \text{.......................................} \qquad (11)$$

So that, we put (10) and (11) into (9), we have

$$\frac{1+fP_bK_d}{\theta}C_1 - DC_1x - DCox + \frac{1+fP_bK_d}{\theta}C_o \qquad \text{..............................} \qquad (12)$$

$$\frac{1+fP_bK_d}{\theta}C_1 - DC_1x = \frac{1+fP_bK_d}{\theta}C_o - DCox \qquad \text{..............................} \qquad (13)$$

$$\Rightarrow \; C_1 (1 + fP_b K_d - Dx) \; = Co(1 + fP_b K_d - Dx)$$

$$\Rightarrow \; C_1 \; = \; Co \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (14)$$

Hence equation (14), entails that at any given distance, x, we have constant concentration of the contaminant in the system

$$\frac{1 + fP_b K_d}{\theta} \frac{\partial C_2}{\partial t} = V \frac{\partial C_2}{\partial x} \frac{\alpha P_b}{\theta} 1 - f \; K_d C - S_k \qquad \ldots\ldots\ldots\ldots \; (4)$$

We approach this system by using the Bernoulli's method of separation of variables

$$C_2 \; = \; XT \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (15)$$

$$\frac{\partial C_2}{\partial t} \; = \; XT^1 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (16)$$

$$\frac{\partial C_2}{\partial x} \; = \; X^1 T \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (17)$$

Put (16) and (17) into (15), so that we have

$$\frac{1 + fP_b K_d}{\theta} XT^1 \; = V \frac{\alpha P_b}{\theta} V \; 1 - f \; K_d C - S_k X^1 T \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (18)$$

i.e. $1 + fP_b K_d \dfrac{T^1}{T} \; = V \dfrac{\alpha P_b}{\theta} V \; 1 - f \; K_d C - S_k \dfrac{X^1}{X} = -\lambda^2 \qquad \ldots\ldots\ldots\ldots\ldots \qquad (19)$

Hence $\dfrac{1 + fP_b K_d}{\theta} \dfrac{T^1}{T} + \lambda^2 \; = \; 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (20)$

That is,

$$\frac{X^1 + \lambda^2}{\frac{1 + fP_b K_d}{\theta}} x \; = \; 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (21)$$

$$1 - fK_d \; C - S_k \; T^1 \; + \lambda^2 T = 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (22)$$

From (21), $X \;\; = \;\; \dfrac{A \, Cos \, \lambda}{\frac{1 + fP_b K_d}{\theta}} t \; + \; \dfrac{B \, Sin \, \lambda}{\frac{1 + fP_b K_d}{\theta}} x \; \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (23)$

And (16) gives

$$\boxed{T \;\; = \; C \, \ell^{\frac{-\lambda^2}{Vd \frac{P_b}{\theta} V 1 - fK_d C - Sk} t}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (24)$$

The model express the parameters like bulk density, partitioning coefficient of the bacterial, velocity of transport, bacterial concentration on kinetics adsorption, porosity of the soil formation, first order mass transfer coefficient and concentration of bacterial. Their function on the system details the influence on the transport of the microbes, at various conditions, denoted with various mathematical tools, further expression processed to equate it to a constant, the expression details the function of other variables in the system, the embellished model expressed the stated phase of the bacterial with respect to time. By substituting (23) and (24) into (15), we get

$$C_2 = \left(A\,Cos \frac{\lambda}{\frac{1+fP_bK_d}{\theta}} x + B\,Sin \frac{\lambda}{\frac{1+fP_bK_d}{\theta}} x \right) C\,\ell^{\frac{-\lambda^2}{Vd\frac{P_b}{\theta}V1-fK_dC-Sk}t} \qquad \text{……………} \quad (25)$$

Further expression were thoroughly detail to accommodate other conditions that could developed different phase in the system as it is expressed in equation [25] different mathematical application were considered in line with the behavior of the bacterial, at different phase of transport migrating to various formation of the soil, velocity of transport were part of the parameter integrated to determine the time of distance travel from one formation to another, the behavior of the soil at different formation were considered as bulk density integrated, to determine the bulk of the soil on the transport process of bacterial to ground water aquifers, in this context the condition of bacterial are expresses with this mathematical tools as it is derived with further expression in other to develop a model that will account for each conditions, these will express the behavior of the bacterial at different soil formation. expressed equation in [25] were emerged with equation 24 to relate with derived model condition of phase two denoted as C_2 under the application of split method techniques, it developed a model that considered the expressed phase that were in the system, two model were found to establish a relationship as expressed in equation [25].

Subject equation (25) to conditions in (5), so that we have

$$C_o = AC \qquad \text{………………………………} \quad (26)$$

Therefore, equation (26) become

$$C_2 = C_o\,\ell^{\frac{-\lambda^2}{Vd\frac{P_b}{\theta}V1-fK_dC-Sk}t}\; Cos \frac{\lambda}{\frac{1+fP_bK_d}{\theta}} x \qquad \text{………………………………} \quad (27)$$

Again, at

$$\left.\frac{\partial C_2}{\partial t}\right|_{x = 0,\ B} = 0,\ t = 0$$

Equation (27) becomes

$$\frac{\partial C_2}{\partial t} = \frac{\frac{\lambda^2}{1+fP_bK_d}}{\theta} C_o \,\ell^{\frac{\lambda^2}{Vd\frac{P_b}{\theta}V1-fK_dC-Sk}t} \; Cos \frac{\frac{Sin\,\lambda}{1+fP_bK_d}}{\theta} x \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (28)$$

$$\frac{\frac{C_o\ \lambda}{1+fP_bK_d}}{\theta} \neq 0 \quad \text{Considering NKP}$$

The derived mathematical equation consider when the bacterial on the migration process does not deposit substrate in the soil formation, the bacterial may be slow in transport; due degradation in some region of the soil, the concept definitely considered these conditions in most cases if bacterial experienced degradation, the bacterial cannot adapt to the condition of the soil, even if the bacterial migrate to another soil formation, during the process of transport, the bacterial may reducing it population through death.

Which is the substrate utilization for microbial growth (population), so that

$$0 = \frac{\frac{-C_o\ \lambda}{\sqrt{1+fP_bK_d}}}{\theta} \; \frac{\frac{Sin\ \lambda}{\sqrt{1+fP_bK_d}}}{\theta} B \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (29)$$

$$\Rightarrow \frac{\frac{C_o\ \lambda}{\sqrt{1+fP_bK_d}}}{\theta} = \frac{n\pi}{2},\ n = 1,2,3 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (30)$$

$$\Rightarrow \lambda = \frac{\frac{n\pi\sqrt{1+fP_bK_d}}{\theta}}{2} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (31)$$

So that equation (27) becomes

$$C_2 = C_o\,\ell^{\frac{-n^2\pi^2\frac{P_b}{\theta}1-fK_dC-Sk}{2Vd\frac{P_b}{\theta}1-fK_dC-Sk}t} \; Cos \frac{\frac{n\pi\sqrt{1+fP_bK_d}}{\theta}}{\frac{2\sqrt{1+fP_bK_d}}{\theta}} x \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (32)$$

$$\therefore \Rightarrow \quad C_2 = C_o\,\ell^{\frac{-n^2\pi^2\frac{P_b}{\theta}1-fK_dC-Sk}{2Vd\frac{P_b}{\theta}1-fK_dC-Sk}t} \; Cos \frac{n\pi}{2} x \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 33)$$

Now, we consider equation (6) which is the steady-flow state of the system

$$\frac{\partial C_3}{\partial x^2} = \frac{V\partial C_3}{\partial x} - d\frac{P_b}{\theta}1-fK_d$$

Applying Bernoulli's method, we have

$$C_3 = XT \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (34)$$

$$\frac{\partial^2 C_3}{\partial x^2} = X^{11}T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (35$$

$$\frac{\partial C_3}{\partial x} = X^1 T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (36)$$

Put (35) and (36) into (6), so that we have

$$DX^{11}T = Vd\frac{P_b}{\theta}1 - fK_dC - Sk\,X^1T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (37)$$

That is,

$$\frac{DX^{11}}{X} = -Vd\frac{P_b}{\theta}1 - fK_dC - Sk\frac{X^1}{X} = \varphi \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (38)$$

$$\frac{DX^{11}}{X} = \varphi \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (39)$$

$$-Vd\frac{P_b}{\theta}1 - fK_dC - Sk\frac{X^1}{X} = \varphi \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (40)$$

That is $X = A\ell^{\frac{\varphi}{D}x}$ $\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$ (41)

And

$$T = B\ell^{\frac{-\varphi}{D}t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (42)$$

Put (41) and (42) into (34), gives

$$C_3 = A\ell^{\frac{\varphi}{Vd\frac{P_b}{\theta}1 - fK_dC - Sk}x} \bullet B\ell^{\frac{-\varphi}{Vd\frac{P_b}{\theta}1 - fK_dC - Sk}x} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (43)$$

$$C_3 = AB\ell^{(t-x)\frac{\varphi}{Vd\frac{P_b}{\theta}1 - fK_dC - Sk}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (44)$$

Subject equation (44) to (7), yield

$$C_3 = (0) = C_o \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (45)$$

So that equation (45), becomes

$$C_3 = C_o\,\ell^{(t-x)\frac{\varphi}{Vd\frac{P_b}{\theta}1 - fK_dC - Sk}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (46)$$

Now assuming that at the steady state flow, there is no NKP for substrate utilization, our concentration here is zero, so that equation (46) become

$$C_3 = 0 \quad \ldots\ldots\ldots\ldots \quad (47)$$

Therefore, solution of the system is of the form
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$$C_3 = C_1 + C_2 + C_3 \quad \ldots\ldots\ldots\ldots \quad (48)$$

We now substitute (14), (33) and (47) into (48), so that we have the model

$$C = C_o + C_o \, \ell^{\frac{-n^2\pi^2 \frac{1+P_b K_d}{\theta}}{2Vd \frac{P_b}{\theta} 1 - fK_d C - Sk} t} \; Cos \, \frac{n\pi}{2} x \quad \ldots\ldots\ldots\ldots \quad (49)$$

$$\boxed{C = C_o 1 + \ell^{\frac{-n^2\pi^2 \frac{P_b}{\theta} 1 - fK_d C - Sk}{2Vd \frac{P_b}{\theta} 1 - fK_d C - Sk} t} \; Cos \, \frac{n\pi}{2} x} \quad \ldots\ldots\ldots\ldots \quad (50)$$

Further mathematical expression were establish as other condition of the microbial behavior were integrated according to the formation variation that were considered in developing system, since the bacterial developed, various behavior under the influence of the formation characteristics including environmental condition were descretize, the expressed equation developed considered this conditions, considered the Bernoulli's method of separation of variables and split method application, they were found to be the correct method that can thoroughly expressed the transport of the bacterial at different condition.

4. Conclusion

Mathematical model to predict the migration of cryptosporidium in homogeneous formation in Obio/Akpor has been developed. Different parameters were considered that are the variables that may influence the microbial transport to groundwater aquifer. The variables considered are bacterial concentration, bacterial concentration on kinetic adsorption, bulk density, partition coefficient of bacteria, porosity, longitudinal dispersion coefficient, coordinate parallel to the flow, pore velocity, first order mass transfer coefficient, first order bacterial deposition coefficient. These variables were considered in formulating the mathematical equation denoted by mathematical tools. The model equations were derived applying split techniques and Bernoulli's method of separation of variables. The split method was applied to descretize the function of the parameters to express their functions on the system at different conditions, under the influence of the microbial behavior. The model will definitely monitor the behavior of the bacteria at different formations of the soil.

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