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Research article

MODELLING PERMEABILITY AND DISPERSION OF PHOSPHORUS DEPOSITION ON KLEBSIELLA MIGRATION IN COASTAL AREA OF PORT HARCOURT, NIGER DELTA OF NIGERIA

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Abstract

Modeling the rate of permeability of soil and deposition of phosphorous on migration of klebsiella in the coastal area of Port Harcourt has been expressed, the model were to determine the rate of permeability and dispersions influence on the migration of klebsiella in coastal formation, several challenges has been confirm to deposit in the coastal area of port Harcourt , the influence from permeability through the rate of micropores determine the rate of dispersion of klebsiella in the study area, it experience increase in microbial population under the influences of phosphorous deposition in the formations, the deposition of microelements' in the formation experienced lots of variations under the influence of coastal formation through environmental factors, stratification variation also influence micronutrients in the formations. To express the rate of concentration in the formation, mathematical model were develop to predict the rate of permeability and dispersion on the migration of klebsiella in coastal area, the model were splitted to express numerous behaviour of the microbes including micronutrient in soil and water environments. The model generated expression in accordance with the condition of the microbes and the formations characteristics in the study locations, experts in the field will applied this concept to determine various concentrations of the contaminants in the study area.

Keywords: modelling permeability, dispersion of phosphorus, and klebsiella migration

1. Introduction

Beyond the important concern of waterborne disease due to consumption of ground water contaminated by surface sources, contaminated ground water may also contribute to surface water microbial pollution. Several studies employing virus tracers and/or chemical tracers have documented transport of wastewater from on-site sewage disposal systems (OSDS, septic tanks) to nearby surface water bodies such as canals, rivers, and marine environments (Paul 1995; Rose and Zhou 1995; Paul 1997; Dillon 1999; Paul 2000; Callahan 2001; Lipp 2001). Contamination of surface water via ground water flow can be more problematic in areas receiving high annual precipitation and that have a high water table. As discussed later, these conditions along with an oftentimes highly conductive hydrogeological setting are particularly evident in the state of Florida. Taken together, these factors present a situation in which the pathogenic microorganisms of concern include three major classes of microbes: viruses, bacteria, and protozoa. These organisms, as reviewed by Macler and Merkle, include waterborne viruses such as coxsackieviruses, echovirus, rotavirus, norovirus, calicivirus, astrovirus, and hepatitis A and E. Bacteria of concern are chiefly pathogenic *E. coli* such as serotype 0157:H7, *Salmonella* and *Shigella* spp., *Campylobacter jejuni*, and *Aeromonas hydrophila*, among others. The main waterborne protozoa that may potentially be transmitted by ground water are *Cryptosporidium parvum* and *Giardia lamblia* (Macler and Merkle 2000). The cause in eight of these outbreaks was determined as Norwalk-like-virus (NLV, norovirus) and *Campylobacter* in three outbreaks (Miettinen 2001). Another European study reported on a community outbreak of illness due to *Shigella sonnei* attributed to well contamination in Greece (Alamanos 2000). *Cryptosporidium parvum* has been implicated in a number of illness outbreaks from ground water as well. Over the period of 1984 - 1994, 4 out of 10 cryptosporidiosis outbreaks from U.S. drinking water systems were attributed to contamination of wells or wells influenced by surface water (Craun 1998). Moreso public water systems in the U.S., 92% rely primarily on ground water for supply (Craun 2002). Worldwide, ground water represents a large majority of the drinking water supply in many nations, including Denmark, Portugal, Italy, Switzerland, Belgium, and the Netherlands, all of which derive more than 2/3 of their drinking water from ground water (Pedley and Howard 1997 Numerous factors have been identified which impact transport of bacteria and/or viruses in ground water. Beyond the bulk flow of water in an aquifer or soil (advection), physical and chemical parameters of the solid matrix, the ground water, and the organisms affect the degree to which microbial particles are retained or transported and the relative rates at which they might move compared to the water itself. The primary mechanisms of retention in soil and aquifers are thought to be adsorption for viruses and size dependent straining for bacterial and protozoan cells, although bacteria and to a lesser degree protozoa are also retained by adsorption (Gerba and Bitton 1984; Newby 2000). Electrostatic adsorption is one mechanism of retention. A major force governing adsorption is the electrostatic interaction between microbial particles and solid surfaces. This force is generally repulsive since microbes and soil surfaces generally have net negative charges. Two major determinants of surface charge on organisms are the is electric point of the cell/virion and pH of the water. By and large, microbial cells/particles have a negative surface charge in near-neutral water (Gerba 1984; Klein and Ziehr 1990; Krekeler 1991).

2. Theoretical background

The rate of permeability are determine by standard laboratory investigation were the coefficient value for soil formation can be determine , the results reflect the permeability of the formation. This analysis is to determine the variation in permeability stratification of the soil, geological influence base on the stratification variable influence the flow net of the soil , the soil rate of flow are determined by the rate of permeability of the formation, the rate of flow in the strata are reflected in the rate of dispersion of contaminant between the formations, subject to this relation, dispersions of solute are expressed by the rate of dispersion the formations deposit, micropores of the formation established lots of variations under the influence of geomorphology and geochemistry of the formation as expressed in the concentrations of klebsiella , the coastal area of Port Harcourt express geologic history that deposit some variation, the formation deposit fluctuation in the formation , the of rate permeability are prone to be very high, therefore the deposition of the microbes in the coastal locations develop more concentration because the degree of permeability are at high rate, the formation of coastal area are normally homogeneous formation, most of the formations are developed through alluvium deposition the coastal formation also develop high depositions of phosphorous, the deposition of microelement in the formation has an interaction with other formation variables in the study area, the influence from formation characteristics determine the rate of deposition, such condition are inline with geological deposition influence , this challenges is a serious threat to soil and water environment that deposit in coastal area of port Harcourt, to evaluate the rate of klebsiella and phosphorous in coastal area, mathematical model were fine suitable to assess the rate of deposition and migration of klebsiella and phosphorous deposition in coastal formation, development of mathematical model were possible through the governing equation, the expression are stated below.

3. Governing Equation

Nomenclature

θb = Soil bulk density unitless
Vθ = Overall volumetric mass coefficient transfer
V = Velocity
K = Permeability
D = Dispersion
C = Concentration of salmonellae
Cwθ = Phosphorus concentration in liquid phase
T = Time
Z = Distance

Governing equation

$$\theta b\frac{\partial C}{\partial t} = V\theta\frac{\partial C}{\partial z} + V\frac{\partial C}{\partial z} - K\frac{\partial C}{\partial z} + D\frac{\partial C}{\partial t} + Cw\theta\frac{\partial C}{\partial z} \qquad \ldots\ldots\ldots\ldots \quad (1)$$

$$\theta b\frac{\partial C_1}{\partial t} = V\theta\frac{\partial C_1}{\partial z} \qquad \ldots\ldots\ldots\ldots \quad (2)$$

$$\left.\begin{array}{l} t = 0 \\ z = 0 \\ C_{(o)} = 0 \\ \dfrac{\partial C_1}{\partial t}\Big| t = 0,\ B \end{array}\right\} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

$$\theta b \frac{\partial C_2}{\partial t} = V \frac{\partial C_2}{\partial z} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

$$\left.\begin{array}{l} t = 0 \\ z = 0 \\ C_{(o)} = 0 \\ \dfrac{\partial C_2}{\partial t}\Big| t = 0,\ B \end{array}\right\} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

$$\theta b \frac{\partial C_3}{\partial t} = -K \frac{\partial C_3}{\partial z} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

$$\begin{array}{l} t = 0 \\ z = 0 \\ Cs_{(o)} = 0 \\ \dfrac{\partial C_3}{\partial t}\Big| t = 0,\ B \end{array} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (7)$$

$$\theta b \frac{\partial C_4}{\partial t} = Cw\theta \frac{\partial C_4}{\partial z} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (8)$$

$$\left.\begin{array}{l} t = 0 \\ z = 0 \\ C_{(o)} = 0 \\ \dfrac{\partial C_4}{\partial t}\Big| t = 0,\ B \end{array}\right\} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (9)$$

Coastal formation that deposit klebsiella are base on the structural stratification of the soil, the deposition of the microelement were found to develop a relation with klebsiella in the formation, the equation from (2) to (9) are the splitted, to descretized it in accordance with the behaviour of klebsiella in the system the expressed equations address different condition under the influence of formation variables, the coastal area develop lots of variations, the expressed equations are splitted to monitor the migration and deposition of phosphorous at deferent conditions.

$$D\frac{\partial C_5}{\partial t} + Cw\theta\frac{\partial C_5}{\partial z} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (10)$$

$$\left.\begin{array}{l} t = 0 \\ z = 0 \\ C_{(o)} = 0 \\ \frac{\partial C_5}{\partial t}\Big| t = 0,\ B \end{array}\right\} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (11)$$

$$D\frac{\partial C_6}{\partial t} - K\frac{\partial C_6}{\partial z} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (12)$$

$$\left.\begin{array}{l} t = 0 \\ z = 0 \\ C_{(o)} = 0 \\ \frac{\partial C_6}{\partial t}\Big| t = 0,\ B \end{array}\right\} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (13)$$

$$D\frac{\partial C_7}{\partial t} + V\theta\frac{\partial C_7}{\partial z} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (14)$$

$$\left.\begin{array}{l} t = 0 \\ z = 0 \\ C_{(o)} = 0 \\ \frac{\partial C_7}{\partial t}\Big| t = 0,\ B \end{array}\right\} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (15)$$

$$D\frac{\partial C_8}{\partial t} + V\frac{\partial C_8}{\partial z} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (16)$$

$$\left.\begin{array}{l} t = 0 \\ z = 0 \\ C_{(o)} = 0 \\ \frac{\partial C_8}{\partial t}\Big| t = 0,\ B \end{array}\right\} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (17)$$

Applying direct integration on (2) we have

$$\theta b\frac{\partial C}{\partial t} = V\theta + K_1 \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (18)$$

Again, integrate equation (18) directly yield

$$\theta b C = V\theta + K_1 + K_2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots \tag{19}$$

Subject to equation (3), we have

$$C_o = K_2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots \tag{20}$$

And subjecting equation (19) to (3)

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

Yield

$$0 = VCs_o + K_2$$

$$\Rightarrow K_2 = -VC_o \qquad \ldots\ldots\ldots\ldots\ldots\ldots \tag{21}$$

So that we put (20) and (21) into (19), we have

$$C_1 = \theta b C_1 t - V\theta t + C_o \qquad \ldots\ldots\ldots\ldots\ldots\ldots \tag{22}$$

$$C_1 - \theta b = C_o - V\theta t \qquad \ldots\ldots\ldots\ldots\ldots\ldots \tag{23}$$

$$\Rightarrow C_1\left[C_1 - \theta b t\right] = C_o\left[C_1 - V\theta\right] \qquad \ldots\ldots\ldots\ldots\ldots\ldots \tag{24}$$

$$\Rightarrow Ct = C_o \qquad \ldots\ldots\ldots\ldots\ldots\ldots \tag{25}$$

$$\theta b \frac{\partial Cs_2}{\partial t} = V \frac{\partial C_2}{\partial z} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \tag{4}$$

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

i.e. $C_2 = ZT$ $\qquad \ldots\ldots\ldots\ldots\ldots\ldots$ (26)

$$\frac{\partial C_2}{\partial t} = ZT^1 \qquad \ldots\ldots\ldots\ldots\ldots\ldots \tag{27}$$

$$\frac{\partial C_2}{\partial z} = Z^1 T \qquad \ldots\ldots\ldots\ldots\ldots\ldots \tag{28}$$

Put (27) and (28) into (26), so that we have

$$\theta b\, ZT^1 = VZ^1 T \qquad \ldots\ldots\ldots\ldots\ldots\ldots \tag{29}$$

$$\theta b \frac{T^1}{T} = V \frac{Z^1}{Z} = -\lambda^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots \tag{30}$$

Hence $\theta b \frac{T^1}{T} = -\lambda^2$ $\qquad \ldots\ldots\ldots\ldots\ldots\ldots$ (31)

$$VZ^1 + \lambda^2 Z = 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots \tag{32}$$

From (32) $T = ACos \frac{\lambda t}{\theta b} + B\ Sin \frac{\lambda z}{\theta b}$ $\qquad \ldots\ldots\ldots\ldots\ldots\ldots$ (33)

And (32) gives

$$T = C\ell \frac{-\lambda^2}{\theta b} t \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (34)$$

By substituting (32) and (33) into (26)

$$C_2 = \left[A Cos \frac{\lambda}{\sqrt{\theta b}} t + B Sin \frac{\lambda}{\sqrt{\theta b}} z \right] C_o \ell^{\frac{-\lambda^2}{\sqrt{\theta b}} t} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (35)$$

$$C_o = Ac \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (36)$$

To monitor the deposition of klebsiella in the system implies that there some variables that stabilize other variable in the system, to ensure this is done establishment of direct integration were necessary, so Equation (2) derived direct integration of some parameters in accordance with the system, directed integration were found essential to correlate the variables, base on the deposition of the substrate reflecting the concentration of the microbes this is under the influence of coastal formations were the concentration of phosphorous and klebsiella may experience high degree of concentration by high rate of permeability in the coastal locations. Variable that were found to express their relation with each other in terms of there pressure of increasing the deposition of phosphorous in microbial population from organic soil were the accumulations of substrate are very high.

Equation (35) becomes

$$C_2 = C_o \ell \frac{-\lambda^2}{V} t \; Cos \frac{\lambda}{V} z \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (37)$$

Again at $\left. \frac{\partial C_2}{\partial t} \right| \begin{matrix} = 0, \; z = 0 \\ t = 0, \; B \end{matrix}$

Equation (37) becomes

$$\frac{\partial C_2}{\partial t} = \frac{\lambda}{\theta b} C_o \ell^{\frac{-\lambda^2}{V} t} \; Sin \frac{\lambda}{\theta b} z \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (38)$$

i.e. $0 = \frac{\lambda}{\sqrt{\theta b}} \; Sin \frac{\lambda}{\theta b} 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (39)$

$C_o \frac{\lambda}{\sqrt{\theta b}} \neq 0$ Considering NKP

$$0 = -C_o \frac{\lambda}{\theta b} \; Sin \frac{\lambda}{\theta b} B \qquad \ldots\ldots\ldots\ldots\ldots \quad (40)$$

$$\lambda = \frac{n\pi\sqrt{\theta b}}{2} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (41)$$

So that equation (38) becomes

$$C_2 = C_o \ell^{\frac{-n^2\pi^2\theta b}{2V}} Cos \frac{n\pi\sqrt{V}}{2\sqrt{\theta b}} z \qquad \text{.....................} (42)$$

$$C_2 = C_o \ell^{\frac{-n^2\pi^2\theta b}{2V}} Cos \frac{n\pi}{2} z \qquad \text{.....................} (43)$$

$$\theta b \frac{\partial C_3}{\partial t} = K \frac{\partial C_3}{\partial z} \qquad \text{.....................} (6)$$

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

$$C_3 = ZT \qquad \text{.....................} (44)$$

$$\frac{\partial C_3}{\partial t} = ZT^1 \qquad \text{.....................} (45)$$

$$\frac{\partial C_3}{\partial z} = Z^1T \qquad \text{.....................} (46)$$

Hence, we put (45) and (46) into (44), so that we have

$$\theta b \frac{ZT^1}{T} = K \frac{Z^1T}{T} \qquad \text{.....................} (47)$$

i.e. $\theta b \frac{T^1}{T} = K \frac{Z^1}{Z} - \lambda^2$ .... (48)

Hence $\theta b \frac{T^1}{T} + \lambda^2 = 0$ .... (49)

i.e. $Z + \frac{\lambda^2}{\theta b} Z = 0$ .... (50)

And $\theta b T^1 + \lambda^2 T = 0$ .... (51)

From (50) $Z = ACos \frac{\lambda}{\theta b} Z + BSin \frac{\lambda}{\theta b} Z$ .... (52)

And (45) gives

$$T = C_o \ell^{\frac{-\lambda^2}{K}t} \qquad \text{.....................} (53)$$

By substituting (52) and (53) into (44), we get

$$C_3 = \left[A\,Cos\frac{\lambda}{\theta b}Z + B\,Sin\frac{\lambda}{\sqrt{\theta b}}Z \right] Cos\ell^{\frac{-\lambda^2}{K}t} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (54)$$

Subject (54) to condition in (6) so that we have

$$C_o = Ac \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (55)$$

Similar conditions are expressed in equation (55) the depositions of phosphorous migrating in costal soil are found to deposit very high concentration of substrate, due the high permeability content, therefore the tendency of fast migration in coastal aquifers is very high under the influence of high rain intensities, this implies that coastal areas increase degree of saturations of the soil including the permeability coefficients, similar condition developed the composition of these parameter integration in equation (55) were see the concentration of the substrate at initial concentration , so the formation strata determined the expressed variable that developed model denoted as $C_s = Ac$ in equation (55).

Equation (55) becomes

$$C_3 = C_o \ell \frac{-\lambda^2}{K} t \;\; Cos\frac{\lambda}{\theta b}Z \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (56)$$

Again at $\frac{\partial C_3}{\partial t}\Big| \;\; t = 0, B$

Equation (56) becomes

$$\frac{\partial C_2}{\partial t} = \frac{\lambda}{\sqrt{\theta b}} Cos\ell^{\frac{-\lambda^2}{K}t} \;\; Sin\frac{\lambda}{\theta b}x \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (57)$$

i.e. $0 = -C_o \frac{\lambda}{\sqrt{\theta b}} \; Sin\frac{\lambda}{\theta b}0$

$C_o \frac{\lambda}{\sqrt{\theta b}} \neq 0$ Considering NKP

Equation (40) and (57) express the influence of the substrate in terms of increase in microbial population, this condition were considered in these various in these two equations, microbial population expected in the to increase in a situation were microbes are predominant. The equations take care of the rate of phosphorous deposition in the formations, the equation in (40) and (55) were expressed the results of high degree of deposition in the formations, the above expressed equation reflect the consequences of phosphorous deposition, there the tendency of increase of microbial population, including high degrees of feeding from the substrate deposition in the formations. This condition generates lots of variations in microbial behaviour in different dimensions. Moreso the degree of substrate considered in the state of microbial transport determined the rate of inhibition from other influence that deposit

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

$$0 = -C_o \frac{\lambda}{\theta b} Sin \frac{\lambda}{\theta b} B \qquad \ldots\ldots\ldots\ldots (58)$$

$$\Rightarrow \frac{\lambda}{\sqrt{\theta b}} = \frac{n\pi}{2} \qquad \ldots\ldots\ldots\ldots (59)$$

$$\Rightarrow \frac{\lambda}{\sqrt{\theta b}} = \frac{n\pi\sqrt{\theta b}}{2} \qquad \ldots\ldots\ldots\ldots (60)$$

So that equation (61)

$$C_3 = C_o \, \ell^{\frac{-n^2\pi^2\theta b}{2K}} \; Cos \frac{n\pi\sqrt{\theta b}}{2\sqrt{\theta b}} Z \qquad \ldots\ldots\ldots\ldots (61)$$

$$\Rightarrow C_3 = C_o \, \ell^{\frac{-n^2\pi^2\theta b}{2K}} \; t \; Cos \frac{n\pi}{2} Z \qquad \ldots\ldots\ldots\ldots (62)$$

Now we consider equation (8)

$$\theta b \frac{\partial C}{\partial t} = Cw\theta \frac{\partial C}{\partial z} \qquad \ldots\ldots\ldots\ldots (8)$$

Using Bernoulli's method of separation of variables, we have

$$C_4 = ZT \qquad \ldots\ldots\ldots\ldots (63)$$

$$\frac{\partial C_4}{\partial t} = ZT^1 \qquad \ldots\ldots\ldots\ldots (64)$$

$$\frac{\partial C_4}{\partial Z} = Z^1 T \qquad \ldots\ldots\ldots\ldots (65)$$

$$\theta b ZT = -Cw\theta Z^1 T \qquad \ldots\ldots\ldots\ldots (66)$$

i.e.

$$\theta b \frac{T^1}{T} = Cw\theta \frac{Z^1}{Z} = \varphi \qquad \ldots\ldots\ldots\ldots (67)$$

$$\theta b \frac{T^1}{T} = \varphi \qquad \ldots\ldots\ldots\ldots (68)$$

$$Cw\theta\frac{Z^{1}}{Z} = \varphi \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (69)$$

$$Z = B\ell^{\frac{\varphi}{Cw\theta}Z} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (70)$$

And

Put (68) and (69) into (63), gives

$$C_4 = A\ell^{\frac{\varphi}{Cw\theta}Z} \quad B\ell^{\frac{\varphi}{Cw\theta}t} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (71)$$

$$C_4 = AB\ell^{(z-t)}\frac{\varphi}{Cw\theta} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (72)$$

Subject equation (69) to (8) yield

$$C_4 = (o) = C_o \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (73)$$

So that equation (73) becomes

$$C_4 = C_o\ell^{(t-z)}\frac{V}{Cw\theta} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (74)$$

Now, we consider equation (10)

$$D\frac{\partial C}{\partial t} + Cw\theta\frac{\partial C}{\partial z} = 0 \quad \ldots\ldots\ldots\ldots \quad (10)$$

Apply Bernoulli’s method, we have

$$C_5 = ZT \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (75)$$

$$\frac{\partial C}{\partial t} = ZT^{1} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (76)$$

$$\frac{\partial C}{\partial Z} = Z^{1}T \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (77)$$

Put (75) and (76) into (10), so that we have

$$DZT^{1} = -Z^{1}T\,Cw\theta \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (78)$$

$$\text{i.e. } D\frac{T^{1}}{T} = \frac{Z^{1}}{Z}Cw\theta = \phi \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (79)$$

$$D\frac{T^{1}}{T} = \phi \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (80)$$

$$Cw\theta\frac{Z^{1}}{Z} = \phi \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (81)$$

$$T = \frac{\phi}{D}t \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (82)$$

And $$Z = B\ell \frac{-\phi}{Cw\theta} Z \qquad \text{.................} \qquad (83)$$

Put (80) and (81) into (73), gives

$$C_5 = A \frac{\phi}{Cw\theta} t \;\; B \frac{-\phi}{Cw\theta} t \qquad \text{.................} \qquad (84)$$

$$C_5 = AB\ell^{(z-t)} \frac{\phi}{Cw\theta} \qquad \text{.................} \qquad (85)$$

Subject equation (83) and (84) into (74) yield

$$C_5 = (o) = C_o \qquad \text{.................} \qquad (86)$$

So that equation (84) and (85) becomes

$$C_5 = (o) = C_o \;\; \ell^{(z-t)} \frac{\phi}{Cw\theta} \qquad \text{.................} \qquad (87)$$

Now, we consider equation (12)

$$D \frac{\partial C_6}{\partial t} - K \frac{\partial C_6}{\partial z} \qquad \text{...........} \qquad (12)$$

Applying Bernoulli’s method of separation of variables, we have

$$C_6 = ZT \qquad \text{.................} \qquad (88)$$

$$\frac{\partial C_6}{\partial t} = ZT^1 \qquad \text{.................} \qquad (89)$$

$$\frac{\partial C_6}{\partial Z} = Z^1 T \qquad \text{.................} \qquad (90)$$

$$DZT^1 - KZ^1 T \qquad \text{.................} \qquad (91)$$

i.e. $$D \frac{T^1}{T} = K \frac{Z^1}{Z} \qquad \text{.................} \qquad (92)$$

$$D \frac{T^1}{T} = \alpha \qquad \text{.................} \qquad (93)$$

$$K \frac{Z^1}{Z} = \alpha \qquad \text{.................} \qquad (94)$$

And $$Z = B\ell^{\frac{\alpha}{D} Z} \qquad \text{.................} \qquad (95)$$

Put (94) and (95) into (88) gives

$$C_6 = A\ell^{\frac{\alpha}{K} t \, *} \;\; B\ell^{\frac{\alpha}{K} t} \qquad \text{.................} \qquad (96)$$

$$C_6 = AB\ell^{(z-t)}\frac{\alpha}{K} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (97)$$

Subject equation (95) and (96) into (97) yield

$$C_6 = (o) = C_o \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (98)$$

So that equation (95 and (98) becomes

$$C_6 = C_o\,\ell^{(t-z)\frac{\alpha}{K}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (99)$$

We consider equation (14)

$$D\frac{\partial C}{\partial t} + V\theta\frac{\partial C}{\partial z} = 0 \ldots\ldots\ldots\ldots \quad (14)$$

$$C_7 = ZT \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (100)$$

$$\frac{\partial C_7}{\partial t} = ZT^1 \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (101)$$

$$\frac{\partial C_7}{\partial Z} = Z^1T \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (102)$$

Put (100) and (101) into (14), so that we have

$$DZT^1 = V\theta Z^1T \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (103)$$

i.e. $D\frac{T^1}{T} = V\theta\frac{Z^1}{Z}$ ……………… (104) $D\frac{T^1}{T} = \rho$

……………… (105)

$$V\theta\frac{Z^1}{T} = \rho \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (106)$$

$$T = A\frac{\rho}{D}t \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (107)$$

And $Z = B\ell^{\frac{-\rho}{V\theta}Z}$ ……………… (108)

Put (106) and (107) into (100), gives

$$C_7 = A\ell^{\frac{\rho}{V\theta}t}\ B\ell^{\frac{\rho}{V\theta}Z} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (109)$$

$$C_7 = AB\ell^{-(z-t)}\frac{\rho}{V\theta} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (110)$$

Subject equation (107) and (109) into (100) yield

$$C_7 = (o) = C_o \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (111)$$

So that equation (109) and (110) becomes

$$C_7 = A\ell^{\frac{\rho}{V\theta}t} \quad B\ell^{\frac{\rho}{V\theta}Z} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (112)$$

Now, we consider equation (16) which is the steady plow rate of the system

$$D\frac{\partial C_8}{\partial t} + V\frac{\partial C_8}{\partial z} \qquad \ldots\ldots\ldots\ldots \qquad (16)$$

Applying Bernoulli's method, we have

$$C_8 = ZT \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (113)$$

$$\frac{\partial C_8}{\partial t} = ZT^1 \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (114)$$

$$\frac{\partial C_8}{\partial Z} = Z^1T \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (115)$$

Put (113) and (114) into (16), so that we have

$$DZT^1 = V\,Z^1T \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (116)$$

i.e. $D\frac{T^1}{T} = V\frac{Z^1}{Z}$ ……………… (117)

$$D\frac{T^1}{T} = \theta \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (118)$$

$$V\frac{Z^1}{Z} = \theta \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (119)$$

$$Z = A\frac{\theta}{D}Z \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (120)$$

And $T = B\frac{\theta}{V}t$ ……………… (121)

Put (119) and (121) into (113), gives

$$C_8 = A\ell^{\frac{\theta}{D}} \bullet B\ell^{\frac{\theta}{V}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (122)$$

$$C_8 = AB\ell^{(t-z)}\frac{\theta}{V} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (123)$$

Subject to equation (122) and (123) yield

$$C_8 = (o) = C_o \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (124)$$

So that equation (123) become

$$C_8 = C_o\ell^{(t-z)}\frac{\theta}{V} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (125)$$

Now, assuming that at the steady flow, there is no NKP for substrate utilization, our concentration is zero, so that equation (124) becomes

In transport system on soil and water environment, velocity of flow determine the time of contaminant, most times variations are experienced in the transport process, there a relation between the velocity and time of flow, because the migration of solute are determined by the velocity of flow through micropores or tortuosity, the stratification rate of variation determined the variation in flow path of the formations, but under homogeneous formation there the tendency of establishing steady flow in the formation are through the influence of soil homogeneity, thus Steady state were considered in the equation as expressed in equation (125), the deposition of klebsiella were expressed under the influences of formation variation in deposition in the strata. But in most condition whereby the formation develop homogeneous deposition, it may maintained uniformity concentration in some formation, it implies that there is the possibility of uniform flow thus substrate and microbial concentration in the formation, therefore such condition may result to uniform flow and concentration from the substrate and klebsiella concentration, so equation (125) expressed such condition in the system, this reflect the behaviour assumed to be steady flow in the migration of the contaminant and the deposition of phosphorous in the study location.

$$C_8 = 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (126)$$

The expression in equation (126) were able to consider the situation substrate were not experienced, this condition are possible in the sense that the may some formations may experienced the substrate inhibition in the formation, thus the concentration will become zero, it implies that there is no deposition of substrate in those formation as Therefore, solution of the system is of the form

$$C = C_1 + C_2 + C_3 + C_4 + C_5 + C_6 + C_7 + C_8 \qquad \ldots\ldots\ldots\ldots\ldots \qquad (127)$$

We now substitute (25), (43), (62), (74), (87), (99), (112) and (125) into (128), so that we have the model of the form

$$C = C_o + C_o \,\ell \frac{-n^2\pi^2\theta b}{2V} Cos \frac{n\pi}{2} Z + C_o \,\ell \frac{-n^2\pi^2\theta b}{2K} \, Cos \frac{n\pi}{2} Z$$

$$+ \; C_o \,\ell^{(t-z)} \frac{\theta b}{Cw\theta} + C_o \,\ell^{(z-t)} \frac{\phi}{Cw\theta} + C_o \,\ell^{(t-z)} \frac{\alpha}{K} +$$

$$C_o \ell^{(t-z)} \frac{\rho}{V\theta} + C_o \ell^{(t-z)} \frac{\theta}{V} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (128)$$

$$\Rightarrow C = C_o \; 1 + \ell \frac{-n^2\pi^2\theta b}{2V} t + Cos \frac{n\pi}{2} Z + C_o \; \ell \frac{-n^2\pi^2\theta b}{2K} t \; Cos \frac{n\pi}{2} Z +$$

$$C_o \,\ell^{(t-z)} \frac{\theta b}{Cw\theta} + C_o \ell^{(z-t)} \frac{\phi}{Cw\theta} + C_o \ell^{(t-z)} \frac{\alpha}{K} + C_o \ell^{(t-z)} \frac{\rho}{V\theta} + C_o \ell^{(t-z)} \frac{\theta}{V} \quad \ldots\ldots \qquad (129)$$

The expressed final model in (129) is from the customized equation, the model considered several conditions that could pressure the deposition of phosphorous in the study location. The deposition of phosphorous were examined thoroughly from dissimilar conditions in the study location, these process were itemizes, in modifying the developed governing equation, numerous conditions that influence the behave of phosphorous deposition were also articulated in the system, since phosphorous are substrate to microbial growth thus determined the population of the microbes in soil and water environments, these condition were streamlined in the resultant model at various phase, the behaviour of phosphorous deposition express the variables denoted mathematically in the system, this condition were determined through the boundary values as express in the model equation, dissimilar stages were expressed on the process of developing the model denoting it through various mathematical tools, from various characteristics of the formations, the rate of the substrate determined the rate of concentration of the microbes under standard condition,. The model if applied will definitely monitored and determine the deposition and growth rate of klebsiella in soil and water environment.

4. Conclusion

Dispersion of klebsiella in soil and water are determine by the structural deposition of the formation, the expressed model were develop to monitor the rate of transport and dispersion of klebsiella in the study location, stratification of the formation influence the migration of klebsiella in soil and water environment, substrate utilization were found to be influenced the same formation in the study location, the study express the rate dispersions of substrate and transport of klebsiella under the influence of the geological setting in the coastal location, environmental factors from climatic conditions were also confirm to have influence the dispersions of klebsiella in soil and water environment., the study is imperative because it will monitor the rate of klebsiella in coastal area, the formation of coastal formation have numerous challenges due to the variation in stratifications, the developed mathematical model will thoroughly express the variation deposition from the rate of concentration in the strata, this will definitely assist experts in the field to assess the concentration at various formation in the study location.

References

[1] Callahan, M. R., Rose, J. B. and Paul, J. H. (2001). Bacteriological and pathogenic water quality assessment of the upper reaches of the Chassahowitzka river. Citrus County, FL, Citrus County Department of Public Works Utility Division.

[2] Craun, G. F., Nwachuku, N., Calderon, R. L. and Craun, M. F. (2002). "Outbreaks in drinking-water systems, 1991-1998." Journal of Environmental Health **65**(1): 16-23.

[3] Craun, G. F., Hubbs, S. A., Frost, F., Calderon, R. L. and Via, S. H. (1998). "Waterborne outbreaks of cryptosporidiosis." Journal American Water Works Association **90**(9): 81-91

[4] Dillon, K. S., Corbett, D. R., Chanton, J. P., Burnett, W. C. and Furbish, D. J. (1999). "The use of sulfurhexafluoride (SF6) as a tracer of septic tank effluent in the Florida Keys." J Hydrol **220**(3-4): 129- 140.

[5] Rose, J. B. and Zhou, X. T. (1995). Phillippi Creek Water Quality Report., Sarasota Bay National Estuary Program

[6] Paul, J. H., McLaughlin, M. R., Griffin, D. W., Lipp, E. K., Stokes, R. and Rose, J. B. (2000). "Rapid movement of wastewater from on-site disposal systems into surface waters in the Lower Florida Keys." Estuaries **23**(5): 662-668.

[7] Paul, J. H., Rose, J. B., Brown, J., Shinn, E. A., Miller, S. and Farrah, S. R. (1995). "Viral Tracer Studies Indicate Contamination of Marine Waters by Sewage Disposal Practices in Key-Largo, Florida." Appl Environ Microbiol **61**(6): 2230-2234.

[8] Paul, J. H., Rose, J. B., Jiang, S., Kellogg, C. and Shinn, E. A. (1995). "Occurrence of Fecal Indicator Bacteria in Surface Waters and the Subsurface Aquifer in Key-Largo, Florida." Appl Environ Microbiol **61**(6): 2235-2241.

[9] Paul, J. H., Rose, J. B., Jiang, S. C., Zhou, X. T., Cochran, P., Kellogg, C., Kang, J. B., Griffin, D., Farrah, S. and Lukasik, J. (1997). "Evidence for groundwater and surface marine water contamination by waste disposal wells in the Florida Keys." Water Res **31**(6): 1448-1454.

[10] Pedley, S. and Howard, G. (1997). "The public health implications of microbiological contamination of groundwater." Q J Eng Geol **30**: 179-188.

[11] Gerba, C. P. (1984). "Applied and Theoretical Aspects of Virus Adsorption to Surfaces." Advances in Applied Microbiology **30**: 133-168.

[12] Gerba, C. P. and Bitton, G. (1984). Microbial pollutants: their survival and transport pattern to groundwater. Groundwater Pollution Microbiology. Bitton, G. and Gerba, C. P. New York, NY, John Wiley and Sons**:** 65-88.

[13] Klein, J. and Ziehr, H. (1990). "Immobilization of Microbial-Cells by Adsorption." Journal of Biotechnology **16**(1-2): 1-16.

[14] Krekeler, C., Ziehr, H. and Klein, J. (1991). "Influence of Physicochemical Bacterial Surface-Properties on Adsorption to Inorganic Porous Supports." Applied Microbiology and Biotechnology **35**(4): 484-490.

[15] Lipp, E. K., Farrah, S. A. and Rose, J. B. (2001). "Assessment and impact of microbial fecal pollution and human enteric pathogens in a coastal community." Mar Pollut Bull **42**(4): 286-293

[16] Newby, D. T., Pepper, I. L. and Maier, R. M. (2000). Microbial Transport. Environmental Microbiology. Maier, R. M., Pepper, I. L. and Gerba, C. P. San Diego, Academic Press**:** 147 - 175.

[17] David E. J 2003 Transport and survival of water quality indicator microorganisms in the ground water environments of Florida: Implications for aquifer storage and waste disposal.