American Journal of Environment, Energy and Power Research
Vol. 1, No. 3, May 2013, PP: 45 - 61
Available online www.ajeepr.com

Research article

MODELING DISPERSION OF BACTERIAL TRANSPORT INFLUENCED BY INHIBITORS AND VARIATION OF AMMONIA DEPOSITION IN UNCONFINED AQUIFER S IN BAYELSA NIGER DELTA OF NIGERIA.

Eluozo, S. N.

Subaka Nigeria Limited, Port Harcourt, Rivers State of Nigeria
Director and Principal Consultant, Civil and Environmental Engineering, Research and Development
E-mail: Soloeluozo2013@hotmail.com
E-mail: solomoneluozo2000@yahoo.com

Abstract

Modeling dispersion of bacterial transport influenced by inhibitors and variation of ammonia deposition in unconfined aquifer s has been expressed, the migration of bacteria's are through the stratification of soil , the study location develop lots of challenges in the study location. To monitor the migration of bacteria's through dispersion found in the stratification of the soil, substrate deposition from ammonia were confirmed to be predominant in the formation, microelement that deposit in the study area influence increase in microbial population, this condition influence the dispersions of bacteria's in soil and water environment. Mathematical model were found suitable to monitor the rate of bacteria migration in the formation, the formation experience several formation variable base its characteristics that develop lots of challenges water quality, the governing equation were derived and it express models in phase that will determine various concentrations from bacteria's concentration in the study area, professional will fine the developed model useful in monitoring the deposition and migration of bacterial including ammonia influence in soil and water environments.

Keywords: modeling dispersion, bacteria's transport ammonia deposition, and unconfined aquifers

1. Introduction

Severe damaging microbes may enter ground water via poor well production, ground water recharge/permeation from the exterior, faulty septic tanks and/or sewer lines, land techniques of sewage

Sludge, and percolation of landfill migration (Sobsey 1979; Pedley and Howard 1997 David,2003). The fate of bacteria in the subsurface are base on two fundamental procedure , survival and transport/retention (Gerba and Bitton 1984). Study of the transport of microorganisms to and through ground water is an entire field onto itself. substantial work has been done to define factors upsetting microbial transport in ground water, generally with two motivating reasons: public health implications from contamination by potential pathogens, and migrates of biodegrading bacteria to aquifer regions contaminated with chemical constituents. Transport studies often involve the use of columns to model movement through a soil matrix or *in-situ* studies of microbial transport which employ monitoring wells to detect the organisms of interest, often a tracer organism, as they are transported with ground water across a study site Column studies are useful for isolating and/or defining specific impacts controlling transport as they offer a controlled environment, while *in-situ* studies allow for evaluating the impact of other factors in the natural environment that are difficult or impossible to model with column studies. Such factors could include predation and antagonism by other organisms, alterations in adsorption and survival in response to natural geochemical constituents and pore size or transmissivity effects of the undisturbed aquifer material, and interrelation of these and other variables (Harvey 1997 David,2003). By and large, microbial cells/particles have a negative surface charge in near-neutral water (Gerba 1984; Klein and Ziehr 1990; Krekeler 1991). But the overall charge on an organism is highly variable. Such rapid transport to surface water in Key Largo sites was largely attributed to tidal pumping, while sites where tidal pumping was not as significant demonstrated slower transport rates of 0.12 - 2 m/h (Paul 1997). The presence of human enteroviruses in surface water of the Florida Keys was also demonstrated (Griffin 1999). There are also indications that coral mucus may concentrate microorganisms of fecal origin, including human enteroviruses, leading to unknown but possibly deleterious effects on these organisms and the associated stressed marine ecosystem of coral reefs (Lipp 2002). Besides the Florida Keys, tracer studies have implicated septic tanks in contamination of surface water at estuarine (Rose and Zhou 1995; Lipp 2001) and freshwater sites in Florida, including demonstration of virus migration from a seeded septic tank to adjacent river waters (Callahan 2001). The potential of SF6 as a ground water tracer has also been reported, including its use in karst limestone and shallow, sandy aquifers (Wilson and Mackay 1993; Dillon 1999; Corbett 2000).

2. Theoretical background

The spread of bacterial in soil and water environment are influenced by several condition that influenced soil and water environment, bacteria's are found in soil and water, the deposition of this contaminants are from biological waste, this bacterial are found every where in the environment, depositing in the soil but can be managed if there is thorough sanitation service especially those that are generated from biological waste, the deposition of bacteria's is a serious concern to environmental health, most bacterial found in the environment are hazardous to fresh water aquifers, the transport of bacteria's in water environment are influenced by formation characteristics, the study location confirm other influence that increase the microbial population and inhibitors most case inhibit the microbes from microbial growth rate, degree of void ration and porosity in deltaic environment experience ground water level are too shallow depths, there are lots of water quality challenges in the study area , this implies that there lots of challenges from the formation characteristics' and other contaminants from man made activities and natural origin, the influence are from the geological setting, the challenged activities in the study area are the determinants of the growth or inhibition of bacteria's, subject to this relation, the behaviour of the bacterial in this condition are influenced by several factors due geomorphology and geochemistry in the study area.

Nomenclature

ϕ - Porosity Dimensionless

V - Void ratio

D - Dispersion

K_c - Coefficient of inhibition [ML^{-3}]

K_o - Half concentration of Ammonia [ML^{-3}]

K_n - Half concentration of substrate under aerobic respiration [ML^{-3}]

C - Concentration of bacteria [ML^{-3}]

T - Time [T]

Z - Distance [M]

3. Governing equation

$$\phi\frac{\partial C}{\partial t} = V\frac{\partial C}{\partial z} + D\frac{\partial C}{\partial z} - K_c\frac{\partial C}{\partial z} + K_o\frac{\partial C}{\partial t} + K_n\frac{\partial C}{\partial z} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

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

$$\left.\begin{aligned} t &= 0 \\ z &= 0 \\ C_{(o)} &= 0 \\ \frac{\partial C_1}{\partial t}\Big| t &= 0,\ B \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

$$\phi\frac{\partial C}{\partial t} = D\frac{\partial C}{\partial z} \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

$$\left.\begin{aligned} t &= 0 \\ z &= 0 \\ C_{(o)} &= 0 \\ \frac{\partial Cs_2}{\partial t}\Big| t &= 0,\ B \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

$$\phi\frac{\partial C_3}{\partial t} = -K_c\frac{\partial C_3}{\partial z} \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

$$t = 0$$

$$z = 0$$

$$C_{(o)} = 0$$

$$\frac{\partial C_3}{\partial t}\Big|\, t = 0, B \qquad \text{..................} \quad (7)$$

$$\phi \frac{\partial C_4}{\partial t} = K_o \frac{\partial C_4}{\partial z} \qquad \text{..................} \quad (8)$$

$$\left.\begin{aligned} t &= 0 \\ z &= 0 \\ C_{(o)} &= 0 \\ \frac{\partial Cs_4}{\partial t}\Big|\, t &= 0, B \end{aligned}\right\} \qquad \text{..................} \quad (9)$$

Several method has been applied to monitor deposition of bacteria's by other experts, but they could completely achieved the eradication of the transport contaminant from bacterial specie in deltaic environment, this is due to several challenges in the geological formation, the equations splitted from (2) to (9) is to descretized the equations according to various conditions base on different level experienced by the transports process including inhibitors and substrate influence, the microbes are under the influence of stratification of the formation at various depths to phreatic aquifers, this condition were found necessary since the substrate increase the growth rate of microbes and in some condition inhibit the microbes in soil and water environments, so it is imperative to ensure that the substrate is thoroughly examined to monitor the rate of deposition at various formation, thus predict their depositions and inhibition at different depths in the study area.

$$K_o \frac{\partial C_5}{\partial t} + K_n \frac{\partial C_5}{\partial z} = 0 \qquad \text{..................} \quad (10)$$

$$\left.\begin{aligned} t &= 0 \\ z &= 0 \\ C_{(o)} &= 0 \\ \frac{\partial C_5}{\partial t}\Big|\, t &= 0, B \end{aligned}\right\} \qquad \text{..................} \quad (11)$$

$$K_o \frac{\partial C_6}{\partial t} - K_c \frac{\partial C_6}{\partial z} \qquad \text{..................} \quad (12)$$

$$\left.\begin{aligned} t &= 0 \\ z &= 0 \\ Cs_{(o)} &= 0 \\ \frac{\partial C_6}{\partial t}\Big|\, t &= 0, B \end{aligned}\right\} \qquad \text{...............} \quad (13)$$

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

$$\left.\begin{array}{l} t = 0 \\ z = 0 \\ C_{(o)} = 0 \\ \frac{\partial Cs_7}{\partial t} \Big| t = 0, B \end{array}\right\} \qquad \ldots\ldots\ldots\ldots\ldots \qquad (15)$$

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

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

Applying direct integration on (2) we have

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

Again, integrate equation (18) directly yield

$$\phi C = V + K_1 + K_2 \qquad \ldots\ldots\ldots\ldots\ldots \qquad (19)$$

Subject to equation (3), we have

$$C = K_2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (20)$$

And subjecting equation (19) to (3)

At $\frac{\partial C_1}{\partial t}\Big|_{t = 0}^{= 0} \quad C_{(o)} = C_o$

Yield

$$0 = \phi C_o + K_2$$

$$\Rightarrow K_2 = \phi C_o \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad 21)$$

So that we put (20) and (210 into (19), we have

$$C_1 = \phi Ct - Vt + C_o \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (22)$$

$$C_1 - \phi = C_o - Vt \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (23)$$

$$\Rightarrow C_1 [C_1 - \phi t] = C_o [C_1 - Vt] \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (24)$$

$$\Rightarrow Ct = C_o \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (25)$$

$$\phi \frac{\partial C_2}{\partial t} = D \frac{\partial C_2}{\partial z} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

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

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

$$\frac{\partial C_2}{\partial t} = ZT^1 \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (27)$$

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

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

$$\phi ZT^1 = VZT^1 \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (29)$$

$$\phi \frac{T^1}{T} = V \frac{Z^1}{Z} = \lambda^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (30)$$

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

$$VZ^1 + \lambda^2 Z = 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (32)$$

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

And (32) gives $T = \frac{-\lambda^2}{C\ell^v} t \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (34)$

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

$$C_2 = \left[ACos \frac{\lambda}{\sqrt{\phi}} t + B\,Sin \frac{\lambda}{\sqrt{\phi}} x \right] Co\ell^{\frac{-\lambda^2}{\sqrt{\phi}} t} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ 35)$$

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

Equation (2) express this condition by direct integration, some of the parameters that has roles in accordance with the condition that express the behaviour of the microbes, directed integration were found necessary to couple the variables such similarity are base on the deposition of the substrate reflecting the concentration of the microbes in soil and water environment, thus the contaminants of bacteria's and may experience high degree of concentration. Variable that were found to express their relation with each other, this is on there pressure of increase in deposition, of bacteria's and increase in population in organic soil were the accumulations of bacterial are very high.

Equation (35) becomes

$$C_2 = C_o \ell \frac{-\lambda^2}{D} t \; Cos \frac{\lambda}{\phi} z \qquad \text{.....................} (37)$$

Again at $\frac{\partial Cs_2}{\partial t}\bigg|\begin{matrix} = 0, \; z = 0 \\ t = 0, \; B \end{matrix}$

Equation (37) becomes

$$\frac{\partial C_2}{\partial t} = \frac{\lambda}{\phi} C_o \ell^{\frac{-\lambda^2}{D}t} \; Sin \frac{\lambda}{\phi} z \qquad \text{.....................} (38)$$

i.e. $0 = -C_o \frac{\lambda}{\sqrt{\phi}} \; Sin \frac{\lambda}{\sqrt{\phi}} 0 \qquad \text{.....................} (39)$

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

$$0 = -C_o \frac{\lambda}{\phi} \; Sin \frac{\lambda}{\phi} B \qquad \text{.....................} (40)$$

$$\lambda = \frac{n\pi\sqrt{\phi}}{2} \qquad \text{.....................} (41)$$

So that equation (38) becomes

$$C_2 = C_o \ell^{\frac{-n^2\pi^2\phi}{2D}} \; Cos \frac{n\pi\sqrt{\phi}}{2\sqrt{\phi}} x \qquad \text{.....................} (42)$$

$$C_2 = C_o \ell^{\frac{-n^2\pi^2\phi}{2D}} \; Cos \frac{n\pi}{2} x \qquad \text{.....................} (43)$$

We consider equation (6)

$$\phi \frac{\partial C_3}{\partial t} = -K_c \frac{\partial C_3}{\partial z} \qquad \text{.....................} (6)$$

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

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

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

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

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

$$\phi \frac{ZT^1}{T} = K_c \frac{Z^1 T}{T} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (47)$$

$$\text{i.e. } \phi \frac{VT^1}{T} = K_c \frac{Z^1}{Z} - \lambda^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (48)$$

$$\text{Hence } V\frac{T^1}{T} + \lambda^2 = 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (49)$$

$$\text{i.e. } Z^1 + \frac{\lambda^2}{\phi} Z = 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (50)$$

$$\text{And } K_c T^1 + \lambda^2 T = 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (51)$$

$$\text{From (50) } Z = ACos\frac{\lambda}{\phi} Z + BSin\frac{\lambda}{\phi} Z \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (52)$$

And (45) gives

$$T = C_o \ell^{\frac{-\lambda^2}{K_c}t} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (53)$$

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

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

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

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

comparable circumstances are expressed in equation (55) the depositions of bacteria's migrating unconfined aquifers are establish to deposit very high concentration of microelement, high deposition of permeability develop of fast migration base on high degree of saturation through high rain intensities, this influence the bacteria's and substrate to migrate to were the permeability deposit higher degree in the soil strata, comparable circumstance developed the composition of these parameter integration in equation (55) were the concentration of the substrate at initial concentration develop faster transportation, formation in the strata determined the expressed variables that developed model denoted as C_s = Ac in equation (55).

Equation (56) becomes

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

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

Equation (56) becomes

$$\frac{\partial C_3}{\partial t} = \frac{\lambda}{\sqrt{\phi}} Cos \frac{-\lambda^2}{K_c} \;\; Sin \frac{\lambda}{\phi} z \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (57)$$

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

$C_o \frac{\lambda}{\phi} \neq 0$ Considering NKP

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

Equation (40) and (57) express the influence of the substrate in terms of increase in microbial population, this condition were considered in two equations, microbial population are expected i to increase in population thus predominant in some part of the formation . The equations take care of the rate of substrate deposition in the formations, the equation in (40) and (55) expressed the results of high degree of bacteria's deposition in the formations, above all the , an expressed equation reflect the consequences of substrate deposition, the tendency increase of microbial population, including high degrees of feeding from the substrate deposition in the formations were express in the system.. 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 in soil and water environment.

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

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

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

So that equation (52)

$$C_3 = C_o \ell^{\frac{-n^2\pi^2\phi}{2K_c}} Cos \frac{n\pi\sqrt{\phi}}{2\sqrt{\phi}} Z \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (61)$$

$$\Rightarrow C_3 = C_o \ell^{\frac{-n^2\pi^2\phi}{2K_c}t} Cos \frac{n\pi}{2} Z \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (62)$$

Now we consider equation (8)

$$\phi \frac{\partial C_4}{\partial t} = K_o \frac{\partial C_4}{\partial z} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

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

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

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

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

$$\phi ZT = -K_o Z^1 T \qquad \ldots\ldots\ldots\ldots\ldots\ldots (66)$$

i.e. $\phi \frac{T^1}{T} = K_o \frac{Z^1}{Z} = \varphi$ $\qquad \ldots\ldots\ldots\ldots\ldots\ldots$ (67)

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

$$K_o \frac{Z^1}{Z} = \varphi \qquad \ldots\ldots\ldots\ldots\ldots\ldots (69)$$

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

And

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

$$C_4 = A\ell^{\frac{\varphi}{K_o}Z} \; B\ell^{\frac{\varphi}{K_o}t} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (71)$$

$$Cs_4 = AB\ell^{(z-t)} \frac{\varphi}{K_o} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (72)$$

Subject equation (70) to (8) yield

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

So that equation (73) becomes

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

Now, we consider equation (10)

$$K_o \frac{\partial C_5}{\partial t} + K_n \frac{\partial C_5}{\partial z} \quad \ldots\ldots\ldots \qquad (10)$$

Apply Bernoulli's method, we have

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

$$\frac{\partial C_5}{\partial t} = ZT^1 \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (76)$$

$$\frac{\partial C_5}{\partial Z} = Z^1 T \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (77)$$

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

$$K_o \; ZT^1 = -Z^1 T \, K_n \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (78)$$

i.e. $K_o \frac{T^1}{T} = \frac{Z^1}{Z} K_n = \alpha \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (79)$

$$K_o \frac{T^1}{T} = \alpha \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (80)$$

$$K_n \frac{Z^1}{Z} = \alpha \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (81)$$

$$T = \frac{\alpha}{K_o} t \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (82)$$

$$Z = B \ell^{\frac{-\alpha}{K_n} z} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (83)$$

And

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

$$C_5 = A \frac{\alpha}{K_n} t \; \frac{-\alpha}{K_n} t \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (84)$$

$$C_5 = AB \ell^{(z-t)} \frac{\alpha}{K_n} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (85)$$

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

$$C_5 = (o) = C_o \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (86)$$

So that equation (84) and (85) becomes

$$Cs_5 = (o) = Cs_o \; \ell^{(x-t)} \frac{\alpha}{K_n} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (87)$$

Now, we consider equation (12)

$$K_o \frac{\partial Cs_6}{\partial t} - K_n \frac{\partial Cs_6}{\partial z} = 0 \quad \ldots\ldots\ldots\ldots \quad (12)$$

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

$$C_6 = ZT \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (88)$$

$$\frac{\partial C_6}{\partial t} = ZT^1 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (89)$$

$$\frac{\partial C_6}{\partial Z} = Z^1 T \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (90)$$

$$ZT^1 K_o - K_o Z^1 T \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (91)$$

i.e. $K_o \frac{T^1}{T} = K_c \frac{Z^1}{Z} = \rho$ $\ldots\ldots\ldots\ldots\ldots\ldots$ (92)

$$K_o \frac{T^1}{T} = \rho \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (93)$$

$$K_c \frac{Z^1}{Z} = \rho \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (94)$$

And $Z = B\ell^{\frac{-\rho}{K_o}z}$ $\ldots\ldots\ldots\ldots\ldots\ldots$ (95)

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

$$C_6 = A\ell^{\frac{A-\rho}{K_c}t} \bullet B\ell^{\frac{\rho}{K_c}t} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (96)$$

$$C_6 = AB\ell^{(z-t)} \frac{\rho}{K_c} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (97)$$

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

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

So that equation (95 and (98) becomes

$$C_6 = C_o \, \ell^{(t-z)\frac{\rho}{K_c}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (99)$$

We consider equation (14)

$$K_o \frac{\partial C_7}{\partial t} + V \frac{\partial C_7}{\partial z} \quad \ldots\ldots\ldots\ldots \quad (14)$$

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

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

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

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

$$C\theta ZT^1 = V\theta Z^1 T \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (103)$$

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

$$C\theta \frac{T^1}{T} = \rho \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (105)$$

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

$$T = A \frac{\rho}{C\theta} t \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (107)$$

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

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

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

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

Subject equation (108) and (109) into (100) yield

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

So that equation (109) and (110) becomes

$$C_7 = C\theta \, \ell^{(t-z)} \frac{\rho}{V\theta} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (112)$$

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

$$C\theta \frac{\partial C}{\partial t} + D \frac{\partial C}{\partial z} \quad \ldots\ldots\ldots\ldots \quad (16)$$

Applying Bernoulli's method, we have

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

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

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

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

$$C\theta Z T^1 = D Z^1 T \qquad \text{.................} \quad (116)$$

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

$$C\theta \frac{T^1}{T} = \theta \qquad \text{.................} \quad (118)$$

$$D \frac{Z^1}{Z} = \theta \qquad \text{.................} \quad (119)$$

$$Z = A \frac{\theta}{C\theta} Z \qquad \text{.................} \quad (120)$$

And $T = B \frac{\theta}{D} t$ .... (121)

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

$$C_8 = A\ell^{\frac{\theta}{C\theta}} \bullet B\ell^{\frac{\theta}{D}} \qquad \text{.................} \quad (122)$$

$$C_8 = AB = \ell^{(t-z)} \frac{\theta}{D} \qquad \text{.................} \quad (123)$$

Subject to equation (122) and (123) yield

$$C_8 = (o) = C_o \qquad \text{.................} \quad (124)$$

So that equation (125) becomes

$$C_8 = C_o \ell^{(t-z)} \frac{\theta}{D} \qquad \text{.................} \quad (125)$$

Steady state were express in equation (125), the deposition of bacterial were expressed under the pressure of formation difference in deposition of the strata. But in most condition were formation experienced homogeneous deposition at the same time maintained substrate uniformity deposition in some formation, it implies that in unconfined aquifers may experience uniform flow of the substrate and microbial concentration in the formation, therefore such condition may result to uniform flow of microbial deposition in water including substrate deposition in the formation, so equation (125) expressed such condition in the system, this reflect the behaviour assumed in the migration of the contaminant and the deposition of substrate including inhibitors in the study location.

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

$$C_8 = 0 \qquad \text{.................} \quad (126)$$

Subject to the expression in equation (126) were able to consider the situation substrate were not experienced, this condition are possible in the sense that in some formations the substrate may experienced inhibition, thus the concentration will become zero, it implies that there is no deposition of substrate in those formation as expressed in equation, this deposition of inhibitors may deposit more concentration more than the substrate as express in (126)

Therefore, solution of the system is of the form

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

We now substitute (25), (43), (62), (74), (87), (99), (110) and (125) into (128), so that we have the model of the form

$$C = C_o + C_o \ell \frac{-n^2\pi^2K}{2D} Cos \frac{n\pi}{2} Z + \ell \frac{-n^2\pi^2K}{2V\theta} t \, Cos \frac{\sqrt{V}}{2} Z + C_o \ell^{(t-z)} \frac{K}{C\theta} + C_o \ell^{(z-t)} \frac{\phi}{V} + C_o \ell^{(t-z)} \frac{\alpha}{V\theta} + C_o \ell^{(t-z)} \frac{\rho}{V\theta} + C_o \ell^{(t-z)} \frac{\theta}{D} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (128)$$

$$\Rightarrow C = C_o \, 1 + \ell \frac{-n^2\pi^2K}{2D} Cos \frac{n\pi}{2} + \ell \frac{-n^2\pi^2K}{2V\theta} t \, Cos \frac{n\pi}{2} Z + C_o \ell^{(t-z)} \frac{K}{C\theta} + C\theta \ell^{(z-t)} \frac{\phi}{V} + C\theta \ell^{(t-z)} \frac{\alpha}{V\theta} + C\theta \ell^{(t-z)} \frac{\rho}{V\theta} + C\theta \ell^{(t-z)} \frac{\theta}{D} \quad \ldots (129)$$

The express mathematical model in (129) is from the customized equation that considered numerous conditions that could influence the deposition of bacteria's in the study location. The deposition of bacterial were investigated thoroughly from different conditions in the study area, these procedure were itemizes, in transforming the developed governing equation, numerous situations that influence the behavious were expressed bacteria under the influence of dispersion influence through the formation characteristics deposition were also expressed in the system, since substrate are for microbial growth, it determined the population of the microbe in soil and water environments, these condition were streamlined in the derived model at various stage, the behaviour of substrate deposition express the concentration variables denoted mathematically in the system, this condition were determined through the boundary values as express in the model equation, different phase were expressed on the process of developing the model denoting it through various mathematical tools, from various characteristics of the formations determine the rate of concentration of the bacteria's the rate of concentration of the microbes under normal condition, some situations were the deposition are very high and there is degradation of the microbes were also considered in the system on the derived mathematical expression. The model if applied will definitely monitored and determine the deposition of bacteria and it growth rate in phreatic aquifers.

4. Conclusion

The deposition of bacteria's in soil and water environment mostly from poor sanitation in the deltaic environment has been evaluated several challenges has been highlighted the deposition of bacteria and substrate including inhibitor, are found to displayed several behaviour due to influence from formation characteristics, the migration of bacteria's in soil and water environment are through the influences from geological formation in the study area ,mathematical model were developed through the governing equation the were derived mathematical equation generate model equation that will monitor the dispersion of bacteria's under the influence of void ratio and variation of ammonia in the study location.

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