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**Research article**

# MODELING PERMEABILITY AND VELOCITY INFLUENCES ON BACILLUS DEPOSITION IN RETARDATION PHASE DEPOSITED IN FINE AND COARSE SAND FORMATION IN WARRI, DELTA STATE OF NIGERIA

**Eluozo, S. N**

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

## Abstract

Velocity of flow are deposited in soil under the influence of permeability coefficient in the soil, bacillus deposition were found to experiences retardation in its deposition, the concentration were investigated through standard method in the study location, the rate of concentration of bacillus were found to experience retardation, several condition can responsible for retardation of bacillus in the system but the focus of the study was to express the influences from permeability and velocity of transport, such formation characteristics were found imperative to monitor due to the geological setting of the formation, climatic condition were also found to influences the study area through high rain intensities, these conditions are found to develop high degrees of soil permeability in the study location, therefore the rate of the two stated parameters played major role on the transport of bacillus in the study area, mathematical modeling approach were found necessary to determined detailed function observed in the transport process of the microbes, population increase were considered in the derived solution were the increase of bacillus concentration played a major roles in the system, the derived model will definitely express the roles both influential parameters has on bacillus deposition in the study area.

**Keywords:** modeling permeability and velocity, retardation phase, coarse and fine sand formation

## 1. Introduction

Ground water possessions are greatly used for household drinking water supplies in most of the world. Furthermore, over 40 million people use ground water to supply their drinking water via domestic wells (Alley 1999). Developed nation like U.S., 92% rely primarily on ground water for supply (Craun 2002). Universal, 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 obtain more than 2/3 of their drinking water from ground water (Pedley and Howard 1997). Aquifers have, until the most recent few decades, been usually considered protected from potential sources of microbial or substance contamination typically found in surface waters. Due to increasing population densities, agriculture, development and industrialization, and increased withdrawals from aquifers, however, the quality of ground water is increasingly a concern. Numerous instances of ground water pollution and waterborne illness due to intake of ground water have been acknowledged. Microbial contamination of ground water has been accountable for numerous disease outbreaks. In the U.S., at least 356 outbreaks of disease caused by polluted ground water were acknowledged between 1971 and 1994, indicating 58% of all waterborne illness outbreaks (Craun and Calderon 1997). Additional current period (1991 - 1998) indicated that 74 outbreaks of waterborne illness occurred due to public water systems that used ground water, representing 68% of the waterborne disease outbreaks during that period (Craun 2002). This is likely an underestimation of generally occurrence of illness due to recurrent no revealing of outbreaks and a lack of exposure on sporadic and self-resolving illnesses. However, serious consequences can be the result, as approximate yearly waterborne disease deaths in the U.S. were reported in one review to be 900 - 1800 (Macler and Merkle 2000). While these high statistics are an estimate, documented illness due to drinking water contamination in the U.S. from 1991 - 1998 included 126 outbreaks and, not including large outbreak of cryptosporidiosis in Milwaukee in 1993, documented deaths. (Craun 2002). Since many individual, non-community, and community ground water wells and systems often are considered to be potable without treatment; disinfection has recurrently not been required unless the aquifer is determined to be under direct influence of surface water. Concerning disease outbreaks due to community and non-community ground water systems, insufficient disinfection or lack of disinfection was accountable for a important fraction of the outbreaks (Craun and Calderon 1997). particularly, inadequate or failed treatment in systems using ground water caused 58 illness outbreaks from 1991 - 1998, 31 of these outbreaks were due to untreated water, mostly in non-community water systems (Craun 2002). Beyond the imperative concern of waterborne disease due to utilization of ground water polluted by surface sources, infected ground water may also donate to surface water microbial contamination. Numerous studies employing virus detectives and/or chemical detectives have documented transportation 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) pollution of surface water via ground water flow can be more challenging in areas receiving high yearly 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 ground water contamination, particularly from OSDS, can have important impacts on surface water microbial quality. A large number of different pathogenic or opportunist microorganisms can be responsible for ground water contamination. 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 coxsackievirus, echovirus, rotavirus, nor are virus, calicivirus, astrovirus, and hepatitis A and E. Bacteria of concern 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, David 2003). Recent studies on the incidence of microbial contamination include an examination of wells in Wisconsin for enteric viral pathogens and indicators which detected viruses in 4 out of 50 wells monitored four times over a year. Wells tested positive for rotavirus in three cases, and rotavirus, Norwalk-like virus and enteroviruses in the fourth positive well. However, there was not a correlation to the presence of F+ RNA bacteriophage or bacterial indicators, and contamination appeared to not be continuous since wells were not positive on consecutive samples (Borchardt 2003). A recent examination of waterborne disease in Finland determined that 13 of 14 waterborne illness outbreaks from 1998 - 1999 were caused by non-disinfected ground water. 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 David 2003).

## 2. Theoretical background

Modeling permeability and velocity of bacillus deposition in retardation phase in fine and coarse sand has been expressed mathematically; this study was found imperative because it will establish the relationship between permeability of flow and velocity of transport in the system. The rate of permeability of fluid are base on the deposition of formation in the study area, similar condition are applicable to velocity of transport. The rate of bacillus transport in soil has been confirmed to develop several variations in the system. The migration of the microbes under plug flow condition has established different concentration with respect to time in soil and water environments. The concept is to monitor the rate of permeability influence and its relationship in different dimensions. The governing equation were develop established a permeability relationship with velocity of transport in various stratifications of the formation. The governing equation will be derived with relevant mathematical approach to establish a model that will monitor permeability and velocity of transport influence on bacillus deposition in the study area. More so However, several data on survival of microbes once in the saturated zone is particularly imperative in areas with shallow aquifers or in situations where possibly polluted surface water may come in direct contact with the aquifer. Also, areas with high annual or seasonal rainfall may experience situations where more rapid transport of surface organisms to aquifers occurs due to greater adjectives flow of water. The study area and other part of the world that deposit similar geological and climatic conditions in such region with high seasonal precipitation, limited vertical topography, and therefore in many places shallow water tables/small vadose zones. The karst geology of the Florida peninsula is also a contributor to more rapid transport of surface water to aquifers than most other areas of the continental U.S. Most studies on survival of public-health-related microorganisms in ground water have considered inactivation of viruses, as these organisms are often considered the most readily transported through the subsurface and most threatening to ground water supplies. But, given the karst geology of Florida, with associated solution channels and sometimes relatively high bulk porosity, larger organisms such as bacteria and intestinal parasite cysts and oocysts are of equal concern. Thus, it is important to examine the fate or survival of all groups of microorganisms in ground water, in the bulk liquid phase of the ground water environment.

## 3. Governing equation

$$R\frac{\partial C}{\partial t} = DK\frac{\partial^2 C}{\partial x^2} - V\frac{\partial C}{\partial x} - \frac{\partial C\mu C}{\partial t} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (1)$$

**Nomenclature**

| | | |
|---|---|---|
| R | = | Retardation factor |
| C | = | Enteric virus concentration |
| D | = | Hydrodynamic Dispersion ($cm^2$/m) |
| V | = | Steady state ground water velocity ($cm^2$/mm) |
| µ | = | Removal rate of coefficient (c/mm) |
| T | = | Time [T] |
| X | = | Distance [M] |
| K | = | $LT^{-2}$ |

$$R\frac{\partial^2 C_1}{\partial t} = DK\frac{\partial^2 C_1}{\partial x^2} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (2)$$

$t = 0$

$$\left.\begin{array}{l} x = 0 \\ C_{(o)} = 0 \\ \left.\dfrac{\partial C}{\partial t}\right|_{t = 0, B} = 0 \end{array}\right\} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (3)$$

$$R\frac{\partial C_2}{\partial t} = V\frac{\partial C^2}{\partial x} \quad \ldots\ldots\ldots\ldots \quad (4)$$

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

$$R\frac{\partial C_3}{\partial t} = -\frac{\partial C_3 \mu c}{\partial t} \quad \ldots\ldots\ldots\ldots \quad (6)$$

$$\left.\begin{array}{l} t = 0 \\ C_{(o)} = 0 \\ \left.\dfrac{\partial C_3}{\partial t}\right|_{t = 0,\ B} = 0 \end{array}\right\} \quad \ldots\ldots\ldots\ldots \quad (7)$$

$$V\frac{\partial C_4}{\partial x} - \frac{\partial C_4 \mu c}{\partial t} \quad \ldots\ldots\ldots\ldots \quad (8)$$

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

$$DK\frac{\partial^2 C_5}{\partial x^2} - V\frac{\partial C_5}{\partial x} \quad \ldots\ldots\ldots\ldots \quad (10)$$

$$\begin{array}{l} x = 0 \\ C_{(o)} = 0 \\ \left.\dfrac{\partial C_5}{\partial x}\right|_{x = 0,\ B} \end{array} \quad \ldots\ldots\ldots\ldots \quad (11)$$

Applying direct integration on (2)

$$R\frac{\partial C_1}{\partial t} = D\phi C + K_1 \quad \ldots\ldots\ldots\ldots \quad (12)$$

Again, integrate equation (12) directly yield

$$RC = DKCt + Kt + K_2 \qquad \text{..........................................} \qquad (13)$$

Subject to equation (3), we have

$$RC_o = K_2 \qquad \text{..........................................} \qquad (14)$$

And subjecting equation (12) to (3) we have

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

Yield

$$0 = D\phi C_o + K_2$$

$$\Rightarrow R_1 = D\phi C_o = K_2 \qquad \text{..........................................} \qquad (15)$$

So that we put (13) and (14) into (13), we have

$$RC_1 = DKC_{1t} - DKCox\ RCo \qquad \text{..........................................} \qquad (16)$$

$$RC_1 - DKC_{1x} = RC_o - DKCox \qquad \text{..........................................} \qquad (17)$$

$$C_1 = C_o \qquad \text{..........................................} \qquad (18)$$

Hence equation (18) entails that at any given distance x, we have constant concentration of the contaminant in the system. Most case the microbes develop constant migration under the influences of formation characteristics in the system, the deposition of permeability in soil defined the rate the structural setting of the formation in any normal condition, therefore constant concentration are reflected from the structural deposition of the formation and it characteristics, these influences generate constant concentration in some region of the formation. The derived solution expressed in the system as one of the condition that be experiences on the transport process of bacillus under the influences of permeability coefficients and velocity of flow in soil and water environment.

$$R\frac{\partial C_2}{\partial t} = -V\frac{\partial C^2}{\partial x} \qquad \text{................} \qquad (4)$$

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

$$C_2 = XT \qquad \text{..........................................} \qquad (19)$$

i.e.

$$R\frac{\partial C_2}{\partial t} = XT^1 \qquad \text{.....................................} \qquad (20)$$

$$V\frac{\partial C_2}{\partial x} = X^1T \qquad \text{..........................................} \qquad (21)$$

Put (20) and (21) into (19), so that we have

$$RXT^1 = -VX^1T \qquad \text{..........................................} \qquad (22)$$

i.e. $R\frac{T^1}{T} = V\frac{X^1}{X} = -\lambda^2$ ...................................... (23)

Hence $R\frac{T^1}{T} + \lambda^2 = 0$ .............................. (24)

i.e. $X^1 + \frac{\lambda}{R}x = 0$ .............................. (25)

$VX^1 + \lambda^2 X = 0$ .............................. (26)

From (25), $X = ACos\frac{\lambda}{R}X + BSin\frac{\lambda}{\sqrt{R}}X$ .............................. (27)

And (20) gives

$$T = C\ell^{\frac{-\lambda^2}{V}t}$$ .............................. (28)

And (20) gives

$$\boxed{C_2 = \left(ACos\frac{\lambda}{\sqrt{R}}t + BSin\frac{\lambda}{\sqrt{R}}t\right)C\ell^{\frac{-\lambda^2}{V}x}}$$ ............................ (29)

Subject to equation (29) to conditions in (5), so that we have

$$C_o = AC$$ .................................... (30)

Equation (30) becomes

$$C_2 = C_o\ell^{\frac{-\lambda^2}{V}x}\ Cos\frac{\lambda}{\sqrt{R}}t$$ .................................... (31)

Again, at

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

Equation (31) becomes

$$\frac{\partial C_2}{\partial t} = \frac{\lambda}{\sqrt{R}}C_o\ell^{\frac{-\lambda}{V}x}\ Sin\frac{\lambda}{\sqrt{R}}t$$ .................................... (32)

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i.e. $0 = -\frac{Co\lambda}{\sqrt{R}} \ Sin\frac{\lambda}{\sqrt{R}}0$

$Co\frac{\lambda}{\sqrt{R}} \neq 0$ Considering NKP

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

$$0 = Co\frac{\lambda}{\sqrt{R}} \ Sin \frac{\lambda}{\sqrt{R}}B \quad \text{…………….……………..} \quad (30)$$

$$\Rightarrow \frac{\lambda}{R} = \frac{n\pi}{2} n,1,2,3 \quad \text{…………………………..} \quad (34)$$

$$\Rightarrow \lambda = \frac{\lambda}{R} = \frac{n\pi\sqrt{R}}{2} \quad \text{…………………………..} \quad (35)$$

So that equation (31) becomes

$$\Rightarrow C_2 = Co\ell \frac{-n^2\pi^2 R}{2} t \ Cos\frac{n\pi\sqrt{R}}{2\sqrt{R}} x \quad \text{…………………………..} \quad (36)$$

$$\Rightarrow C_2 = Co\ell \frac{-n^2\pi^2 R}{2} t \ Cos\frac{n\pi}{2} x \quad \text{…………………………..} \quad (37)$$

Now, we consider equation (7), we have the same similar condition with respect to the behaviour

$$R \frac{\partial C_3}{\partial t} = -\frac{\partial C_3 \mu C}{\partial t} \quad \text{……………………} \quad (6)$$

$$C_3 = XT^1 \quad \text{…………………………..} \quad (38)$$

$$\frac{\partial C_3}{\partial t} = XT^1 \quad \text{…………………………..} \quad (39)$$

i.e. $R\dfrac{\partial C_3}{\partial t} = XT^1$ ………………………….. (40)

Put (20) and (21) into (19), so that we have

$RXT^1 = -XT^1\mu C$ ………………………….. (41)

i.e. $R\dfrac{T^1}{T} = -\dfrac{T^1}{T}\mu C - \lambda^2$ ………………………….. (42)

$R\dfrac{T^1}{T} + \lambda^2 = 0$ ………………………….. (43)

$X^1 + -\dfrac{\lambda}{R}\varphi = 0$ ………………………….. (44)

And $RT^1 + \lambda^2 t = 0$ ………………………….. (45)

From (44), $t = ACos\dfrac{\lambda}{R}t + BSin\dfrac{\lambda}{\sqrt{R}}t$ ………………….. (46)

and (39) give

$$\boxed{T = C\ell\frac{-\lambda^2}{\mu C}t}$$ ………………………….. (47)

By substituting (46) and (47) into (38), we get

$$\boxed{C_3 = \left(ACos\frac{\lambda}{R}t + BSin\frac{\lambda}{\sqrt{R}}t\right)C\ell\frac{-\lambda^2}{\mu C}t}$$ ……………… (48)

Subject equation (48) to conditions in (7), so that we have

$$Co \; = \; AC \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \qquad (49)$$

Equation (49) becomes

$$C_3 \; = Co\,\ell\, \frac{-\lambda^2}{\mu C} t \; Cos\, \frac{\lambda}{R} t \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \qquad (49)$$

Again, at $\left.\frac{\partial C_3}{\partial t}\right|_{t\; = 0, B} \; = \; 0 \quad t = \; 0$

Equation (50) becomes

$$\frac{\partial C_3}{\partial t} = \frac{\lambda}{R}\, Co\,\ell\, \frac{-\lambda}{\mu C} t \; Sin\, \frac{\lambda}{R} t \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \qquad (51)$$

i.e. $0 = \; Co \frac{\lambda}{R} \; Sin\, \frac{\lambda}{R} 0$

$Co \frac{\lambda}{R} \; \neq \; 0$ Considering NKP again

Due to the rate of growth, which is known to be the substrate utilization of the microbes we have

$$0 = \; - Co \frac{\lambda}{\sqrt{R}} \; Sin\, \frac{\lambda}{\sqrt{R}} B \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \qquad (52)$$

The transport process has been express in several condition of the soil, substrate deposition in formation of the soil, therefore the microelements are considered to deposit in some part t of the region, the depositions of this substrate are found to increase the population of bacillus in the formation, the concentration increasing with respect to formation characteristics in the soil formation, the population increase in the formation are influenced by the rate of permeability of the soil, the transport of bacillus are influenced by this stated parameters including velocity of transport in the system, the expressed derived solution at these condition considered these conditions in sequenced through to mathematical approach to expressed these condition of transport process of bacillus in substrate condition in the formations.

$$\Rightarrow \frac{\lambda}{R} = \frac{n\pi}{2} n,1,2,3 \qquad \text{………………………..} \qquad (53)$$

$$\Rightarrow \lambda = \frac{n\pi\sqrt{R}}{2} \qquad \text{………………………..} \qquad (54)$$

So that equation (50) becomes

$$C_3 = Co\ell \frac{-n^2\pi^2 R}{2\mu C} t \, Cos \frac{n\pi}{2} t \qquad \text{………………………..} \qquad (55)$$

Now, we consider equation (8), we have

$$V \frac{\partial C_4}{\partial x} - \frac{\partial C_4 \mu C}{\partial t} \qquad \text{……………………} \qquad (8)$$

Using Bernoulli's method, we have

$$C_4 = XT \qquad \text{………………………..} \qquad (56)$$

$$\frac{\partial C_4}{\partial x} = X^1 T \qquad \text{………………………..} \qquad (57)$$

$$\frac{\partial C_4}{\partial t} = XT^1 \qquad \text{………………………..} \qquad (58)$$

Put (57) and (58) into (56), so that we have

$$VX^1T = -XT^1 \mu C \qquad \text{………………………..} \qquad (59)$$

i.e. $V \frac{X^1}{X} = -\frac{T^1}{T} \mu C$ ……………………….. (60)

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$$V\frac{X^1}{X} = \varphi \qquad \text{..............................} \qquad (61)$$

$$\frac{T^1}{T}\mu C = \varphi \qquad \text{..............................} \qquad (62)$$

$$X = A\,\ell\,\frac{\varphi}{V}t \qquad \text{..............................} \qquad (63)$$

Put (62) and (63) into (56), gives

$$C_4 = A\,\ell\,\frac{\varphi}{\mu C} \bullet B\,\ell\,\frac{-\varphi}{\mu C}x \qquad \text{..............................} \qquad (64)$$

$$C_4 = AB\,\ell^{(t-x)}\frac{\varphi}{\mu C} \qquad \text{..............................} \qquad (65)$$

Subject equation (66) to (8)

$$C_4\ (o) = Co \qquad \text{..............................} \qquad (66)$$

So that equation (67) becomes

$$\boxed{C_4 = Co\,\ell^{(t-x)}\frac{\varphi}{\mu C}} \qquad \text{..............................} \qquad (67)$$

Considering equation (10), we have

$$DK\frac{\partial^2 C_5}{\partial x^2} - V\frac{\partial C_5}{\partial x} \qquad \text{.....................} \ (10)$$

$$C_5 = XT \qquad \text{..............................} \qquad (68)$$

$$\frac{\partial^2 C_5}{\partial x^2} + X^{11}T \qquad \text{.............................} \qquad (69)$$

$$\frac{\partial C_5}{\partial x} + X^1 T \qquad \text{.............................} \qquad (70)$$

Put (69) and (70), so that we have

$$D\phi X^{11}T - VX^1T \qquad \text{.............................} \qquad (71)$$

$$DK\frac{X^{11}}{X}T - V\frac{X^1}{X} \qquad \text{.............................} \qquad (72)$$

$$DK\frac{X^{11}}{X} = \varphi \qquad \text{.............................} \qquad (73)$$

$$V\frac{X^1}{X} = \varphi \qquad \text{.............................} \qquad (74)$$

$$X^1 = A\ell\frac{\varphi}{DK}x \qquad \text{.............................} \qquad (75)$$

Put (74) and (75) into (68), gives

$$C_5 = A\ell\frac{\varphi}{V} \bullet B\ell\frac{-\varphi}{V}x \qquad \text{.............................} \qquad (76)$$

$$C_5 = AB\ell^{(x-x)}\frac{\varphi}{V} \qquad \text{.............................} \qquad (77)$$

Subject (76) to (10)

$$C_5\ (o) = Co \qquad \text{.............................} \qquad (78)$$

So that equation (78) becomes

$$C_5 = Co\ell^{(x-x)}\frac{\varphi}{V} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (79)$$

Now, assuming that at the steady flow, there is no NKP for substrate utilization, our concentration here is zero, so that equation (79) becomes

$$C_5 = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (80)$$

Therefore, $C_1 + C_2 + C_3 + C_4 + C_5$ …………………. (81)

We now substitute (18), (37), (55), (67) into (81) so that we have the model of the form

$$C = Co + Co\ell\,\frac{-n^2\pi^2 R}{2V} x\,Cos\frac{n\pi}{2}t \bullet Co\ell\,\frac{-n^2\pi^2 R}{2\mu C} t\,Cos\frac{n\pi}{2}t +$$

$$Co\ell^{(t-x)}\frac{\varphi}{\mu C} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (82)$$

$$\Rightarrow C = Co + 1 + \ell\,\frac{n^2\pi^2 R}{2V} x\,Cos\frac{n\pi}{2} \bullet Co\ell\,\frac{-n^2\pi^2 R}{2\mu C} t\,Cos\frac{n\pi}{2}t +$$

$$Co\ell^{(t-x)}\frac{\varphi}{\mu C} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (83)$$

The expression in [83] is the developed models from the governing equation, the expression from the derived solution are base on the stated functional parameter that influences the deposition of bacillus in soil and water environments, modeling of permeability and velocity of bacillus transport in the study area are to establish their functional influences in the deposition of bacillus in the formation, modeling this transport process influenced by this two stated parameters are to express the rate of migration with respect to time under variation of depths, the rate of contaminant are determined by the rate of permeability and velocity of flow in the system.

## 4. Conclusion

Modeling the transport of bacillus under the influence of permeability and velocity of transport is to establish functional detailed that determined the influences of the stated parameters in the transport process of bacillus in the study area. The transport of bacillus were influenced by permeability and velocity through the stratification deposit under the influences of geological setting of the formation retardation were examined in the system as most examine water quality produced result of microbial contamination reducing with respect to time, definitely there should be the tendency of influences causing the retardation factors in the concentration of bacillus in the formation. Retardation phase in the deposition of bacillus may be influences by other minerals as an inhibitor but the rate of permeability of fluid flow study are carried out to monitor the influences velocity and permeability in the formation has on the retardation phase of bacillus in the formation. Therefore the expressed mathematical model will definitely determined the rate of retardation of microbes as well as express the rate velocity and permeability influences in bacillus deposition in warri Nigeria.

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