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Research article

MODEL PREDICTION TO MONITOR MASS RATE OF E.COLI TRANSPORT INFLUENCED BY HOMOGENEOUS PERMEABILITY AND VELOCITY IN PHREATIC DEPOSITED FORMATIONS AT YENAGOA METROPOLIS, NIGER DELTA OF NIGERIA

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Abstract

The flow net in every formation are determined by the rate of permeability through the structural stratification deposition that can generate ground aquifers, this condition has been expressed from the derived model through the developed system that produce the principal equation, the rate of E.coli deposition were confirm increasing at high degree, such deltaic formation were found to deposit this type of microbial specie at high rate thus accumulating base on the rate of leaching in mass from the ground surface to unconfined formation. Several approach has been applied and could not produce productive result, base on this factors mathematical modeling approach was found necessary for the study, the developed model were generated from the system that produces all the variables, the derived equation developed the model solution for the study, experts will definitely fine the developed model favuorable as a tool in monitor the rates of E.coli transport in homogeneous permeability and velocity in the study area.

Keywords: Model prediction E.coli, homogeneous permeability, velocity and Phreatic deposited formation

1. Introduction

Potentially harmful microbes may enter ground water via poor well construction, ground water recharge/infiltration from the surface, faulty septic tanks and/or sewer lines, land application of sewage sludge, and percolation of landfill leachate (Sobsey 1979; Pedley and Howard 1997). The fate of microorganisms in the subsurface depends on two basic processes, 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. Considerable work has been done to define factors affecting microbial transport in ground water, generally with two motivating reasons: public health implications from contamination by potential pathogens, and transport 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). Also, many physical parameters of water and contaminant transport, such as dispersion, have scale dependency, and thus *in-situ* studies more accurately model these parameters.

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).

To predict the presence of pathogens in water, a separate group of microorganisms is usually used, generally known as fecal indicator organisms (Pedley et al., 2005). Many microorganisms have been suggested as microbial indicators of fecal pollution (like enterococci, coliphages and sulphite reducing clostridia spores; Medema et al., 2003), but two of the most important indicators used worldwide are *Escherichia coli* and thermotolerant coliform bacteria (for microbiological definitions of these indicators, *E. coli* is the preferred indicator of fecal contamination, as it is the only member of the thermotolerant coliform group that is invariably found in feces of warm-blooded animals and it outnumbers the other thermotolerant coliforms in both human and animal excreta (Medema et al., 2003). Thermotolerant coliforms are a less reliable index of fecal contamination than *E. coli*, although under most circumstances their concentrations are directly related to *E. coli* concentrations (Payment et al., 2003). Viruses may be considered as the most critical or limiting microorganism. Because of their small size, their mostly negative surface charge, and their high persistence in the environment, they may travel long distances in the subsurface. In addition, they can be highly infectious (Schijven, 2001). In the study by Karim et al. (2004a), although *E. coli* and thermotolerant coliforms as representatives of the group of fecal indicator organisms have often been found in groundwater systems, to date there has been no

comprehensive report evaluating and discussing their transport characteristics. Various authors have reviewed the transport and survival of pathogenic and/or non-pathogenic micro-organisms originating from wastewater Some of the reviews concentrate on the movement of bacteria and viruses in aquifers in a qualitative way, without attempting to predict their migration (e.g. Romero, 1970; Lewis et al., 1980; Hagedorn et al., 1981; Crane and Moore, 1984; Bitton and Harvey, 1992; Stevik et al., 2004). Others mainly focus on first-order die-off rates, thereby neglecting the transport component including attachment and detachment processes (e.g. Reddy et al., 1981; Barcina et al., 1997). Murphy and Ginn (2000) mainly summarize the mathematical descriptions of the various physico-chemical and biological processes involved in the transport of bacteria and viruses, without indicating the relative importance of these processes and their occurrence in the natural environment. Merkli (1975) and Althaus et al. (1982) have presented a comprehensive bacteria transport model based on the colloid filtration theory (Herzig et al., 1970; Yao et al., 1971), including the effects of dispersion, diffusion, sedimentation, and filtration.

2. Theoretical background

In general, aquifer passage reduces pathogenic microorganism concentrations, and several breakthroughs have been reported in cases, like non-natural recharge schemes or riverbank filtration projects, where microbes were fully isolated. Groundwater may be polluted, when wastewater infiltrates into the soil and recharges groundwater via leaking sewerage systems, leakage from manure, wastewater or sewage sludge spread by farmers on fields, waste from animal feedlots, waste from healthcare facilities, leakage from waste disposal sites and landfills, or artificial recharge of treated waste water. If the distance from source of pollution to point of abstraction is small, there is a real chance of abstracting pathogens. To predict the presence of pathogens in water, usually a separate group of microorganisms is used. (Jan, 2007: David; 2003).

Widespread expressive term for this group of organisms is fecal indicator organisms (Medema et al., 2003), from which *Escherichia coli* (or *E. coli*) and thermotolerant coliform bacteria are two important members. *E. coli* is widely preferred and used as an index of fecal contamination (World Health Organization, 2003), because its detection is relatively simple, fast and reliable, and the organism is routinely measured in water samples throughout the world. The same applies to thermotolerant ('fecal') coliforms. These coliforms are a less reliable index of fecal contamination than *E. coli*, although under most circumstances their concentrations are directly related to *E. coli* concentrations (World Health Organization, 2003). Viruses may be considered more critical to Groundwater quality than *E. coli*. Because of their smaller size, stability, and negative charge, they may be transported even further through the ground, and because of their infectiousness they represent a major threat to public health. However, the detection and enumeration of viruses, including bacteriophages requires more technical skills and laboratory infrastructure than for *E. coli*. (Jan, 2007, David: 2003).

3. Governing Equation

$$K\frac{\partial v}{\partial x}-\phi\frac{\partial^2 v}{\partial x^2}-Q\frac{\partial v}{\partial x}=V_t\frac{\partial v}{\partial t} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (1)$$

The expression in equation [1] is the principal equations that were developed through the system formulated from the influential variables deposited in the study environment. Mass rate of E.coli were found migrating in

quantity, this implies that the development of quality water will definitely become very difficult, meanwhile it has been noted that lots of contaminants are always found in environment that develop several formation characteristic influences. Aquifers have, until the last few decades, been normally considered protected from possible sources of microbial or substance contamination characteristically found in surface waters. Due to growing population densities, agriculture, expansion and industrialization, including increased withdrawals from aquifers, however, the quality of ground water is increasingly a concern. Numerous instances of ground water contamination and waterborne illness due to ingestion of ground water have been documented. Microbial contamination of ground water has been responsible for many disease outbreaks

Nomenclature

v = Mass Rate of Transport of [LT^{-1}]

K = Dispersion coefficient in longitudinal location (MT^{-1})

V = Void Ratio [-]

T = Time [T]

X = Distance [M]

V = Velocity [LT^{-1}]

ϕ = Porosity [-]

$$K\frac{\partial^2 v}{\partial t} - \phi\frac{\partial_{\ V}}{\partial x} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$t = 0$

$x = 0$

$C_{(o)} = 0$

$$\left.\frac{\partial v}{\partial t}\right| \quad = 0 \qquad t = 0, B$$

$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$ (3)

$$K\frac{\partial v}{\partial t} - Q\frac{\partial v^2}{\partial x^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

$t = 0$

$x = 0$

$q_{(o)} = 0$

$$\left.\frac{\partial q}{\partial t}\right| \quad t = 0, \ B$$

$\ldots\ldots\ldots\ldots\ldots\ldots$ (5)

$$K\frac{\partial v_3}{\partial t} - = V_t \frac{\partial v_3}{\partial t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

$t = 0$
$C_{(o)} = 0$ } $\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$ (7)

$$\left.\frac{\partial v_3}{\partial t}\right| \quad = 0 \quad t = 0,\ B$$

$$Q\frac{\partial v_4}{\partial x} - = V_t \frac{\partial v_4}{\partial t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (8)$$

$x = 0$

$t = 0$

$C_{(o)} = 0$ $\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$ (9)

$$\left.\frac{\partial v_4}{\partial x}\right| \quad = 0 \quad x = 0,\ B$$

$$\phi\frac{\partial^2 v_5}{\partial x^2} - Q\frac{\partial v_5}{\partial x} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (10)$$

$x = 0$

$q_{(o)} = 0$ $\ldots\ldots\ldots\ldots\ldots\ldots$ (11)

$$\left.\frac{\partial v_5}{\partial x}\right| \quad x = 0,\ B$$

Applying direct integration on (2)

$$K\frac{\partial v_1}{\partial t} = \phi v + K_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (12)$$

Again, integrate equation (12) directly yield

$$Kv = \phi v t + Kt + K_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (13)$$

Subject to equation (3), we have

$$Vv_o = K_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (14)$$

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

$$\text{At } \left.\frac{\partial v_1}{\partial x}\right| \quad = 0 \quad v(o) = vo \quad t = 0$$

Yield

$$0 = \phi v + K_2$$

$$\Rightarrow V_1 = \phi v_o = K_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (15)$$

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

$$Kv_1 = \phi v_{1t} - \phi vox\ Kvo \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (16)$$

$$Kv_1 - \phi v_{1x} = Kv_o - \phi vox \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (17)$$

$$v_1 = v_o \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (18)$$

Hence equation (18) entails that at any given distance x, we have constant concentration of the contaminant in the system. Constant concentration are found to deposit in some region of the formation, this is due to homogeneous structure of the soil, in most instances the homogeneity of the deposited formation influences the deposition of E.coli concentration as it is considered in [18].

$$K\frac{\partial v_2}{\partial v} = -Q\frac{\partial v}{\partial x} \quad \ldots\ldots\ldots\ldots \quad (4)$$

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

$$v_2 = XT \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (19)$$

$$\text{i.e.} \quad K\frac{\partial v_2}{\partial x} = X^1T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (20)$$

$$K\frac{\partial_2}{\partial x} = X^1T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (21)$$

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

$$KXT^1 = -QX^1T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (22)$$

$$\text{i.e.}\ K\frac{X^1}{X} = Q\frac{X^1}{X} = -\lambda^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (23)$$

$$\text{Hence} \quad K\frac{T^1}{T} + \lambda^2 = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (24)$$

$$\text{i.e.} \quad X^1 + \frac{\lambda}{K}x = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (25)$$

$$KX^1 + \lambda^2 X = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (26)$$

$$\text{From (25),}\ X = ACos\frac{\lambda}{K}X + BSin\frac{\lambda}{\sqrt{K}}X \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (27)$$

And (20) gives

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

And (20) gives

$$C_2 = \left(ACos\frac{\lambda}{K}x + BSin\frac{\lambda}{\sqrt{K}}x\right)C\ell^{\frac{-\lambda^2}{V}x} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (29)$$

The established model in [29] considered when the microbes migrate to a certain region of the formation and found formation influences pressuring it rates of concentration under the influence of homogeneous permeability and velocity in the formation. These conditions were considered in the transport process, the concepts were integrated in the derived solution to generate the developed model in [29].

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

$$V_o = AC \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (30)$$

Equation (30) becomes

$$v_2 = v_o \ell^{\frac{-\lambda^2}{K}x} Cos\frac{\lambda}{\sqrt{K}}x \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (31)$$

Again, at

$$\left.\frac{\partial v_2}{\partial x}\right| \begin{matrix} = 0,\ x = 0 \\ x = 0,\ B \end{matrix}$$

Equation (31) becomes

$$\frac{\partial v_2}{\partial x} = \frac{\lambda}{\sqrt{K}} v_o \ell^{\frac{-\lambda}{V}x} Sin\frac{\lambda}{\sqrt{K}}x \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (32)$$

i.e. $0 = -\frac{vo\lambda}{K} Sin\frac{\lambda}{KV}0$

$vo\frac{\lambda}{K} \neq 0$ Considering NKP

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

$$0 = vo\frac{\lambda}{\sqrt{K}} Sin\frac{\lambda}{\sqrt{K}}B \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (33)$$

$$\Rightarrow \frac{\lambda}{K} = \frac{n\pi}{2} n,1,2,3 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (34)$$

$$\Rightarrow \lambda = \frac{\lambda}{K} = \frac{n\pi\sqrt{R}}{2} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (35)$$

So that equation (31) becomes

$$\Rightarrow v_2 = vo\ell \frac{-n^2\pi^2 R}{2} t\ Cos \frac{n\pi\sqrt{K}}{2\sqrt{K}} x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (36)$$

$$\Rightarrow v_2 = vo\ell \frac{-n^2\pi^2 R}{2} x\ Cos \frac{n\pi}{2} x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (37)$$

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

$$v\frac{\partial q_3}{\partial x} = -V_t \frac{\partial v}{\partial t} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

$$v_3 = XT^1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (38)$$

$$\frac{\partial v_3}{\partial x} = X^1 T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (39)$$

i.e. $K\frac{\partial v_3}{\partial t} = XT^1$ $\ldots\ldots\ldots\ldots\ldots\ldots\ldots$ (40)

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

$$KX^1 T = -XT^1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (41)$$

i.e. $K\frac{x^1}{x} = -V_t \frac{T^1}{T}$ $\ldots\ldots\ldots\ldots\ldots\ldots\ldots$ (42)

$$K\frac{T^1}{T} + \lambda^2 = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (43)$$

$$X^1 + -\frac{\lambda}{K} t = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (44)$$

And $KT^1 + \lambda^2 t = 0$ $\ldots\ldots\ldots\ldots\ldots\ldots\ldots$ (45)

From (44), $x = ACos \frac{\lambda}{K} x + B\,Sin \frac{\lambda}{\sqrt{K}} t$ $\ldots\ldots\ldots\ldots\ldots$ (46)

And (39) give

$$T = C\ell \frac{-\lambda^2}{V_t} t \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (47)$$

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

$$v_3 = \left(A Cos \frac{\lambda}{K} tx + B Sin \frac{\lambda}{\sqrt{K}} t \right) C\ell \frac{-\lambda^2}{V_t} t \qquad \ldots\ldots\ldots\ldots\ldots \qquad (48)$$

The generated model in [48] continue to redevelop because the transport process were found to meet regions that is deltaic nature, the conditions of the formation from its geological structural setting determines the level of migration, the developed model in [48] are always considered in the migration process because there is the tendency of regeneration of the geological structural setting that always influences the transport process to be condition in the this phase as it is expressed in the model develop in [48]

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

$$vo = AC \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (49)$$

Equation (49) becomes

$$v_3 = vo\ell \frac{-\lambda^2}{\rho} t\ Cos \frac{\lambda}{K} t \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (49)$$

Again, at $\left. \frac{\partial v_3}{\partial x} \right|_{t = 0, B} = 0 \quad t = 0$

Equation (50) becomes

$$\frac{\partial q_3}{\partial x} = \frac{\lambda}{K} Co\ell \frac{-\lambda}{V_t} t\ Sin \frac{\lambda}{K} t \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (51)$$

i.e. $0 = vo \frac{\lambda}{K}\ Sin \frac{\lambda}{K} 0$

$vo\frac{\lambda}{K} \neq 0$ Considering NKP again

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

$$0 = -vo\frac{\lambda}{\sqrt{K}}\ Sin\ \frac{\lambda}{\sqrt{K}}B \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (52)$$

$$\Rightarrow \frac{\lambda}{K} = \frac{n\pi}{2} n,1,2,3 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (53)$$

$$\Rightarrow \lambda = \frac{n\pi\sqrt{V}}{2} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (54)$$

So that equation (50) becomes

$$v_3 = vo\ell\ \frac{-n^2\pi^2 R}{2V_t} x\ Cos\frac{n\pi}{2}t \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (55)$$

Growth rates of microbes vary due to it influences from substrate deposition, it is confirm not to deposit homogenous in some location of the deltaic formation. This implies that the deposition of microelements will not be consider in most instance, but not in every formation as it is expressed in the derived solution, the concept at this stage of the expressed derived solution integrate the conceptualize condition of substrate deposition at this phase of the model, therefore the generated model in [55] are found to shoulder this phase of the derived model as it is established in [55].

Now, we consider equation (8), we have

$$K\ \frac{\partial v_4}{\partial x} - V_t\frac{\partial v_4}{\partial x} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (8)$$

Using Bernoulli's method, we have

$$v_4 = XT \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (56)$$

$$\frac{\partial v_4}{\partial x} = X^1 T \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (57)$$

$$\frac{\partial v_4}{\partial t} = X\ T^1 \quad \text{……..} \quad (58)$$

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

$$KX^1T = -X\ T^1 V_t X^1 T \quad \text{……} \quad (59)$$

i.e. $K\frac{X^1}{X} \quad -= \rho\frac{T^1}{T}$ …… (60)

$$K\frac{X^1}{X} = \varphi \quad \text{……..} \quad (61)$$

$$V_t v\frac{T^1}{T} = \varphi \quad \text{……} \quad (62)$$

$$X = A\ \ell\ \frac{\varphi}{V_t}x \quad \text{……..} \quad (63)$$

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

$$v_4 = A\ \ell\ \frac{\varphi}{V_t} \bullet B\ \ell\ \frac{-\varphi}{V_t}t \quad \text{……} \quad (64)$$

$$v_4 = AB\ \ell^{(t-x)}\ \frac{\varphi}{V_t} \quad \text{……..} \quad (65)$$

Subject equation (66) to (8)

$$V_4\ (o) = Vo \quad \text{……..} \quad (66)$$

So that equation (67) becomes

$$\boxed{v_4 = Ko\ \ell^{(t-x)}\ \frac{\varphi}{V_t v}} \quad \text{……..} \quad (67)$$

Permeability and velocity deposition at high degree in the strata has continue to put the transport condition of the microbes in fast migration, such condition were always considered in the derived solution as it is noted in the study environments. Base on this factors the derived expressed the model considered it at every condition in the derived solution as it is expressed in [67].

Considering equation (10), we have

$$\phi \frac{\partial v_5}{\partial x} - Q\frac{\partial v^2{}_5}{\partial x^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (10)$$

$$q_5 = X^{11}T \quad \ldots\ldots\ldots\ldots\ldots\ldots (68)$$

$$\frac{\partial v_5}{\partial x} + X\ T^1 \quad \ldots\ldots\ldots\ldots\ldots\ldots (69)$$

$$\frac{\partial v_5}{\partial t} + X\ T^1 \quad \ldots\ldots\ldots\ldots\ldots\ldots (70)$$

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

$$\phi X^1 T - TX\ T^1 \quad \ldots\ldots\ldots\ldots\ldots\ldots (71)$$

$$\phi \frac{X^{11}}{X} T - Q\frac{T^1}{T} \quad \ldots\ldots\ldots\ldots\ldots\ldots (72)$$

$$\phi \frac{X}{X} = \varphi \quad \ldots\ldots\ldots\ldots\ldots\ldots (73)$$

$$Q\frac{T^1}{T} = \varphi \quad \ldots\ldots\ldots\ldots\ldots\ldots (74)$$

$$X^1 = A\ell\frac{\varphi}{Q}t \quad \ldots\ldots\ldots\ldots\ldots\ldots (75)$$

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

$$v_5 = A\ell\frac{\varphi}{Q} \bullet B\ell\frac{-\varphi}{Q}x \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (76)$$

$$v_5 = AB\ell^{(x-t)}\frac{\varphi}{Q} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (77)$$

Subject (76) to (10)

$$v_5\ (o) = vo \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (78)$$

So that equation (78) becomes

$$v_5 = vo\ell^{(x-x)}\frac{\varphi}{Q} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (79)$$

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

$$v_5 = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (80)$$

The condition of not developing substrate in some region of the formation were considered in the derived solution, the expression at this state of the transport system found to consider the phase were the substrate are not deposited in some region of the formation, this condition were considered in the expression established in the derived model at [80] were the solution become zero.

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

$$v = vo + vo\ell\frac{-n^2\pi^2Q}{2Q}x\ Cos\frac{n\pi Q}{2}t \bullet vo\ell\frac{-n^2\pi^2Q}{2T}t\ Cos\frac{n\pi}{2}t +$$

$$qo\ell^{(t-x)}\frac{\varphi}{Q} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (82)$$

$$\Rightarrow q = qo + 1 + \ell\frac{n^2\pi^2Q}{2Q}x\ Cos\frac{n\pi}{2} \bullet Co\ell\frac{-n^2\pi^2Q}{2T}t\ Cos\frac{n\pi}{2}t +$$

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

The expression in [83] is the final developed models for the deposition of E.coli influenced by permeability and velocity, such condition were found to predominantly influence the entire behaviour of E.coli deposition and migration in the study environment. The behaviour of E.coli in the deltaic environment was found to generate some variation, because there are variables in all the formation characteristic thus mineral deposition in the formations. Therefore the expression in [83 defined all the behaviour of the microbes at various phase on the transport process, the stratification of the formation were expressed through the rate homogeneity of the permeability and velocity of flow in the strata. Such definitions of the formation established the derived solution to generate the derived final model expressed in [83].

4. Conclusion

Permeability and velocity deposition has definitely influences the rate of E.coli migration and deposition at various formations of the soil. The deltaic natures of the study environment were found to have played some roles in the migration process of E.coli in the study area. Such circumstances were considered on the formulation of the system to generate the governing derived equation for the study. The developed model were derived in phases considering various behaviour that are influenced by formation characteristics in the study area, these factors were expressed in the derived solution that generates the final model, the final expression couple various developed model according to their condition considered in the study of E.coli deposition and migration in the study environment. Furthermore it has in years past reported that the regulatory framework sets standards for maximum contaminant levels (MCL) and treatment technology effectiveness for surface water and ground water systems are under the direct influence of surface water. Ground water under the direct influence of surface water is determined by microscopic examination of samples from the aquifer and detection of particulates associated with surface water such as insect parts, plant debris, rotifers, and other materials. Thus, ground water under the direct influence of surface water is regulated, the same as surface water, the concepts in such environment are way of preventing of spread of E.coli and other contaminants, and this can be applied for E.coli deposition and migration in the study location.

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