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Research article

MODELING VOLUMETRIC WATER CONTENT IN HETEROGENEOUS FORMATION INFLUENCED BY VELOCITY AND VOID VRATIO ON E.COLI MIGRATION IN COSTAL AREA OF BAKANA, RIVERS STATE OF NIGERIA

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Abstract

Volumetric water content in coastal area of Bakana were found to developed serious pressured on transport process, base on the factors it become imperative to monitored the pressure of volumetric water content so that the rate of influences can observed, Modeling the Transport of E.coli influenced by volumetric Water Content in Heterogeneous Coarse Sand in Coastal Area of Bakana express volumetric water content as paramount variables in the system; the model was developed to monitor the activities of E.coli under the influence of volumetric water content. The volumetric water in heterogeneous deposit under the influences of void ratio and velocity that deposit high degree in the study area, some parameters that reflect the influence of water content were showcased in the system, such conditions streamlined several variations which reflect the behaviour of E.coli in soil and water environment. Volumetric water content are influenced by environmental conditions such as degree of saturation through high rain intensities., the conceptualized study showcased the activities of E.coli through the formation characteristics know as hydraulic conductivities and permeability of the soil in geologic formation . Based on these conditions modeling the migration of considering volumetric water content was applies to actually detail the influence and behaviour volumetric water content on E.coli migration in soil and water environment. The study is imperative because experts will in this dimension will understand better the rate of influence of volumetric water content in E.coli activities in the study location.

Keywords: volumetric water content, heterogeneous, velocity and void ratio, and E.coli transport

1. Introduction

Physical and mathematical models for describing the fate of biocolloids (i.e., virus and bacteria) in porous media have been suggested for more than a decade [e.g., *Vilker*, 1978; *Vilker and Burge*, 1980; *Funderburg et al*., 1981; *Grosser*, 1985; *Corapcioglu and Haridas*, 1984, 1985; *Yates et al*., 1987; *Matthess et al*., 1988; *Harvey and Garabedian*, 1991, Roger, et al 1997]. However, application of these models has suffered in part from a lack of systematic field and laboratory research. Accumulation of experimental data and validation of existing or newly developed models with data are essential. The major factors controlling virus and bacteria fate in subsurface porous media are attachment to and detachment from the porous medium surfaces, growth and inactivation, and advection and dispersion [*Bales et al*., 1991; *Gerba et al*., 1991; *Harvey*, 1991]. Advection depends on groundwater velocity. Dispersion depends on velocity and aquifer heterogeneity and is scale dependent. Attachment and detachment rates are sensitive to groundwater chemical conditions, such as *p*H, ionic strength, and the composition of the porous media [*Gerba*, 1984; *Bales et al*., 1993], and in many cases are the most important factors controlling bacteria and virus transport. Inactivation of viruses depends strongly on temperature [*Yates et al*., 1987] and is typically slow compared to the rates of advection, attachment, and detachment [*Bales et al*., 1995 Roger, et al 1997]. Accurate prediction of virus transport through porous media near their source therefore often depends solely on the correct evaluation of the rates at which viruses attach to or detach from the porous medium surfaces

Ammonia is used in fertilizer and animal feed production and in the manufacture of fibbers, plastics, explosives, paper, and rubber. It is used as a coolant, in metal processing, and as a starting product for many nitrogen-containing compounds (*3*). Ammonia and ammonium salts are used in cleansing agents and as food additives (*1*,*4*), and ammonium chloride is used as a diuretic [Source: *Hazardous Substances Data Bank: Ammonium chloride.* Bethesda, MD, National Library of Medicine, 1990, WHO 1996) Microelements are nutritional components that occur and function in many locations and on many levels of organism. They are present in the organism at very low concentrations and are an indispensable component in numerous enzymatic, catalytic, regulating and activating processes, usually as activators and co-factors. Microelements enter the organism through the feed; in developing foetuses they enter through the placenta. Concentration of microelements in blood of supplemented mothers correlates positively with concentrations in calf blood. An important source of microelements for a newborn calf is the colostrums (Abdurrahman and Kincaid 1993; Lacetera 1996; Underwood and Suttle 1999; Pavlata et al. 2003). Microelements also affect the quality and composition of the colostrums and milk and affect the health of the udder. For example, the colostrums and milk of selenium-supplemented cows has a higher concentration of selenium and contains a higher concentration of immunoglobulin's; cows supplied with selenium have lower incidence of mastitis (Hogan et al. 1993; Knowles et al. 1999; Pavlata et al. 2004a); supplementation of zinc to dairy cows decreases the number of somatic cells in milk (Pechová et al. 2006), and copper affects the ability of neutrophils to kill phagocytosed bacteria and decreases susceptibility of the udder to infection (Scaletti et al. 2003). Microelement deficiencies in dairy and beef cattle in the Czech Republic are frequent (Pavlata et al. 2005a; Slavík et al. 2006; Podhorský et al. 2007). Ruminant nutrition routinely uses several methods and forms to supplement microelements.

A slightly problematic period for ensuring adequate supplementation of microelements to dairy cows is the dry period, when only a small amount of seeds is usually fed and microelements are thus difficult to add to the feed. Application forms include supplementation by adding minerals to the feed, mineral licks, and/or single/repeated injection of individual microelements, or combinations of the above. Other methods of supplementation include boluses, projectiles or pills (depending on the shape of administration form), containing a precisely defined amount of microelements combined with a carrier or auxiliary substance. Another method of supplementation of microelements consists in long-acting injections (Lee et al. 1999; Pavlata 2004a; Kinal et al. 2004; Pechová et al. 2006; Mulligan et al. 2006; Chládek and Zapletal 2007, Eluozo 2013).

2. Theoretical background

Migration of E.coli influenced by volumetric water content in soil and water environment has thoroughly expressed in the system. Several influences from high deposition of volumetric water content in heterogeneous formation has some pressured that developed several ground water pollution in the study area. The influences in different dimension determine the rate of pollution transport from these sources either reducing or increase, preceding studies carried out on the study area could not develop concrete solution that will prevent the migration of E.coli influenced by volumetric water content, the degree of mass water content has been noted to develop more influence on the transport of E.coli , the degree of rain intensities including void influences from this climatic pressure in the study location cannot be over emphasized, environmental influences has played major roles through high degree of rain intensities, the conditions developed high degree of water content in soil were the rate of permeability in the soil increase drastically, such condition has influenced the migration and depositions E.coli in soil and water environment, the development are some of the causes of fast tract of microbial activities in the study location, the formation variation base on its geological setting through structural stratification of the formation influenced by deltaic environments, these are one of the influences of microbial activities ,these are based on strata deposition structure of the formation under the influence of disintegration of the settlement from sedimentary deposition in geologic conditions. Volumetric water content are determined through the influence of such conditions under the influence of soil matrix that developed high hydraulic conductivity, which determines the volumetric water content in every vadose of the formation. The expressed stratification determines the rate of porosity which is reflected on microbial activities under the influence of transportation to groundwater aquifers, volumetric mass water content influences the activities of shigellae under the influence of the flow net conditions through the permeable and impermeable layer [Eluozo, 2013].

According Eluozo, [2013] micronutrients with its the deposition of substrate ammonia and others influencing the transport of E.coli has been comprehensively evaluated, the conceptualization of the study was to ensure the behaviour of ammonia are thoroughly expressed in the system, the influence of ammonia on the deposition of thermotolerant in the formation are base on different conditions in the environment, the climatic condition play major roles in the behaviour and influence of the ammonia in soil and water environment, such condition express in were considered in the developed governing equation this will express the deposition and behaviour of ammonia in the study locations, the developed governing equation were derived to generate a model that will expressed the behaviour of ammonia including the deposition of thermotolerant in soil and water environment in the study area. Several boundary values were considered in the system to ensure that the behaviour of thermotolerant are thoroughly expressed under the influence of variation of soil stratification through geologic history of the study area, the model if applied will express the exponential condition of thermotolerant in the study area, since the study area is situated in coastal area of Niger delta region, the influence from climatic condition developed lots variation in microbial behaviour in the strata. The model expressed several derived solution model considering several condition under the influences of variation of substrate utilizations deposition in the formations, the developed model will definitely express the behaviour and deposition of ammonia in the coastal area of [Eluozo, 2013].

3. Governing equation

$$\theta wV \frac{\partial C}{\partial t} = Om \frac{\rho_b}{\rho_w} V \frac{\partial C^2}{\partial x^2} \qquad \text{……………………………..} \qquad (1)$$

The developed principal equation generated established volumetric water content influence of E.coli in heterogeneous formations. This principal equations reflects influential variables that were considered to affect the deposition and activity of shigellae in the study location. Mass water content is influenced by several geologic conditions under the influence of formation characteristics; these were considered on the governing equation because such variables play a serious role on the activities of shigellae in soil and water environment. Velocity of solute was expressed in the governing equation that play major roles on migration process of shigellae under the influence of high degree of hydraulic conductivities that depends on stratification variations

Substituting solution $C = XT$ into (1), we have

$$\theta wV\, XT^1 = \theta m \frac{\rho_b}{\rho_w} V\, X^{11} T \qquad \text{……………………………..} \qquad (2)$$

$$\theta wV \frac{T^1}{T} = -\; \theta m \frac{\rho_b}{\rho_w} V \frac{X^{11}}{X} \qquad \text{……………………………..} \qquad (3)$$

$$\theta wV \frac{T^1}{T} \;-\; \theta m \frac{\rho_b}{\rho_w} V \left[\frac{X^{11}}{X} \right] \qquad \text{……………………………..} \qquad (4)$$

$$\theta wV \frac{T^1}{T} \;-\; \frac{X^{11}}{X} \qquad \text{……………………………..} \qquad (5)$$

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Considering when $Ln\ X \to 0$

$$\theta w V T^1 = \theta m \frac{\rho_b}{\rho_w} V \frac{X^{11}}{X} - T = \lambda^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (6)$$

$$\theta w V \frac{T^1}{T} = \lambda^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (7)$$

$$\frac{X^{11}}{X} = \lambda^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (8)$$

$$\theta m \frac{\rho_b}{\rho_w} V = \lambda^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (9)$$

This implies that equation (10) can be expressed as:

$$\theta m \frac{\rho_b}{\rho_w} V \frac{X^{11}}{X} = \lambda^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (10)$$

$$\theta m \frac{\rho_b}{\rho_w} V \frac{X^2}{X} = \lambda^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (11)$$

$$\theta w V \frac{d^2 y}{dx^2} = \lambda^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (12)$$

$$\theta w \frac{\rho_b}{\rho_w} V \frac{d^2 y}{dx} = \lambda^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (13)$$

$$\theta w \frac{d^2 y}{dx^2} = \lambda^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (14)$$

$$\frac{d^2 y}{dx} = \frac{\lambda^2}{\theta w V} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (15)$$

$$d^2 y = \left[\frac{\lambda^2}{\theta w V} \right] dx^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (16)$$

$$\int d^2y = \int \frac{\lambda^2}{\theta wV} dx^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (17)$$

$$dy = \frac{\lambda^2}{\theta wV} x\, dx \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (18)$$

$$\int dy = \int \frac{\lambda^2}{\theta wV} X\ dx + C_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (19)$$

$$y = \frac{\lambda^2}{\theta wV} + C_1 + C_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (20)$$

$$y = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (21)$$

$$\Rightarrow \frac{\lambda^2}{\theta wV} X^2\ C_{1x} + C_2 = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (22)$$

Applying quadratic expression, we have

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (23)$$

Where $a = \frac{\lambda^2}{\theta wV}$, $b = C_1$ and $c = C_2$

$$X = \frac{-(C_1) \pm \sqrt{(C)^2 - 4\left(\frac{\lambda^2}{\theta wV}\right)C_2}}{2\frac{\lambda^2}{\theta wV}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (24)$$

$$X = \frac{-C_1 + \sqrt{C_1{}^2 - 4C_2 \frac{\lambda^2}{\theta wV}}}{2\frac{\lambda^2}{\theta wV}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (25)$$

$$X = \frac{-C_1 + \sqrt{C_1^{\,2} - 4C_2 \frac{\lambda^2}{\theta wV}}}{2\theta wV} \qquad \text{..............................} \qquad (26)$$

$$X = \frac{-C_1 + \sqrt{C_1^{\,2} - 4C_2 \frac{\lambda^2}{\theta wV}}}{2\theta wV} \qquad \text{..............................} \qquad (27)$$

$$X = \frac{-C_1 - \sqrt{C_1^{\,2} - 4C_2 \frac{\lambda^2}{\theta wV}}}{2\frac{\lambda^2}{\theta wV}} \qquad \text{..............................} \qquad (28)$$

Substituting equation (20) to the following condition and initial values condition.

$$t = 0, C = 0 \qquad \text{..............................} \qquad (29)$$

Therefore, $X_{(x)} = C_1 e^{x} - e^{-mx} + C_2 M^{em2x}$ .... (30)

$$C_1 Cos M_{1x} + C_2 Sin M_{2x} \qquad \text{..............................} \qquad (31)$$

$$y = \frac{\lambda^2}{\theta wV} + C_1 + C_2 \qquad \text{..............................} \qquad (32)$$

$$C(x,t) = \left[C_1 Cos M_1 \frac{\lambda^2}{\theta wV} x + C_2 Sin M_2 \frac{\lambda^2}{\theta wV} x \right] \text{..............} \qquad (33)$$

But if $x = \frac{v}{t}$

Therefore, equation (33) can be expressed as:

$$C(x,t) = \left[C_1 Cos M_1 \frac{\lambda^2}{\theta wV} \frac{v}{t} + C_2 Sin M_2 \frac{\lambda^2}{\theta wV} \frac{v}{t} \right] \text{..............} \qquad (34)$$

Monitoring of E.coli activities were found to be pressured by volumetric water content in heterogeneous formation Derived solution generated model equation in (34), it showcased the final model equation from the derived solution in the system, several variables that are influential in the activities of E.coli deposition and its transport process. Have been expressed. Such conditions are reflected in the system as it expressed several influence based on geologic structure in the study location. Formation characteristics through geologic history developed lots of influence as it showcases some influential behaviour on the microbial formation in soil and water environment. It is of interest to note that formation characteristics such as high hydraulic conductivities are reflected on the rate of volumetric water content in soil and water environment. Such conditions were thoroughly considered in the system because it showcased various relations of the expressed parameters that are influential in the activities of E.coli in water content deposition.

4. Conclusion

Volumetric water continent influence has been thoroughly expressed in the system, it has reflected much on the transportation of E.coli in heterogeneous formation. These are considered as influential parameters that detail more on the activities of E.coli reflected through volumetric water content, thus, climatic conditions through high rain intensities including high degree of soil saturation were expressed. Geologic history of the formations are the generally considered variables that showcased other influential parameters as expressed in the system, due to these conditions, the formulated principal equation were found suitable to thoroughly express the influential condition of mass water content that reflects on the activities of E.coli in heterogeneous formation. Mathematical model that showcased the role of volumetric water content in the system on E.coli activities were thoroughly expressed, this is to determine the role of volumetric water content on E.coli depositions within the soil intercedes based on formation characteristics.

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