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Research article

MATHEMATICAL MODEL TO MONITOR THE TRANSPORT OF SHIGELLAE INFLUENCED BY MASS WATER CONTENT IN HOMOGENEOUS COARSE SAND IN COASTAL AREA OF BORIKIRI, RIVERS STATE, NIGERIA

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Abstract

Mathematical Model to Monitor the Transport of Shigellae influenced by Mass Water Content in Homogeneous Coarse Sand in Coastal Area of Borikiri has been expressed; the model was developed to monitor the activities of shigellae under the influence of water content. Some parameters that reflect the influence of water content were showcased in the system, such conditions streamlined several variations which reflect the behaviour of shigellae in soil and water environment. Mass water content are influenced by environmental conditions such as degree of saturation through high rain intensities., the conceptualized study showcased the activities of shigellae through the formation characteristics know as hydraulic conductivities and permeability of the soil in geologic formation . Based on these conditions mathematical model was applies to actually detail the influence of mass water content on shigellae migration in soil and water environment. The study is imperative because experts will in this dimension understand the rate of influence of mass water content in shigella activities in the study location.

Keywords: Mathematical model, shigellae and mass water content.

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.

Theoretical background

The transport of shigella in soil and water environment has thoroughly expressed in the system. The study was to ensure that the rate of pollution transport from these sources reduces to the lowest minimum if stop, previous studies carried out on the study area could not develop concrete solution that will prevent the transport of shigellae to ground water aquifers, the degree of mass water content has been noted to develop more influence on the transport of shigella, the degree of rain intensities in the study location can not be over emphasized, environmental influences has played major roles in 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 transport of shigella in soil and water environment, the development are some of the causes of fast tract of microbes in the study location, the formation variation base on its geological depositions are one of the influences of the increase in 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. Mass water content are determined through the influence of such conditions under the influence of soil matrix that developed high hydraulic conductivity, which determines the mass 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 mss water content influences the activities of shigellae under the influence of the flow net conditions through the permeable and impermeable layer.

Shallow aquifers were found to be predominant in the study location as it is reflected in groundwater tables that are shallow; this expressed the environmental influence under climatic conditions which generates high water table under the pressure of high degree of rain intensities. Shigellae deposits in such conditions use all the stated variables to migrate from one stratum to the other reflecting plug flow application. Predominance of alluvium deposition are reflected on homogeneous deposition of the strata influencing homogeneous velocity of the transport of shigellae to groundwater aquifer within a short period of time. The study is imperative because the expressed mathematical governing equations are formulated from these variables as a system; this will produce a model through the expressed derivations to monitor the influence of mass water content on shigellae migration in soil and water environment under plug flow conditions**.**

3. Governing equation

$$V\vartheta_M \frac{\partial c}{\partial t} = \frac{M_W}{M_S} V \frac{\partial c}{\partial x} \quad \ldots\ldots \ (1)$$

The governing equation developed is to express mass water content influence of shigellae in soil and water environment. This governing equation 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 equation (1) we have:

$$V\theta_M XT^1 = \frac{M_W}{M_S} VX^1 T \quad \ldots\ldots \ (2)$$

$$V\vartheta_M \frac{T^1}{T} = \frac{M_W}{M_S} V \frac{X^1}{X} \quad \ldots\ldots \ (3)$$

$$V\theta_M \frac{T^1}{T} = \frac{M_W}{M_S} V \left(\frac{X^1}{X} \right) \quad \ldots\ldots \ (4)$$

$$V\theta_M \frac{T^1}{T} = \frac{X^1}{X} \quad \ldots\ldots \ (5)$$

Considering when $Ln\, x \to 0$

$$V\theta_M \frac{T^1}{T} = \frac{M_W}{M_S} V \frac{X^1}{X} - T = \lambda^2 \quad \ldots\ldots \ (6)$$

$$V\theta_M \frac{T}{T} = \lambda^2 \qquad \text{.............} \qquad (7)$$

$$\frac{M_W}{M_S} V \frac{X^1}{X} = \lambda^2 \qquad \text{.............} \qquad (8)$$

$$\frac{M_W}{M_S} V = \lambda^2 \qquad \text{.............} \qquad (9)$$

The derived solution in equation (9) denotes the expressed parameter with a mathematical symbol (λ^2), this showcased the differential roles of the variables in the system to detail their functions reflecting the behaviour of the microbes, In some conditions some environmental influence dominates the activities that is expressed in a particular formation under the influence of high predominance of the variable.

This implies that equation (9) can be expressed

$$\frac{M_W}{M_S} V \frac{X^1}{X} = -\lambda^2 \qquad \text{.............} \qquad (10)$$

$$\frac{M_W}{M_S} V \frac{X^1}{X} \frac{dy}{dx} = \lambda^2 \qquad \text{.............} \qquad (11)$$

$$\frac{M_W}{M_S} V \frac{dy}{dx} = \lambda^2 \qquad \text{......} \qquad (12)$$

$$\frac{dy}{dx} = \frac{\lambda^2}{V\theta_M} \qquad \text{.............} \qquad (13)$$

$$dy = \left(\frac{\lambda^2}{V\vartheta_M} \right) dx \qquad \text{.............} \qquad (14)$$

$$\int dy = \int \frac{\lambda^2}{V\theta_M} dx \qquad \text{.............} \qquad (15)$$

$$dy = \frac{\lambda^2}{V\theta_M} \times dx \qquad \text{.............} \qquad (16)$$

$$\frac{dy}{dx} = \frac{\lambda^2}{V\theta_M} \qquad \text{.............} \qquad (17)$$

$$dy = \frac{\lambda^2}{V\theta_M} \; dx \qquad \text{.............} \qquad (18)$$

$$\int dy = \int \frac{\lambda^2}{V\theta_M} dx + C_1 \qquad \ldots\ldots\ldots\ldots. \qquad (19)$$

$$y = \frac{\lambda^2}{V\theta_M} \int dx + C_1 \qquad \ldots\ldots\ldots\ldots. \qquad (20)$$

$$\frac{\lambda^2}{V\theta_M} x + C_1 \qquad \ldots\ldots\ldots\ldots. \qquad (21)$$

$$y = \frac{\lambda^2}{V\theta_M} x + C_1 \qquad \ldots\ldots\ldots\ldots. \qquad (22)$$

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

$$a = \lambda^2, \; b = \lambda^2 C_1$$

$$x = \frac{-\left(\lambda^2 C\right) \pm \sqrt{(C_1)^2 - 4n\frac{\left(\lambda^2\right)}{V\theta_M}}}{2\frac{\lambda^2}{V\vartheta_M}} \qquad \ldots\ldots\ldots\ldots. \qquad (24)$$

$$x = \frac{-\lambda^2 C \pm \sqrt{\lambda^2 C_1{}^2 - 4\frac{\lambda^2}{V\theta_M}}}{2\frac{\lambda^2}{V\theta_M}} \qquad \ldots\ldots\ldots\ldots. \qquad (25)$$

$$x = \frac{-\lambda^2 C \sqrt{\lambda^2 C_1{}^2 - 4\frac{\lambda^2}{V\theta_M}}}{2\frac{\lambda^2}{V\theta_M}} \qquad \ldots\ldots \; (26)$$

Substituting equation (26) into the following boundary and initial values condition

$$t = 0, C = 0 \qquad \ldots\ldots\ldots\ldots. \qquad (27)$$

Therefore,

$$X_{(x)} = C_1 \ell - M_{1x} + M_{2x} \qquad \ldots\ldots\ldots\ldots. \qquad (28)$$

$$C_1 \, CosM_{1x} + Sin\, M_{2x} \quad \text{………….. (29)}$$

$$y = \frac{\lambda^2}{V\theta_M} + C_1 \quad \text{………….. (30)}$$

$$C_{(x,t)} = \left[C_1 \, CosM_1 \frac{\lambda^2}{V\theta_M} \frac{d}{v} + Sin\, M_2 \frac{\lambda^2}{V\theta_M} \frac{d}{v} \right] \quad \text{………….. (31)}$$

But if $T = \dfrac{d}{v}$

Therefore, equation (31) will be expressed as the form

$$C_{(x,t)} = \left[C_1 \, CosM_1 \frac{\lambda^2}{V\theta_M} \frac{d}{v} \; Sin\, M_2 \frac{\lambda^2}{V\theta_M} \frac{d}{v} \right] \quad \text{………….. (32)}$$

Derived mathematical model in equation (32) showcased the final model equation from the derived solution in the system, several variables that are influential in the activities of shigellae deposition and its migration. 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 shigellae in water content deposition.

Conclusion

Volumetric water continent influence has been thoroughly expressed in the system, it has reflected much on the transportation of shigellae to groundwater aquifers. These are considered as influential parameters that detail more on the activities of shigellae reflected through mass water content, thus, climatic conditions. 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 governing equation were found suitable to thoroughly express the influential condition of mass water content that reflects on the activities of shigellae in shallow aquifers. Mathematical model that showcased the role of mass water content in the system in microbial activities were thoroughly expressed, this is t determine the role of mass water content on shigellae depositions within the soil intercedes based on formation characteristics.

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