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Research article

MODELING DISPERSIONS OF VIRUS INFLUENCED BY HOMOGENOUS VELOCITY AND VOID RATIO IN HOMOGENEOUS GRAVEL FORMATION IN DEGEMA, RIVERS STATE OF NIGERIA.

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Abstract

Viruses are known to be one of the microbes found in soil and water environment. These types of microbial species can be found in every contaminated environment. The dispersions of virus has express lots of spread in entire study location, rapid increase of virus are influenced in this location from high degree of porosity in the formations. Environmental influences are found to play some roles in the dispersion of virus through high rain intensities in the study area. Virus migration in soil and water environment under the influence of various soil characteristics has express its significant role in the transport of virus. The concepts is to monitor the transport process at various condition, virus known to have lots of varieties of behaviour, these conditions were considered when the system are developed, the major variables in the system are porosity of the soil, these parameters determine the rate of virus deposition in every formation, degree of porosity also has lots of variation reflecting its behaviour from the influence of soil porosity, the system developed an equation considering this parameters as a major role in fast migration of virus, under the influence of this variables. Other variables were considered that played other roles in the transport expressed .in the system. The study and development of the model will be a base line for ground water experts in prevention of virus contaminant in ground water.

Keywords: modeling dispersions, virus influenced, homogenous velocity, and void ratio

1. Introduction

The Riverine area of the Niger Delta is a coastal belt of swamps nearby the Atlantic Ocean. The swamps are vegetated tidal flats formed by a reticulate pattern of interconnected meandering creeks and distributaries of the River Niger. The forests are of two types: nearest the sea is a belt of saline/ brackish mangrove swamp separated from the sea by sand beach ridges (except west of Benin River). Within the mangrove swamp forest, numerous sandy islands occur with fresh water vegetation (Allen, 1965; 1970; Nedeco, 1961; Weber, 1971). Fresh water swamps gradually supersede the mangroves on the landward side. About 70% of Nigeria's crude oil and gas production is from this area. The Riverine area is home to a large population living mainly in small villages scattered along the banks of rivers and creeks. Rainfall in this coastal belt is heavy varying from 2400 to 4000 mm annually [Eluozo2013]. Water is of fundamental importance to plants and animals particularly man. It is then very vital in maintaining life processes and growth (Ogbe, 2003). Potable drinking) water is not commonly found and its provision limits the setting up of villages and towns to the places where supply exist (Shankar, 1994 and Huisman, 1966).

Unfortunately, these were the only available source of water, despite the increased demand for potable water in the region due to increase in the population within the last few years A better knowledge of the near surface aquifer distribution, formation and type in this area is therefore important so as to ascertain whether the aquifer is prone to contamination or not since the surface water have been polluted. (Oseji et al 2006). Most of the side effects of oil production are the possible pollution of water and the destruction of aquatic lives. Water pollution occurs when rainwater combines with the by-products of gas flaring in the atmosphere, (Ebeniro et al 1996).

According to Bernard et al, 1994 groundwater occurs in pore spaces and fractures within sedimentary rocks. Underground Water sustains and maintains stream flow when it is close to the surface, but where it intersects the surface, a spring or watering hole is formed. Okolie et al, (2005) carried out the determination of the source of River Ethiope in Delta State of Nigeria (Oseji, 2011). Groundwater has been described as the main source of potable water supply for domestic, industrial and agricultural uses in the southern part of Nigeria especially the Niger Delta, due to long retention time and natural filtration capacity of aquifers (Odukoya et al., 2002; Agbalagba et al., 2011; Ehirim and Ofor, 2011). Water that is safe for drinking, pleasant in taste, and suitable for domestic purposes is designated as potable water and must not contain any chemical or biological impurity (Horsfall and Spiff, 1998 Eluozo, 2013). Development of Groundwater the main basis of potable water supply for domestic has been express as the major man utilization of human. The application of agricultural uses in the southern part of Nigeria especially the Niger Delta express long retention time and natural due to filtration capacity of aquifers (Odukoya et al., 2002; Agbalagba et al., 2011; Ehirim and Ofor, 2011). Ground Water that is protected for drinking, satisfying in taste, and proper for domestic purposes is designated as drinkable water and must not restrain any substance or biological contamination (Horsfall and Spiff, 1998 Eluozo, 2013).

2. Theoretical background

Dispersions of virus in soil and water environment have been evaluated by several researchers around the globe. But none could be able to monitor the rate of dispersion under the influences of formation characteristics and environmental influences in soil and water environmental, the study was carried out to monitor the rate of dispersion in the system, the dispersion of virus in soil and water has been expressed through thorough investigation carried out in the study location, environmental condition were found to rapidly increase the spread of the contaminants in the entire location. The structural deposition of the strata was found to express high rate of porosity in the study location, environmental condition through high rain intensities, thus increase hydraulic conductivity in the study area the expression of rapid increase of virus generation high degree of water pollution in the study area.

Over the past years in deltaic environment ground water are known to have a lots of qualities, these complies in the raw state, these include drinking water standard, however, in definite areas, the natural ground water chemistry is such that it does not comply with the standard for human utilization, the pollution source are arsenic nitrates fluorides iron manganese, further more the number and variety of microorganism in natural waters in different place are under different conditions. Bacterial are washed into the water from air, the soil from almost every conceivable object. Significant numbers of bacterial can move through media even when the percentage retained is very high. The faeces of animals contain vast numbers of bacterial and enter many natural water systems, the size of opening in subsurface material can be assumed to be variable and are generally not measured, but porosity and permeability measurement on aquifers sediments indicate that adequate, even in some dense porous rocks. Spaces for bacterial exist in many types of sediment types [Eluozo 2013].

3. Governing equation

$$D_L \frac{\partial C}{\partial t} = \overline{VV} \frac{\partial^2 C}{\partial Z^2} - \frac{\partial C}{\partial Z} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (1)$$

Boundary condition $C(o,t) = Co \; for \; t > 0 \; (z,o)$ and $(\infty,t) = Co \; for \; t \geq 0$

The Laplace transform for a function $f(t)$ which is defined for all values of $t \geq 0$ is given.

$$\rho f(z) = f(s) = \int_0^\infty e^{-sz} \; f(z)dz \;\; f(z) = \rho^{-1} f(s) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \qquad (2)$$

$$\rho f(z) = s\rho = s\rho f(z) - f(o) \; where \; \rho^1(z) = \frac{\partial f}{\partial Z} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \qquad (3)$$

Taking the Laplace transform of the function c with respect to t eqn (1) changes to

$$D_L\ \rho\left[\frac{\partial C}{\partial t}\right] = \overline{VV}\left[\frac{\partial^2 C}{\partial Z}\right] - \rho\frac{\partial C}{\partial Z} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (4)$$

Where $D_L\ \rho\left[\frac{\partial C}{\partial Z}\right] = D_L\rho(c) - C\ (z,o)$

[*C* is a function of *z* and *t* i.e. *C (z, t) = f(t)*, therefore *ρf(t) = ρC(z, f)* = $\overline{C}$]

Let $\overline{C} = D_L\ \rho(c)\ then\ \rho\left[\frac{\partial C}{\partial Z}\right] = \frac{\partial}{\partial Z}\rho(C) = \frac{\partial\overline{C}}{\partial Z}\ and\ \rho\left[\frac{\partial^2}{\partial Z^2}\right] = \frac{\partial^2}{\partial Z^2}\ \rho(c) = \frac{\partial^2\overline{C}}{\partial Z^2}$

Where $\overline{C}(z) = \rho C(z,t)$, that is only t changes to s and z is unaffected and s is the Laplace parameter.

At $z = 0 : \overline{C}(z) = \int_0^\infty e^{-st}\,C(z,t)\,dt = \int_0^\infty e^{-st}\,C_o\,dt = \Big|_0^\infty -\frac{1}{s}e^{-st}C_o = \frac{C_o}{s}$

At $z = \infty : \overline{C}(z) = \int_0^\infty e^{-st}\,C(z,t) = 0$

Therefore at $z = 0,\ \overline{C}(z) = \frac{C_o}{s}$, and at $z = \infty,\ \overline{C}(z) = 0$

[Since this is one dimensional flow equation, partial derivative changes to the full derivative, *s* is a Laplace parameter, which disappears on taking the inverse].

From the substitution Eq

$$D_L\ s\overline{C} = \overline{VV}\left[\frac{dc}{\alpha z}\right] - \left[\frac{d\overline{c}}{dz}\right] \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (5)$$

Let $\overline{C} = Ae^{\lambda z}$ be the solution of the above linear ordinary differential equation. [This is a standard way of solving this class of equations].

The $\frac{d\overline{c}}{dz} = A\lambda e^{\lambda^2}\ and\ \frac{d^2\overline{c}}{dz^2} = A\lambda^2 e^{\lambda^2} \qquad \ldots\ldots\ldots\ldots\ldots\ (6)$

Solution of these values in Eq (5) gives

$$D_L \;\; A\lambda^2 e^{\lambda^2} = \;\; \overline{\Phi V} A\lambda e^{\lambda^2} - \phi\lambda e^{\lambda^2} \;\; or \left[e^{\lambda^2} = \lambda^2 \frac{\overline{VV}}{D_L} \lambda - \frac{s}{D_L} \right] \quad \ldots\ldots\ldots\ldots\ldots \quad (7)$$

This will be a solution of the auxiliary equation or the characteristics Equation = 0, this implies that

$$\left[\lambda^2 - \frac{\overline{VV}}{D_L} \lambda - \frac{s}{D_L} \right] = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Equation (8) is the standard quadratic equation and the solution is expressed in this form.

$$\lambda = \frac{\frac{\overline{VV}}{D_L} \pm \sqrt{\frac{\overline{VV}^2}{D_L{}^2} + \frac{4s}{D_L}}}{2}$$

That is $\lambda_1 = \frac{\overline{VV} + \sqrt{\overline{VV}^2 + 4sD_L}}{2D_L}$ $and \;\; \lambda_2 = \frac{\overline{VV} - \sqrt{\overline{VV}^2 + 4sD_L}}{2D_L}$

Therefore, either $\overline{C} = Ae^{\lambda_1 z}$ $or \; \overline{C} = Ae^{\lambda^2 z}$ is a solution. However, only the latter satisfies the boundary condition.

At $z = \infty, \;\; \overline{C} = \frac{C_o}{s}, e^{-\infty} = 0$ {because λ_2 is -ve and λ_1 is +ve}

Therefore $\overline{C} = A \left[e^{\frac{\overline{VV} - \sqrt{\overline{VV}^2 + 4sD_L}}{2D_L}} \right] z$ is the solution

At $Z = 0 \;\; \overline{C} = \frac{C_o}{s}$ give $A = \frac{C_o}{s}$

Therefore $\overline{C} = \frac{C_o}{s} \left[\exp \left[\exp^{\frac{\overline{VV} - \sqrt{\overline{VV}^2 + 4sD_L}}{2D_L}} \right] \right]$ is the solution $\quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$

From Equation (9) $C(z,t)$ can be determined as $\rho^{-1}\overline{C}(z)$

Equation (9) can further be expressed as:

$$C_o \exp\left(\frac{\overline{V}Vz}{2D_L}\right) - \frac{1}{\phi s}\exp\left[\frac{-z}{\sqrt{D_L}}\left(\frac{\overline{VV}^2}{4D_L} + s\right)^{\frac{1}{2}}\right]$$

Application of the inverse Laplace transform to the above equation gives

$$C(z,t) = \rho^{-1}\overline{C}(z) = \rho^{-1}\left[C_o \exp\left(\frac{\overline{V}Vz}{2D_L}\right) - \frac{1}{s}\exp\left[\frac{-z}{\sqrt{D_L}}\left(\frac{\overline{VV}^2}{4D_L} + s\right)^{\frac{1}{2}}\right]\right]$$

$$= \quad C(z,t) = \rho^{-1}\overline{C}(z) = \rho^{-1}\left[C_o \exp\left(\frac{\overline{V}Vz}{2D_L}\right)\rho^{-1}\left[\frac{1}{s}\exp\left[\frac{-z}{\sqrt{D_L}}\left(\frac{\overline{VV}^2}{4D_L} + s\right)^{\frac{1}{2}}\right]\right]\right] \ldots\ldots\ldots \quad (10)$$

From the Laplace transform table

$$\rho^{-1}\left(\frac{1}{s}\exp\left(-\alpha\sqrt{\beta^2+s}\right)\right) = \int_0^t \frac{\alpha}{2\sqrt{\pi,\beta}}\exp\left[-\left(\frac{\alpha^2}{4u} + \beta^2 u\right)du\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (11)$$

Here $\frac{Z}{\sqrt{D_L}}$ *and* $\beta = \frac{V\overline{V}}{2\sqrt{D_L}}$

Therefore

$$C(z,t) = \rho^{-1}\overline{C}(z) = C_o \exp\left(\frac{\overline{V}Vz}{2D_L}\right)\left[e^{-\alpha\beta}\int_0^t \frac{\alpha}{2\sqrt{\pi,\beta}}\exp\left[-\frac{\alpha^2}{4u} - \beta^2 u + \alpha\beta du\right]\right] \ldots\ldots\ldots \quad (12)$$

The term in the bracket = $\left[e^{-\alpha\beta}\int_0^t \frac{\alpha}{2\sqrt{\pi,\beta}}\exp\left[\frac{(\alpha-2\beta u)^2}{4u}du\right]\right]$ ……………. (13)

$$= e^{-\alpha\beta}\int_0^t\left[\frac{\alpha+2\beta u}{4\sqrt{\pi u^3}} + \frac{\alpha-2\beta u}{4\sqrt{\pi u^3}}\right]\exp\left[-\frac{(\alpha-2\beta u)^2}{4u}du\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (14)$$

$$= e^{-\alpha\beta}\left[\int_0^t\left[\frac{\alpha+2\beta u}{4\sqrt{\pi u^3}}\exp\left[\frac{(\alpha-2\beta u)^2}{4u}du\right] + e^{2\alpha\beta}\int_0^t\frac{\alpha-2\beta u}{4\sqrt{\pi u^3}}\right]\exp\left[\frac{(\alpha+2\beta u)^2}{4\sqrt{\pi u^3}}du\right]\right] \ldots\ldots\ldots \quad (15)$$

Let $\frac{\alpha-2\beta u}{\sqrt{4u}} = A \text{ and } \frac{\alpha+2\beta u}{\sqrt{4u}} = B$ ……………. (16)

Differentiating the term in Equation (16) give

$$\frac{dA}{du} = \frac{\sqrt{4u}(0-2\beta) - 2\frac{1}{2}\sqrt[\frac{1}{2}]{u}\,(\alpha-2\beta u)}{4u} \text{ and } \frac{\sqrt{4u}(0+2\beta) - 2\frac{1}{2}\sqrt[\frac{1}{2}]{u}\,(\alpha-2\beta u)}{4u} \quad \text{…….} \quad (17)$$

Or $\frac{dA}{du} = \frac{-4\beta\sqrt{u}\frac{-\alpha}{u}+2\beta\sqrt{u}}{4u} = \frac{-2\beta u-d}{4\sqrt{u^3}} = \frac{-(\alpha+2\beta u)}{4\sqrt{u^3}}$

And $\frac{dB}{du} = \frac{4\beta\sqrt{u}\frac{-\alpha}{u}-2\beta\sqrt{u}}{4u} = \frac{2\beta u-d}{4\sqrt{u^3}} = \frac{-(\alpha-2\beta u)}{4\sqrt{u^3}}$

Or $dA = \frac{-(\alpha+2\beta u)}{4\sqrt{u^3}}du \text{ and } dB = \frac{-(\alpha-2\beta u)}{4\sqrt{u^3}}du$ ……………. (18)

$$C(z,t) = C_o \exp\left(\frac{\overline{VV}z}{2D_L}\right)\left[-\int_0^{\frac{\alpha-2\beta t}{\sqrt{ut}}} \exp\left(-A^2\right)\frac{dA}{\sqrt{\pi}} - e^{2\alpha\beta}\int_{\infty}^{\frac{\alpha+2\beta t}{\sqrt{4t}}} \exp\left(-\beta^2\right)\frac{dB}{\sqrt{\pi}}\right] \quad \text{………} \quad (19)$$

For the limit when $u = 0$

$$A = \frac{\alpha-2\beta.0}{0} = \infty B = \frac{\alpha+2\beta.0}{0} = \infty, \text{and when}$$

$$u = t, A = \frac{\alpha-2\beta t}{\sqrt{4t}} = \text{ and } B = \frac{\alpha+2\beta:t}{\sqrt{4t}}du$$

Changing the integral limits in Equation (19), it is given as

$$\frac{1}{2}\frac{2}{\sqrt{\pi}}e^{-\alpha\beta}\int_{\frac{\alpha-2\beta t}{\sqrt{4t}}}^{\infty} \exp\left(-A^2\right)dA + \frac{1}{2}\frac{2}{\sqrt{\pi}}e^{\alpha\beta}\int_{\frac{\alpha-2\beta t}{\sqrt{4t}}}^{\infty} \exp\left(-B^2\right)dB \quad \text{…………….} \quad (20)$$

The complimentary error function is defined as $erfc\,x = \frac{2}{\sqrt{\pi}} \int_{\frac{\alpha - 2\beta t}{\sqrt{4t}}}^{\infty} \exp\left(-t^2\right) dt$

For which Equation (20) changes to

$$\frac{e^{-\alpha\beta}}{2} erfc \frac{\alpha - 2\beta t}{\sqrt{4t}} + \frac{e^{-\alpha\beta}}{2} erfc \frac{\alpha + 2\beta t}{\sqrt{4t}} \qquad \ldots\ldots\ldots\ldots\ldots \qquad (21)$$

The various combinations of α and β can be simplified as follows:

$$\alpha\beta = \frac{Z}{D_L} \frac{\overline{VV}}{2\sqrt{D_L}} = \frac{\overline{VV}z}{2\sqrt{D_L}};\ \frac{\alpha + 2\beta t}{\sqrt{4t}} = \frac{\frac{Z}{\sqrt{D_L}} + \frac{\overline{VV}t}{\sqrt{D_L}}}{2\sqrt{t}} = \frac{Z + \overline{VV}t}{2\sqrt{D_L{}^t}} \text{ and}$$

$$\frac{\alpha - 2\beta t}{\sqrt{4t}} = \frac{\frac{Z}{\sqrt{D_L}} + \frac{\overline{VV}t}{\sqrt{D_L}}}{2\sqrt{t}} = \frac{Z - \overline{VV}t}{2\sqrt{D_L{}^t}}$$

Using these, equation (21) changes to

$$\frac{e\frac{\overline{VV}Z}{2D_L}}{2} erfc\left[\frac{Z - \overline{VV}t}{2\sqrt{D_L{}^t}}\right] + \frac{e\frac{\overline{VV}Z}{2D_L}}{2} erfc\left[\frac{Z + \overline{VV}t}{2\sqrt{D_L{}^t}}\right]$$

Therefore finally, Equation (11) with equation (14) changes to

$$C(z,t) = C_o \exp\left(\frac{\overline{VV}z}{2D_L}\right)\frac{1}{2}\exp\left(-\frac{\overline{VV}z}{2D_L}\right) erfc\left[\frac{Z - \overline{VV}t}{2\sqrt{D_L{}^t}}\right]\frac{1}{2}\exp\left(\frac{\overline{VV}z}{2D_L}\right) erfc\left[\frac{Z + \overline{VV}}{2\sqrt{D_L{}^t}}\right]$$

Or $C(z,t) = \frac{C_o}{2}\left[erfc\left[\frac{Z - \overline{VV}t}{2\sqrt{D_L{}^t}}\right] + \exp\left(\frac{\overline{VV}z}{D_L}\right) erfc\left[\frac{Z + \overline{VV}t}{2\sqrt{D_L{}^t}}\right]\right]$ .... (22)

Conclusion

The generations of virus are through human and animal activities these are unsewered settlement, through the onsite hygiene. Including cemeteries waste dump, site and feedlots, in such area, microorganism will definitely be predominant in those locations, the condition implies that in soil and water environment, they will accumulated to a very high concentration, in the case of ground water aquifers, it will absolute deposition with high concentration under the influence of constant regeneration in those waste dump locations, the concept is peculiar in bacterial deposition, and the behaviour of the microbes varies in terms of transportation process, under the pressure of the dissimilarity in soil stratification. The influenced of geochemistry and geomorphology of the formation is not left behind, as this also play A major role in some condition on the transport process, in this situation, the transportation of virus occur in the transport process, because in some instant, the deposition of the soil base on the intercedes of the particle grain size, influenced the behaviour of transport from one formation to the other, therefore transportation of virus are determined through these influence, the developed mathematical equation considered these experience as variable in the formulation of the system. There inverse transport of bacterial definitely should be considered in transport for thorough predictive model, the developed model will definitely provide a précised management method for bacterial transport in soil and water environment.

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