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Research article

MODELING BACILLUS AND SELENIUM TRANSPORT IN HOMOGENOUS VELOCITY AND PERMEABILITY ON RETARDATION PHASE IN FINE SAND IN IGBO ETCHE, RIVERS STATE OF NIGERIA

Eluozo, S. N.

Subaka Nigeria Limited, Port Harcourt, Rivers State of Nigeria
Director and Principal Consultant Civil and Environmental Engineering,
Research and Development
E-mail: Soloeluozo2013@hotminthe srail.com
E-mail: solomoneluozo2000@yahoo.com

Abstract

Bacillus and selenium deposition in the study location has generated serious negative impact in the study environment, the study of selenium and bacillus were found through risk assessment previously carried out, the negative impact were very high, such unhealthy situation has generated lots of ill health in the study environment, the deposition of selenium and bacillus in the formation are influences by high degree of permeability and velocity of flow, depositing in different direction of flow, the study consider this conditions in establishing the system that produce the model for the study, the rate of migration of selenium and bacillus are determined by the deposition rate of soil permeability and its velocity, it is reflected on the level of concentration in the strata, although there other influences, but in this research study, the predominant parameters are high degree of velocity and permeability in the study area, experts will definitely apply the conceptual framework in management and prevention of this contaminants in the study environment.

Keywords: bacillus, selenium transport, velocity and retardation phase

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1. Introduction

The presence of appropriate microorganisms at the actual site of contamination has long been recognized as a key factor in determining if biodegradation will occur, as well as in influencing the rate of biodegradation. A technology for uniform introduction of nutrients and microorganisms has been the principal bottleneck in the successful field implementation of in situ bioremediation (Zappi et al., 1993). An emerging technology for treating petroleum contaminated-sites using in situ bioremediation methods is through the application of direct electric fields to enhance the contact probability of the bacteria and their hydrophobic organic compounds (HOC) by transporting bacteria to contaminant into heterogeneous and low permeability soils for the homogenization of microorganisms in soil (Wick and Harms, 2007) or inverse (Shi and Wick, 2008). Many laboratory (Lahlou et al., 2000), field-scale (Dybas et al., 2002; Major et al., 2002) and modeling studies (Schafer et al., 1998; Shein and Devin, 2002; Kim SB numerical analysis of bacterial, 2006, Eluozo 3013) have been performed to understand and predict microbial transport in porous media. As microbes are generally negatively charged, DC fields will cause their transport towards the anode (DeFlaun and Condee, 1997; Lee, 2001; Eluozo 3013) and/or bacterial migration with the electroosmotic water flow to the cathode (Suni, 2004; Wick et al., 2004; Eluozo 3013). These methods all rely on more selective and gentler ways to move microbes (and contaminants) through the soil and have in common that they do not require the excavation of soil or the mechanical mixing of the soil matrix. The success of using of electric fields depends on the specific conditions encountered in the field, including the types and amount of contaminant present, soil type, pH and organic content (Acar et al., 1996; Wick et al., 2004; Borroni and Rota, 2003).

2. Theoretical background

The deposition of selenium and bacillus in the surroundings in most cases expand negative impact of in the environment, in most circumstance it is usual due to indecent supervision of the substance that develop numerous negative impact, therefore it is essential to assess and monitor the rate of concentration of the substances, this substances and enteric virus were found to be major depositor in the study environment, both pollutants in the formation were found in the study location, this investigation were carried out through risk evaluation, but this assessment could not develop efficient solution, the deposition of bacillus and selenium at different direction predominantly deposit in the study environment, these are base on high deposition of porosity and velocity through formation characteristics observed in the study area. The direction of deposition are base on the pressure from high percentage of porosity and velocity, The rate of velocity variation determined the rate of fast transport of selenium and bacillus in the study location, the parameters were found transporting base on the influences from this formation characteristics, various location deposit different variables of both parameters, it will definitely reflect on the concentration of the contaminants in the system. therefore the deposition of both parameters generates different direction, but may have merge on the transportation process , the tendency of concentration fluctuating between both parameters may exhibits inhibition depending on the parameters that deposition more concentration, the

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developed model examined this condition as produced from the derived principal equation to monitor this two direction of flow.

3. Governing equation

Nomenclature

R	=	Retardation factor [-]
C	=	Concentration of bacillus [cm^3/m]
D	=	Hydrodynamic Dispersion [cm^2/m]
V	=	Velocity [cm^2/sec]
μ	=	selenium [cm^3/m]
T	=	Time [T]
X	=	Distance [M]
ϕ	=	Porosity [-]

$$R\frac{\partial c}{\partial t} = D\phi\frac{\partial^2 c}{\partial y^2} - V\frac{\partial c}{\partial x} - \mu c\frac{\partial c}{\partial y} + \lambda(x, y) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Generated governing equation in [1] is the developed mathematical expression that will be derived to monitor two different solute at different direction of flow, there deposition and transport process of the two parameters were found to be influenced by porosity and velocity of the formation, the transport of bacillus and selenium in the strata can be expressed through the stated equation, the developed governing equation will be derived to generate model that will examine the deposition of both parameters in the study area.

$$R\frac{\partial c}{\partial t} = D\phi\frac{\partial^2 c}{\partial y^2} = \lambda(x, y) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (2)$$

Let $C = TX$

$$\frac{\partial c}{\partial t} = T^1 X \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (3)$$

$$\frac{\partial c}{\partial y} = TY^{11} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (4)$$

$$\phi T^1 + D\phi TY^{11} = \lambda \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (5)$$

$$\phi\frac{T^1}{T} = \lambda \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (6)$$

$$D\phi \frac{Y^{11}}{Y} = \lambda \qquad \text{.............................. (7)}$$

From (6), $R\frac{dT}{T} = \lambda dt$ .... (8)

$$\int \frac{dT}{T} = \int \frac{\lambda}{f} dt \qquad \text{.............................. (9)}$$

$$LnT = \frac{\lambda}{f} t + a_1 \qquad \text{.............................. (10)}$$

$$T = \ell^{\frac{\lambda}{f} t + a_1} \qquad \text{.............................. (11)}$$

$$T = C_1 \ell^{\frac{\lambda}{f} t} \qquad \text{.............................. (12)}$$

$$D\phi \frac{dy}{y} = \lambda dy \qquad \text{.............................. (13)}$$

$$\int \frac{dy}{y} = \int \frac{\lambda}{D\phi} dy \qquad \text{.............................. (14)}$$

$$LnY = \frac{\lambda}{D\phi} y + a_2 \qquad \text{.............................. (15)}$$

$$Y = \ell^{\frac{\lambda}{D\phi} x + a_2} \qquad \text{.............................. (16)}$$

$$Y = C_2 \ell^{\frac{\lambda}{D\phi} y} \qquad \text{.............................. (17)}$$

But $C = TX$

$$C_1 = C_1 \ell^{\frac{\lambda}{D\phi} t} \bullet C_2 \ell^{\frac{\lambda}{D\phi} y} \qquad \text{.............................. (18)}$$

$$C_1 = C_1 C_2 \ \ell^{\left(\frac{t}{R} + \frac{\lambda}{D\phi}\right)\lambda} \qquad \text{.............................. (19)}$$

$$C_1 = C\,\ell^{\left(\frac{t}{R} + \frac{y}{D\phi}\right)\lambda}$$ ………………………….. (20)e the inclination of selenium and bacillus transport penetrating unconfined bed zone of the formations may be on exponential stage, influences from the perch aquiferous zone are determined by velocity and porosity deposition in the formation, were microbial activities depend on the structural setting of the formation, but at this phase of the transport system the condition of the substances and the microbes were found to deposit rapidly at the overdose zone in the system, the expressed model in [20] are derived to monitor this condition in the stated condition.

$$R\frac{\partial c}{\partial t} = -V\frac{\partial c}{\partial x}$$ ………… (2)

Let $C = TX$

$$\frac{\partial c}{\partial t} = T^1 X$$ ………………………….. (21)

$$\frac{\partial c}{\partial x} = TX^1$$ ………………………….. (22)

$$RT^1 X + VTX^1 = \lambda^2$$ ………………………….. (23)

Let $\frac{RT^1}{T} = V\frac{X^1}{X} = -\lambda^2$ ………………………….. (24)

$$\int \frac{dT}{T} = \int \frac{P^2}{R}\,dt$$ ………………………….. (25)

$$LnT = -\frac{P^2}{R}t + a_3$$ ………………………….. (26)

$$T = \ell^{-\frac{P^2}{R}t + a_3}$$ ………………………….. (27)

$$Y = C_3\,\ell^{\frac{-P^2}{R}t}$$ ………………………….. (28)

$$\frac{VX^1}{X} = -P^2$$ ………………………….. (29)

$$\frac{dx}{dx} + \frac{P^2}{V}x = 0$$ ………………………….. (30)

Auxiliary equation is

$$M^2 + \frac{P^2}{V} = 0 \qquad \text{..............................} (31)$$

$$M = \pm i \frac{P}{V} \qquad \text{..............................} (32)$$

$$X = A Cos \frac{P}{\sqrt{V}} x + B Sin \frac{P}{\sqrt{V}} y \qquad \text{..............................} (33)$$

Combine (23) and (32), we have

$$C_2 = TX$$

$$C_2 = C_3 \ell^{-\frac{P^2}{R}t} \left(A Cos \frac{P}{\sqrt{V}} t + A Sin \frac{P}{\sqrt{V}} x \right) \qquad \text{........................} \qquad (34)$$

The developed model in [34] set up the deposition of the contaminants and its migration, it has observed degradation base on numerous influences, such circumstance will first call to mind change in concentration with respect to distance and depth of soil formation, the rate of concentration may be reduces base on this condition or other influences in the system, the expressed model defined this condition as presented in t[34].

$$R \frac{\partial c}{\partial t} = -\frac{\partial c}{\partial y} \mu c \qquad \text{...........} \qquad (3)$$

Let $C_4 = TY$

$$\frac{\partial c}{\partial t} = T^1 Y \qquad \text{..............................} (35)$$

$$\frac{\partial c}{\partial y} = Y^1 T \qquad \text{..............................} (36)$$

$$RT^1 Y = \mu c Y^1 T \qquad \text{..............................} (37)$$

$$\frac{RT^1}{T} = \mu c \frac{Y^1}{Y} = \varphi^2 \qquad \text{..............................} (38)$$

$$\frac{RT^1}{T} = \varphi^2 \qquad \text{…………………………….. (39)}$$

$$\mu c \frac{T^1}{T} = \varphi^2 \qquad \text{…………………………….. (40)}$$

$$Ln\ T = \frac{\varphi}{R} T + a_4 \qquad \text{…………………………….. (41)}$$

i.e. $T = \ell^{\frac{\varphi^2}{R} t + a_4}$ …………………………….. (42)

$$T = C_4\, \ell^{\frac{\varphi^2}{R} t} \qquad \text{…………………………….. (43)}$$

$$\mu c \frac{Y^1}{Y} = \varphi^2 \qquad \text{…………………………….. (44)}$$

$$\frac{dy}{dy} - \frac{\varphi^2}{\mu c} y = 0 \qquad \text{…………………………….. (45)}$$

Auxiliary equation

$$M^2 - \frac{\varphi}{\mu c} = 0 \qquad \text{…………………………….. (46)}$$

$$Y = D\ell^{\frac{\varphi}{\mu c} y} + E\ell^{-\frac{\varphi}{\mu c} y} \qquad \text{…………………………….. (47)}$$

Combine (43) and (47), yield

$$C_3 = TY$$

i.e. $C_3 = C_4\, \ell^{\frac{\varphi^2}{R} t} \left(D\ell^{\frac{\varphi}{\sqrt{\mu c}}} + E\ell^{-\frac{\varphi}{\mu c} y} \right)$ …………………………….. (48)

$$V \frac{\partial c_4}{\partial x} = -\mu c \frac{\partial c_4}{\partial y} \qquad \text{………… (4)}$$

Let $C_5 = XY$

$$\frac{\partial c}{\partial x} = X^1 Y \quad \text{.............................. (49)}$$

$$\frac{\partial c}{\partial y} = XY^1 \quad \text{.............................. (50)}$$

$$VX^1Y = \mu cXY^1 \quad \text{.............................. (51)}$$

$$V\frac{X^1}{X} = K^2 \quad \text{.............................. (52)}$$

$$\mu c\frac{X}{X} = K^2 \quad \text{.............................. (53)}$$

$$Ln\ X = \frac{K^2}{\mu c} + a_5 \quad \text{.............................. (54)}$$

i.e. $X = \ell\frac{K^2}{V} + a_5$ .... (55)

$$X = C_5\,\ell^{\frac{K^2}{V}x} \quad \text{.............................. (56)}$$

$$\mu c\frac{Y^1}{Y} = K^2 \quad \text{.............................. (57)}$$

$$\frac{dy}{dy} = \frac{K^2}{\mu c}y = 0 \quad \text{.............................. (58)}$$

Auxiliary equation

$$M^2 = \frac{K^2}{\mu c} = 0 \quad \text{.............................. (59)}$$

$$Y = f\,\ell^{\frac{K}{\mu c}y} + f\,\ell^{-\frac{K}{\mu c}y} \quad \text{.............................. (60)}$$

Combine (56) and (60) we have

$$C_4 = XY$$

i.e. $$C_4 = C_5 \ell^{-\frac{K^2}{V}x} \left(ACos \frac{K}{\sqrt{\mu c}} x + ASin \frac{K}{\sqrt{\mu c}} \right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (61)$$

Combining (20), (38), (48) and (61)

$$C(x, y) = C_1 + C_2 + C_3 + C_4$$

$$C(x, y) = C \ell^{\left(\frac{t}{R} + \frac{y}{D\phi}\right)\lambda} + C_3 \ell^{\frac{P^2}{R}t} \left(ACos \frac{P}{\sqrt{V}} + ASin \frac{P}{\sqrt{V}} t \right) +$$

$$C_4 \ell^{\frac{\varphi^2}{R}t} \left(D \ell^{\frac{\varphi}{\sqrt{\mu c}}} + D \ell^{-\frac{\varphi}{\mu c}} \right) + C_5 \ell^{\frac{K^2}{V}x} \left(ACos \frac{K}{\sqrt{\mu c}} + ASin \frac{K}{\sqrt{\mu c}} \right) \quad \ldots\ldots\ldots.. \quad (62)$$

The concluding governing model are expressed in [62], this model defined numerous condition considered in the system, the progressive phase overriding the developed model, the rate of porosity and velocity were found to express high predominant in the formation as it is definite in the derived solution, such circumstances has reputable influences on the developed system that generated the derived equation, the model no doubt has express different measurement of the parameters that deposit in the study area. The concept of this study is to develop model that will prevent and monitor the rate of selenium and bacillus in soil and water environment, the model were developed in stages, this is to ensure that the derived solution accommodate every defined objectives and other influences that are reflected on the transport process.. Numerous human settlers has become victim of this negative impact, this call for severe action to make sure that such ugly scourge are removed or thoroughly managed in the study environment.

4. Conclusion

The deposition of pollutant are determined by the rate of waste production including its point sources and the level of supervision system, the study location management methods are very poor, this condition has developed high concentration of pollutant of different types, the negative impact of this pollutant has generated different types of diseases in the study location, due to misconduct of waste dumping in the study area, it maintain to enhance pollution in soil and water environment. The deposition of selenium and bacillus were predominantly discovered in the study area, such condition call for serious concern due to high negative impact it has on human settlement, base on this situation, development of mathematical model were found suitable, the derived model were created through the generated system for the study, experts will definitely find the model faviourable in monitoring and assessment as well as avoidance of this contaminants in the study environment.

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