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Research article

MODELING BURKHOLDERIA PSEUDOMALLEI TRANSPORT IN HETEROGENEOUS SILTY FORMATION IN AHOADA REGION OF RIVERS STATE NIGER DELTA OF NIGERIA

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Abstract

Modeling burkholderia pseudomallei transport in heterogeneous silty formation has been expressed. The expressions are base on the formation characteristics such as dispersions and degree of porosity of the soil, such condition were monitored through desk studies carried out in the study location. Application of mathematical modeling techniques were applied to monitor the rate of burkholderia pseudomallei in heterogeneous formation, this condition are base on the fact that groundwater is considered to be of exceptional phase because of the soil barricade, This is accurate for most groundwater resources although we know that many aquifers all over the globe are contaminated and/or is being polluted. Bacteria are washed into the water from the air, the soil and from almost every conceivable object. Significant numbers of bacteria can move through media even when the proportion retained is very high. The faeces of animals contain vast numbers of bacteria and many enter natural water systems. The sizes of openings in subsurface material can be assumed to be variable and are generally not measured. The model developed will monitor the migration of Burkholderia pseudomallei in heterogeneous silty formation.

Keywords: modeling burkholderia pseudomallei, transport, and heterogeneous silty formation

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1. Introduction

The amount and multiplicity of the microorganisms in natural waters vary very much in different places and under dissimilar conditions. Bacteria are washed into the water from the air, the soil and from almost every conceivable object. Important statistics of bacteria can migrate through media even when the proportion reserved is very high. The faeces of animals contain vast numbers of bacteria and many enter natural water systems. The sizes of openings in subsurface material can be assumed to be variable and are generally not measured, but porosity and permeability measurements on aquifer sediments indicate that adequate spaces for bacteria exist in many sediment types, even in some rather dense porous rocks (McNabb and Dunlap, 1975). The interstices of the shallow aquifer sediments can easily accommodate bacteria and probably

Protozoa and fungi as well. Larger organisms will be excluded from most subsurface formations, except for gravelly and cavernous aquifers (Ghiores and Wilson, 1988). More than 150 pathogens found in livestock manure are associated with risks to humans, including *Campylobacter spp.*, *Salmonella spp.*, *Listeria monocytogenes*, *Escherichia coli* O157:H7, *Cryptosporidium parvum* and *Giardia lamblia*, which account for over 90% of food and waterborne diseases in humans (USEPA, 2003). An understanding of the overland transport mechanisms from land applied waste is needed to improve design of BMPs and modelling of NPS pollution for development and implementation of Total Maximum Daily Loads (TMDL). The process of classifying sources of NSP pollution could be greatly simplified by identifying the predominant species of *Enterococcus* that are associated with specific sources of fecal pollution. The Biology System identifies microorganisms based on carbon source utilization (Blog, 2003). Hagedorn *et al.* (2003) employed carbon source utilization as a form of phenotypic fingerprinting to classify enterococcal isolates from known fecal sources in four different geographical regions. Environmental and public health problems associated with the spreading of sewage on land have been observed since the dawn of the 20th century. Instances of land application of sewage are increasing because this disposal process removes some of the pollutants from the applied sewage, constitutes a possible aquifer recharge source, and increases crop yields by supplying essential nutrients and by improving soil properties (Lance *et al.*, 1982; Tim *et al.*, 1988). However, disadvantages of land application may include degradation of quality of surface and groundwater through chemical and microbial contamination, and accumulation of heavy metals in soil. Spreading agricultural wastes may constitute a source of pathogens to the groundwater, surface water and soil. The application of these wastes to agricultural lands can cause environmental problems even when the application procedures are within the current guidelines. Problems have been demonstrated in Ontario by Dean and Foran (1990a, b, 1991), Fleming *etal.* (1990) and Palmateer *etal.* (1989) where applications of liquid manure to agricultural fields have resulted in rapid movement of a tracer bacterium, nalidixic acid-resistant *Escherichia coli*, through the soil and under drain systems leading to contamination of surface receiving waters. Microbial contamination of water and soil due to land application of liquid manure and other liquid wastes is difficult to treat, because once applied; manure becomes a potential non-point source of pollution, less susceptible to correction than a point source (Crane *et al.*, 1983; Khaleel *et al.*, 1980). Pathogenic bacteria and viruses known to cause disease have been detected in groundwater. Contaminated groundwater causes almost half of the outbreaks of water-borne diseases each year in the United States (Craun, i979, 1984). The most important pathogenic bacteria and viruses that might be transported to groundwater include *Salmonella* sp., *Shigella* sp., *Escherichia coli and Vibrio* sp., and hepatitis virus, Norwalk virus, echovirus, poliovirus and coxsackievirus (Corapcioglu and Haridas, 1984; Craun, 1984; Gerba and Keswick, 1981).

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2. Theoretical background

The deposition of burkholderia pseudomallei transport in heterogeneous silty formation has been of serious concern in the upland location of Rivers State, such location that deposit lacustrine from it geologic history has also from interpretations of desk studies carried out are found to deposit heterogeneous formation in Ahoada, the transgression and regression from sombrero River generated these type deposition as expressed in the interpretation of the desk studies, base on these condition the formation variation were evaluated to determine the rate of burkholderia pseudomallei deposition in the study area. Biological waste dumped indiscriminately in the study location are point sources of pollution, formation characteristics such as degree of saturation and porosity were expressed, this influence the dispersion rate of the microbes as expressed in the system, such influence were confirmed from risk assessment carried out to determine the rate of pollution but not to solve the ugly scourge. The study situate in the upland location of oil rich state in Nigeria several man made activities that generate pollution are found to be paramount in the study area. As municipal and manufacturing development continues to increase around the world's rivers and coastlines, so does the rate of inadvertent discharge of contaminants to subsurface and surface waters require effective evaluation of such surroundings. Groundwater/surface water connections in estuarine environments are influenced by a numeral processes forming complex spatially and temporally changeable systems. Mass contrasts between the characteristically fresh groundwater and saline to brackish marine and estuarine surface waters leads to mixing and convective circulation at the groundwater discharge. Boundary in the system is characterised by the intrusion of saltwater into the adjacent coastal aquifer. Although there is still no single conceptual definition for such a surficial mixing zone, the terms 'hyporheic zone', 'subsurface estuary' and 'groundwater/surface water interface' or 'GSI' are gaining common usage in the scientific literature. Habitats containing only a single kind of microorganism are found only in the laboratory. Natural habitats contain many kinds of organisms which interact in complex ways. The great reservoir of bacteria in nature is the soil, which contains both the largest population and the greatest variety of species. Most bacteria that are found in surface waters are derived from the soil. However, the quality of subsurface waters may be impacted both by naturally occurring processes as well as by actions directly attributable to human activities.

3. Governing equation

$$\frac{\phi \partial C}{\partial t} = \frac{\partial C}{\partial x}\left[\phi D \frac{\partial C}{\partial x}\right] - V\frac{\partial C}{\partial x} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (1)$$

The dispersion of the microbes is of serious concern, base on the rate of spread in contaminant to ground water aquifers in the study area. The expression in [1] is the governing equation the will monitor the rate of spread and variation of porosity at different formation of the soil, the governing equation considered several influence in the system, it integrated most influential parameters that pressured the deposition of contaminant in the system. Such expressions from these parameters are in line with the pressure from formation variation that influences the stratification of the formation.

Applying Laplace transformation into equation (1) we have

$$\frac{\partial C}{\partial t} = SC_{(t)} - C_{(o)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$\frac{\partial C}{\partial x} = SC_{(x)} - C_{(o)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

$$\frac{\partial C}{\partial x} = SC_{(x)} - C_{(o)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

$$\frac{\partial C}{\partial x} = SC_{(x)} - C_{(o)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

$$C = C_{(o)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

Substituting equation (2), (3), (4), (5) and (6) into equation (7) yields

$$\phi\left\lfloor SC_{(t)} = SC_{(x)} - C_{(o)}\right\rfloor - \phi D\left\lfloor SC_{(x)} = SC_{(x)} - C_{(x)}\right\rfloor - V\,C_{(o)} \quad \ldots\ldots \quad (7)$$

$$\phi\,SC_{(x)} - \phi S^{1}{}_{(x)} - C_{(o)} - \phi D\,SC_{(o)} - \phi D\,C_{(o)} - V\,C_{(o)} \quad \ldots\ldots\ldots\ldots\ldots\ldots$$

(8)

Considering the following boundary as:

at $t = 0,\ C^{1}{}_{(o)} = C_{o} = 0$ .... (9)

We have

$$C_{(x)}\left(\phi S - \phi S - \phi DS\right) = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (10)$$

$$C_{(x)} \neq 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (11)$$

Considering the boundary condition

at $t > 0,\ C(^{1}{}_{(o)} = C_{(o)} = C_{o}$ .... (11)

$$SC_{(t)} - \phi DS_{(x)} - VC_{(x)} = \phi\,SC_{o} + \phi D\,C_{o} + V\,C_{o} \quad \ldots\ldots\ldots\ldots \quad (12)$$

$$\left[\phi S - \phi D - V\right] C_{(x)} = \left[\phi S + \phi + \phi D\right] C_o \qquad \ldots\ldots\ldots\ldots\ldots \qquad \ldots\ldots \qquad (13)$$

$$C_{(x)} = \frac{\phi S + \phi + \phi D}{\phi S - \phi DS + V} C_o \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (14)$$

Applying quadratic expression, we have

$$S = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (15)$$

Where $a = \phi$, $b = \phi D$, $c = V$

$$\frac{-\phi D \sqrt{-\phi D^2 + 4\phi v}}{2\phi} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (16)$$

$$C_{(x)} = A \exp \frac{\left\lfloor -\phi D + \sqrt{-\phi D^2 + 4\phi v}\right\rfloor}{2\phi} t = -\exp \frac{\left\lfloor -\phi D + \sqrt{-\phi D^2 + 4\phi v}\right\rfloor}{2\phi} t \qquad \ldots\ldots \qquad (17)$$

Subjecting equation (17) to the following boundary condition and initial value condition

$$x = 0,\ C_{(o)} = 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (18)$$

We have $B = -1 \; and \; A = 1$ $\qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (19)$

So that our particular solution, will be in this form

$$C_{(x)} = \exp\left[-\phi D + \left(\phi D^2 - 4\phi v\right)^{1/2}\right] x - \exp \frac{\left\lfloor -\phi D + \sqrt{-\phi D^2 + 4\phi v}\right\rfloor}{2\phi} t \qquad \ldots\ldots \qquad (20)$$

But $e^x - e^{-x} = 2Sin\, x$

Therefore, the expression of (20) can be of this form

$$C_{(x)} = 2Sin\left[\phi D^2 + \left(\phi D^2 + 4\phi v\right)^{1/2}\right] x \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (21)$$

But if $x = \dfrac{V}{t}$

Therefore, the model can be expressed as:

$$C_{(x)} = 2Sin\left[\phi D^2 + \left(\phi D^2 + 4\phi v\right)^{1/2}\right] \frac{V}{t} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (22)$$

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Again $\frac{V}{t} = x$

We have

$$C_{(x)} = 2Sin\left[\phi D + \left(\phi D^2 + 4\phi v\right)^{1/2}\right]x \qquad \text{……………………………..} \qquad (23)$$

Considering (22) and (23) yield

$$\boxed{C_{(x,t)} = 2Sin\left[\phi D + \left(\phi D^2 + 4\phi v\right)^{1/2}\right]x + 2Sin\left[\phi D + \left(\phi D^2 + 4\phi v\right)^{1/2}\right]x} \qquad \text{….} \qquad (24)$$

The factors that control the transport of bacteria through porous media are not well understood while the study of microbial movement in the field under unsaturated flow conditions has received only limited study to date. Advection, dispersion, deposition (clogging) and entrainment (declogging) are all processes that affect transport in noticeable ways The outbreaks of typhoid fewer at the turn of the century from eating raw vegetables grown on soil fertilised with raw sewage resulted in extensive studies of the survival of enteric bacteria in soil (Gerba, Wallis & Melnick, 1975). Viruses are more resistant to environmental changes and may have a larger lifespan in the subsurface than bacteria. The number and variety of the microorganisms in natural waters vary greatly in different places and under different conditions. Bacteria are washed into the water from the air, the soil and from almost every conceivable object. Significant numbers of bacteria can move through media even when the percentage retained is very high. The faeces of animals contain vast numbers of bacteria and many enter natural water systems. The sizes of openings in subsurface material can be assumed to be variable and are generally not measured, but porosity and permeability measurements on aquifer sediments indicate that adequate spaces for bacteria exist in many sediment types, even in some dense porous rocks (McNabb and Dunlap, 1975). The interstices of the shallow aquifer sediments can easily accommodate bacteria and probably protozoa and fungi as well. Larger organisms will be excluded from most subsurface formations, except for gravelly and cavernous aquifers (Ghiores and Wilson, 1988).

4. Conclusion

Microbiological pollution derived mostly from human and animal activities such as, unsewered settlements; on-site sanitation; cemeteries; waste disposal; waste disposal; feedlots; etc. Microorganisms certainly will be the dominant forms of life and, in most cases, they will be the only forms of life present in aquifers. However, with very few exceptions the only waterborne microbial pathogens of man are essentially human bacteria, viruses and protozoa, and in considering the safety of drinking water from the point of view of infectious diseases one can almost completely ignore any source of infectious agents except human excreta. In relation to microbial pollution of groundwater it is therefore only necessary to ensure that at the point of extraction no contamination with human excreta occurs various families and sometimes in very high numbers. Although the original water source may be without bacteria, the largest reservoir of bacteria is the soil zone. Consequently, shallow as well as deep aquifers all show a variety and diversity of bacterial populations. Certain naturally occurring organisms which, for example, form a part of the nitrification/denitrification cycle, can be pathogenic under certain conditions.

Groundwater contains many species of bacteria with various survival rates. Various known and unknown factors increase and decrease bacterial numbers in groundwater. It is also obvious those groundwaters not only transport bacteria, but also sustain bacterial growth. What is unknown is where the bacteria originated from in artesian groundwater that is 5 000 years old. It is important that when groundwater is analysed for microbiological parameters, one needs to specify what you are looking for. Otherwise many groundwater sources would be rendered unfit for human consumption without knowing that these bacteria are totally harmless in the water. However, it is true that some of them can be pathogenic under certain conditions. This expressed model definitely monitor theses conditions at different phase of the microbes in to aquiferous zone.

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