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**Research article**

# MODELING DECOMPOSE PHASE CONDITION OF FLAVOBACTERIUM DEPOSITION IN HOMOGENEOUS SILTY FORMATION IN COASTAL AREA OF BORIKIRI, PORT HARCOURT METROPOLIS

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## Abstract

Modeling decomposing phase of Flavobacterium in homogeneous silty formation were found to deposit predominantly in the study environments. The study were express the behaviour of the microbes on the region where it pressured by some formation characteristics to experiences degradation, such condition where observed in the deposition of the microbes through investigation previously done on soil pollution analysis in the study area, development of mathematical model were appropriate when the previous investigation could not develop better solution to evaluate the rate of decomposition of the microbes as well as determine the level of regeneration in the study environments, the developed model were expressed in this direction by ensuring that every condition that cause decomposition of Flavobacterium are integrated in the system, in other to produces results that will represent the rate of decomposing of the microbes. The study is imperative because experts in the field will apply this model to monitor the rate of decomposing of the microbes in the transport process, the formation where the microbes have experiences this decomposition that the aquiferous zone may be good for human consumption will be determined in the study area.

**Keywords:** modelling, decompose phase, Flavobacterium and homogeneous silty formation

## 1. Introduction

Subsurface Stormflow in steep unchanneled soil mantled hillslope is the dominant runoff generation process in many parts of the Pacific Rim. A number of studies have demonstrated specific processes for subsurface Stormflow occurrence, including transmissivity feedback, flow through the fractured bedrock, kinematic wave routing and flow through discrete preferential pathways. Perhaps the most common mechanism for rapid subsurface flow on steep, wet hillslope is lateral preferential flow at the soil-bedrock interface (Mosley, 1979; McDonnell, 1990; Tsuboyama et al., 1994; Weiler et al., 1998; 2003; Sidle et al., 1995; 2000). For this study, we define predominantly vertically oriented preferential pathways with lengths comparable to the soil depths as "micropores and slope parallel preferential flow pathways as "pipes". These pipes can either be formed by soil fauna (mole and mouse burrows) or more frequently in forest soils by dead root channels (sometimes eroded). In this study we do not consider the continuous, large pipe networks that were frequently observed in Britain and in other loess-dominated places of the world (Jones and Connelly, 2002, Markus. 2003). As urban and industrial development continues to expand around the world's rivers and coastlines, so does the rate of unintentional release of contaminants to subsurface and surface waters and the need for effective assessment of such environments (winter, 2000). Hydrologists have long known that surface waters and groundwater are intrinsically linked systems (e.g. Glover, 1959; Cooper, 1959; Clement et al., 1996; Simpson et al., 2003). Areas around streams, rivers, lakes and coastal environments represent zones of interaction and transition between the two systems where dissolved constituents such as pollutants can be diluted, exchanged, transformed or destroyed. Identifying predominant processes affecting solute exchange across transition zones is therefore, critical in assessing contaminant fluxes to the sediment/water interface, and ultimately in estimating contaminant exposures for the receiving ecosystems. Groundwater/surface water interactions in estuarine environments are influenced by a number of processes forming complex spatially and temporally variable systems. Density contrasts between the typically fresh groundwater and saline to brackish marine and estuarine surface waters leads to mixing and convective circulation at the groundwater discharge boundary so that the system is characterised by the intrusion of saltwater into the adjacent coastal aquifer (Glover, 1959; Cooper, 1959; Reilly and Goodman, 1985; Ataie-Ashtiani et al., 1999; Simpson and Clement, 2004 Eluozo 2013). Tidal activity can often induce a fluctuating water table as well as infiltration of surface water into sediments, forming a surficial mixing zone with groundwater discharging from the adjacent aquifer (Robinson et al., 1998; Ataie-Ashtiani et al., 1999; Boudreau and Jorgensen, 2001; Acworth and Dasey, 2003 Eluozo 2013). 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 White (1993) conceptually defined the hyporheic zone as 'the saturated interstitial area beneath the stream bed and into the stream banks that contain some proportion of channel water or that have been altered by channel water infiltration'. This definition may be broadened to include rivers, lakes, estuaries and coastal environments where surface water infiltrates into the underlying sediments and interacts with groundwater. Although numerous studies have addressed groundwater and solute inputs to surface water bodies (e.g. Harvey et al., 1987, Gallagher et al., 1996, Portney et al., 1998, Krabbenhoft et al., 1990, Lorah and Olsen, 1999, winter, 2000; Tobias et al., 2001), few studies to date have examined near-shore groundwater discharge in detail. Studies of note however, include those by Robinson and Gallagher (1999); Smith and Turner (2001); Linderfelt and Turner (2001); Simpson et al. (2003) and the initial study by Westbrook et al. (2000) related to the current work (Westbrook et al 2005 Eluozo 2013).

## 2. Theoretical background

The state of inactivity of microbes are on condition that expert need to understand the causes and what may have lead to such condition in microbial depositions in soil and water environments, most microbes do not survive in every environment there lots of other influences that may cause degradation of microbes, temperature variation in soil may cause degradation of microbes , the structure of the soil including the mineral deposition some cases determined the level of temperature in the formation, this condition influences the level of decompose phase of microbes in the study area. Such development influences microbial activates and it migration process in the study environment, the transport and survivor of microbes determined on the geological deposition reflection of the formation deposited influence at various strata. More so the behaviuor of microbes in soil and water environment; therefore potentially harmful microbes may enter ground water via poor well construction, ground water recharge/infiltration from the surface, faulty septic tanks and/or sewer lines, land application of sewage sludge, and percolation of landfill leachate (Sobsey 1979; Pedley and Howard 1997). The fate of microorganisms in the subsurface depends on two basic processes, survival and transport/retention (Gerba and Bitton 1984). Study of the transport of microorganisms to and through ground water is an entire field onto itself. Considerable work has been done to define factors affecting microbial transport in ground water, generally with two motivating reasons: public health implications from contamination by potential pathogens, and transport of biodegrading bacteria to aquifer regions contaminated with chemical constituents. Transport studies often involve the use of columns to model movement through a soil matrix, or *in-situ* studies of microbial transport which employ monitoring wells to detect the organisms of interest, often a tracer organism, as they are transported with ground water across a study site. Column studies are useful for isolating and/or defining specific impacts controlling transport as they offer a controlled environment, while *in-situ* studies allow for evaluating the impact of other factors in the natural environment that are difficult or impossible to model with column studies. Such factors could include predation and antagonism by other organisms, alterations in adsorption and survival in response to natural geochemical constituents and pore size or transmissivity effects of the undisturbed aquifer material, and interrelation of these and other variables (Harvey 1997). Also, many physical parameters of water and contaminant transport, such as dispersion, have scale dependency, and thus *in-situ* studies more accurately.

### 3. Governing equation

$$K\phi\frac{\partial^2 c_{(x)}}{\partial t^2} = KV_{(x)}\frac{\partial c}{\partial x} + KD\frac{\partial c}{\partial x} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (1)$$

The expression in [1] is the principal equation in the study location, the behaviour of the Flavobacterium the formation are reflected on the formation deposited influences that pressure the deposition of Flavobacterium in study location permeability play predominant role in the rate of migration of the microbes to some region were change in strata deposition may developed unfavourable condition for the microbes if it cannot adapt it will migrate or degrade by reducing it microbial population.

$$\left.\begin{array}{l} t = 0 \\ x = 0 \\ C_{(o)} = C_o \\ \left.\frac{dc}{dt}\right|_{t=0} = 0 \end{array}\right\} \qquad \text{.............................. (2)}$$

$$K\phi \frac{\partial^2 c}{\partial t^2} = -KD\frac{\partial c}{\partial x} \qquad \text{.............................. (3)}$$

$$\left.\begin{array}{l} t = 0 \\ x = 0 \\ C_{(o)} = C_o \\ \frac{dc}{dt} \end{array}\right\} \qquad \text{.............................. (4)}$$

$$KV_{(x)}\frac{\partial c}{\partial x} + KD\frac{\partial c}{\partial x} \qquad \text{.............................. (5)}$$

$$\left.\begin{array}{l} x = 0 \\ C_o = C_o \\ \left.\frac{dc}{dx}\right|_{x=0} = 0 \end{array}\right\} \qquad \text{.............................. (6)}$$

Apply direct integration on (2)

$$K\phi \frac{\partial c}{\partial t} = K\phi s + K_1 \qquad \text{.............................. (7)}$$

Again, integrate equation (8) directly, it yields

$$K\phi s + K\phi s + K_1 + K_2 \qquad \text{.............................. (8)}$$

Subject to equation (3), we have

$$K\phi s\ C_o \ = \ K_2 \qquad \text{.............................. (9)}$$

and subjecting equation (8) to (3)

at $\left.\frac{dc}{dt}\right|_{t\ =\ 0} = 0 \quad C_{(o)} \ = \ C_o$

Yield

$$0 \ = K\phi s\ C_o + K_2 \qquad \text{.............................. (10)}$$

So that we put (10) and (11) into (9), we have

$$K\phi s = C_o\, Cst \ - \ C_o\, Cst \ + \ K\phi \qquad \text{.............................. (11)}$$

$$K\phi C_o \ = Cs\, C_o t \ = \ K\phi C_o - \ Cs\, C_o t \qquad \text{.............................. (12)}$$

$$\Rightarrow C_o, \left(K\phi - Cst\right) = \ C_o \ \left(K\phi - Cst\right)$$

$$\Rightarrow C_o \ = \ C_o \qquad \text{.............................. (13)}$$

Hence equation (13) entails that at any given distance *x*, we have constant concentration of the contaminant in the system.

$$K\phi \frac{\partial c}{\partial t} \ = \ - KD \frac{\partial c}{\partial x} \qquad \text{.............} \quad (4)$$

We approach the system by using the Bernoulli's method of separation of variable

$$C_o \ = \ ZT \qquad \text{.............................. (14)}$$

i.e. $\frac{\partial^2 c}{\partial x^2} \ = \ XT^{11}$ .............................. (15)

$$\frac{\partial^2 c}{\partial x} \ = \ X^1 T \qquad \text{.............................. (16)}$$

Put (15) and (16) into (14), so that we have

$$K\phi XT^{11} \ = \ KD\, X^1 T \qquad \text{.............................. (17)}$$

i.e. $K\phi \frac{T^{11}}{T} \ = \ KD \frac{X^1}{X} = -\lambda^2$ .............................. (18)

Hence

$$K\phi \frac{T^1}{T} = \lambda^2 X = 0 \quad \text{.............................. (29)}$$

i.e. $X^1 + \lambda^2 X = 0$ .............................. (20)

And

$$KDX^1 + \lambda^2 X = 0 \quad \text{.............................. (21)}$$

From (20) $T = ACos \frac{\lambda}{\sqrt{K\phi}} t + BSin \frac{\lambda}{\sqrt{KD}} x$ .............................. (22)

And (16) give

$$X = C_o \ell^{\frac{-\lambda^2}{\sqrt{KD}} x} \quad \text{.............................. (23)}$$

By substituting (23) and (24) into (15) we get

$$Co_2 = \left( ACos \frac{\lambda}{\sqrt{K\phi}} t + BSin \frac{\lambda}{\sqrt{KD}} t \right) Co \ell^{\frac{-\lambda}{\sqrt{KD}} x} \quad \text{.............................. (24)}$$

Exponential phase of the microbe were considered in the phase of the derived solution, the expression here considered the migration process to the point where change in formation may developed unfaviourable condition for the microbes ,degradation process begin to take place, whereby decomposition degrade the population of the microbes. Such condition are considered as the developed model at [24] were establish to accommodate the condition of rapid transport to where change in formation will cause decomposition on the microbes.
Subject to equation (25) to condition in (5), so that we have

$$C_o = AC \quad \text{.............................. (25)}$$

$\therefore$ Equation (26) becomes

$$Co_2 = Co \ell^{\frac{-\lambda^2}{\sqrt{KD}} x} \, Cos \frac{\lambda}{\sqrt{K\phi}} t \quad \text{.............................. (26)}$$

Again

$$\left. \frac{dc_2}{dt} \right|_{t = 0, B}^{= 0} x = 0$$

Equation (26) becomes

$$\frac{dc_2}{dt} = \frac{\lambda}{\sqrt{K\phi}} \ell^{\frac{-\lambda^2}{\sqrt{KD}}x} \; Sin \; \frac{\lambda}{\sqrt{K\phi}} t \quad \text{………………………….. (27)}$$

i.e. $0 \; = \; Sin \; \frac{\lambda}{\sqrt{K\phi}} 0$

$\frac{C_o \lambda}{\sqrt{K\phi}} \; \neq \; 0$ Considering NKP

Which is the substrate utilization for microbial growth (population), so that

$$0 \; = \; \frac{-C_o \lambda}{\sqrt{K\phi}} Sin \; \frac{\lambda}{\sqrt{K\phi}} B \quad \text{………………………….. (28)}$$

$$\Rightarrow \; \frac{\lambda}{\sqrt{K}} = \frac{n\pi}{2} n = 1, 2, 3 \quad \text{………………………….. (29)}$$

$$\Rightarrow \; \lambda \; = \frac{n\pi\sqrt{K\phi}}{2} \quad \text{………………………….. (30)}$$

So that equation (26) becomes

$$Co_2 \; = \; Co \, \ell^{\frac{-n^2\pi^2 K\phi}{2KD}x} \; Cos \; \frac{n\pi}{2} \frac{\sqrt{KD}}{2\sqrt{KD}} t \quad \text{………………………….. (31)}$$

$$Co = \; Co \, \ell^{\frac{-n^2\pi^2 K\phi}{2KD}x} \; Cos \; \frac{n\pi}{2} t \quad \text{………………………….. (32)}$$

Substrate depositions are one of the source of energy and increase of microbial population in soil and water environment, the study has stress on the behaviour of the microbes when it migrate to some environment of the formation and it experiences discomfort, it will try to establish adaptation, for any reason it they could not adapt, they will migrate to where it will faviourable for them, such condition there is the tendency that they will migrate to another formation where there substrate deposition, therefore regeneration of Flavobacterium will occur and it activities continue and it continue to increase in microbial population. The establish model in [32] will be useful to monitor the deposition of the microbes in such progressive state.

Now we consider equation (6) which is the steady flow state of the system

$$KV_{(x)} \frac{\partial c}{\partial x} - KD \frac{\partial c}{\partial x} \quad \text{………… (6)}$$

Using Bernoulli's method, we have

$$C_3 = XT \qquad \text{.............................} \qquad (33)$$

$$\frac{\partial c_3}{\partial t} = X^1T \qquad \text{.............................} \qquad (34)$$

$$\frac{\partial c_3}{\partial t} = X^1T \qquad \text{.............................} \qquad (35)$$

Put (34) and (35) into (6), so that we have

$$KV_{(x)}X^1T = -KDX^1T \qquad \text{.............................} \qquad (36)$$

i.e. $KV_{(x)}\frac{X^1}{X} = -KD\frac{X^1}{X} \quad \varphi$ ............................. (37)

$$KV_{(x)}\frac{X^1}{X} = \varphi \qquad \text{.............................} \qquad (38)$$

$$-KD\frac{X^1}{X} = \varphi \qquad \text{.............................} \qquad (39)$$

i.e. $X = A\ell^{\frac{\varphi}{KV_{(x)}}x}$ ............................. (40)

And $X = B\ell^{\frac{\varphi}{KD}x}$ ............................. (41)

Put (40) and (41) into (33), gives

$$C_3 = A\ell^{\frac{\varphi}{KD}x} \bullet B\ell^{\frac{-\varphi}{KD}x} \qquad \text{.............................} \qquad (42)$$

The migration process of microbes are found to experiences stead state flow, even when they degradations are observed in the migration and deposition process, such condition has been expressed in the system, this may take places when the migration process is on the motion to appoint were formation influences may pressure them to station at some particular region of the formation, such condition were considered in the system and therefore the derived expression developed this model at [42]to monitor the system in the direction

Subject equation (40) to (7) yield

$$C_3 = (o) = C_o \qquad \text{.............................} \qquad (43)$$

So that equation (44) becomes

$$C_3 = C_o \ell^{(x-y)\frac{\varphi}{KD}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (44)$$

Now assuming that at the steady flow, there is NKP for substrate utilization, our concentration here is zero, so that equation (45) becomes

$$C_3 = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (45)$$

Therefore, solution of the system is of the form

$$C_o = C_1 + C_2 + C_3 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (46)$$

We now substitute (13, (32) and (46) into (47), so that we have the model of the form

$$C_o = C_o + Co \ell^{\frac{-n^2\pi^2 K\phi}{KD}t} Cos \frac{n\pi}{2} x \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (47)$$

$$C_o = C_o \left(1 + \ell^{\frac{-n^2\pi^2 K\phi}{2KD}t} Cos \frac{n\pi}{2} x\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (48)$$

The expression in [48] is the final model equation that been develop from the derived governing equation, the final equation is the summation of all the model at various considered condition, the expression integrated all condition to generate the final expression that will monitor the decompose phase of Flavobacterium in soil and water environment. Predominant formation characteristics such as porosity and permeability deposition were found to pressure the system while on the process the it experiences degradation in some region of formation, such condition considered these behaviour under the influences of formation characteristics in the study location, this were observed in most condition on transport process of such types microbial specie in the study environment the final model will definitely express this condition to ensure that the final model monitor the microbes in decompose phase condition in the study environment .

## 4. Conclusion

The deposition of microbes in soil are influenced by lots formation characteristic at various structural setting of the study environment, the decompose state of the microbes in most instance are determined by the rate of formation influences at different stratum of the formation, the study centred on the decomposing state of the microbes, permeability and porosity were predominant formation characteristics influences in the study environment, the pressure from these two parameters determine to an extend the level concentration and transport rate of the microbes in the study location, such condition implies that the migration of Flavobacterium are influenced by the rate porosity and permeability degree in the various stratum, geological setting may deposit homogeneous formation in some region of the study environment and this may influence the state of decomposing rate of the microbes, monitoring the rate of decomposing state at various formation of the soil need a serious approach to ensure it produces thorough results. Modelling the decomposing phase of Flavobacterium require serious evaluation which was done to ensure that every influential parameters are fully represented, the express derived solution developed the model in different phase to ensure that every behaviour from formation influences are accommodated in the model, finally all the developed model were integrated to produces the final developed model to monitor decomposing state of the microbes in homogeneous silty formation.

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