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Research article

MODELING EDWARDSIELLA TRANSPORT INFLUENCED BY PHYSIOCHEMICAL DEPOSITION IN HOMOGENEOUS VELOCITY AND PERMEABILITY IN UNCONFINED BED IN COASTAL AREA OF WARRI, NIGER DELTA OF NIGERIA

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Abstract

The deposition of Edwardsiella in unconfined bed in coastal area of warri was expressed through analytical procedure, this concept was developed since other application used to monitor the deposition and rate of concentration at different strata proof abortive, risk assessment carried could not provide better solution that can reduce or prevent the migration of Edwardsiella from surface of the soil to unconfined bed, the study also in another development confirmed Excessive usage of different types of chemical constituents through the activities of man has cause lots of pollution in soil and water environment. The deltaic environment developed reflection of the rate of migration in the formation as it is expressed from the result from previous investigation on water quality assessment at different location. This has reflected on high concentration of different types of pollution sources influenced by the activities of man. Formation characteristics that reflect the deltaic nature of the soil, it has been expressed in geologic history to be predominant with alluvium deposition with high yield rate of groundwater known as Benin formation. Such condition has generated degradation of water quality in the study area. In line with this conceptual framework, mathematical model were developed expressing these variables in the system that influence the migration of Edwardsiella, this is under the influence of physiochemical deposition at various formations. The model will definitely monitor the behaviour of Edwardsiella transport under the influence of formation characteristics including physiochemical influences in soil and water environment.

Keywords: modeling Edwardsiella, physiochemical deposition, homogenous velocity and porosity and unconfined bed

1. Introduction

Indicator organisms are frequently used in place of disease causing pathogens because their presence is indicative of pathogen presence and indicator organisms are easier to detect. Another reason for using simple indicator tests is that pollution is often irregular. It is better to monitor drinking water frequently by means of a simple test than occasionally using more complicated direct pathogen detection tests. Indicator organisms, however, are not universal. Many studies have shown that while traditional indicators may have worked for developed countries in temperate climates, they are not necessarily appropriate for developing countries in tropical environments (Eluozo and. Afiibor 2013). There is a need to investigate the suitability of these indicators for their use in tropical environments for the detection of recent fecal contamination in drinking water supplies. Extensive research has already been carried out in this area. These indicators have different characteristics and their significance to the microbial quality of drinking water can vary depending on the monitoring region. After the most appropriate indicator organisms are identified, the methods for their detection are assessed and compared. There is a wide variety of methods available for testing the microbial quality of drinking water through indicator organisms. The two most common methods that are studied in detail in this thesis are the Presence/Absence (P/A) test and Membrane Filtration (MF) test. The P/A test is a simple method to identify the presence or absence of the indicator organism and is often indicated by a color chang (Eluozo and. Afiibor 2013). While the P/A test may be adequate for detecting the presence of indicator organisms, it is unable to assess the extent of contamination in the water sample. The ability to enumerate indicator organisms is particularly important when assessing the performance of a water treatment device such as a water filter. It allows the researcher to calculate microbial removal efficiency by finding out how much of the indicator organisms are removed by the filter. Since the quality of the water supply is often variable and cannot be adequately controlled for millions of people in developing countries, one viable approach could be the implementation of simple, low-cost point-of-use (POU) treatment systems to ensure the provision of safe water for consumption. Point-of-use treatment systems refer to the treatment of water at the household level as opposed to centralized, larger capacity municipal or private systems that carry out treatment of water for a larger population. While an advanced large-scale water treatment system is able to supply many households at any one time, a simple and affordable household water treatment system will be able to reach even the most rural areas of developing countries such as Nepal, therefore reducing their dependency on unsafe drinking water supplies. A good POU system should also satisfy the criteria of requiring minimum training and being easily and cheaply maintained. According to WHO, not all potential waterborne human pathogens are of equal public health significance. Some of them present a serious risk of disease whenever they are consumed in drinking water and are given high priority for health significance. Examples include strains of *Escherichia coli, Salmonella, Shigella, Vibrio cholerae, Yersinia enterocolitica,* and *Campylobacter jejuni*. On the other hand, some organisms may cause disease .opportunistically..

These organisms cause infection mainly among people with impaired natural defense mechanisms. These people include the very old, the very young, Immunocompromised people, and patients in hospitals. Examples of these organisms include *Pseudomonas, Klebsiella,* and *Legionella* (WHO, 1996). For pathogens of fecal origin, drinking water is the main route of transmission. Unhygienic practices during the handling of food, utensils and clothing also play an important role. Humans are typically the main carriers of large populations of these bacteria, protozoa, and viruses (WHO, 1996). Pathogens originating from human sources, often from human feces, are called .enteric. (of intestinal origin) pathogens. An example is *E.coli* O157:H7. The intestine of many domestic and wild animals, their meat, milk and dairy products, are sources of the bacteria *Yersinia enterocolitica* and *Campylobacter* (WHO, 1996). The persistence of a pathogen in water also affects their transmission to humans. A more persistent pathogen that can survive longer outside the host body is more likely to be transmitted to other people. Bacteria are single-celled prokaryotes (without nucleus) with sizes ranging from 0.3 to 100 micrometers (μm) in length (Metcalf and Eddy, 1991). Therefore, these organisms can survive for long periods in water habitats (WHO, 1996). *Shigella*, also part of Enterobacteriaceae, causes dysentery in humans and is usually transmitted through direct contact. Other bacteria species of significance but not part of this family include the following: *Vibrio cholerae,* specifically the serogroups O1, causes cholera, an acute intestinal disease with massive diarrhea, vomiting, dehydration, possibly leading to death. Some other pathogenic bacteria include *Campylobacter* and opportunistic pathogens such as *Legionella pneumophila* and *Aeromonas E.coli* are characterized by their ability to produce potent .Enterotoxins.. Enterotoxins are similar to hormones which act on the small intestine, causing massive secretion of fluids which lead to the symptoms of diarrhea (Madigan et al., 2000, Chian, 2001). Another important protozoan, the *Cryptosporidium* species, also causes diarrhea. Specifically, *C. parvum* is the major species causing the disease. Human beings are the reservoir for these infectious protozoa's and one infected human can excrete 109 oocysts a day. *C. parvum* oocysts are 4 to 6 μm in size and spherical in shape. Similar to *Giardia* cysts, *C. parvum* oocysts can survive for several months in water at 4ºC and are highly resistant to chlorine. *C. parvum* also has a low infective dose. The disease was produced in two primates when they were given a dose of only 10 oocysts (Miller et al., 1990). While these indicator bacteria or viruses are not necessarily pathogenic themselves, some of them have the same fecal source as the pathogenic bacteria and can therefore indicate fecal contamination of water (WHO, 1993a). One example which fulfils many of the above criteria is the indicator organism *E.coli*. Therefore, it may be sufficient to get an indication of the presence of pathogens of fecal origin with the detection and enumeration of *E.coli*. Such a substitution is especially valuable when resources for microbiological examination are limited as in Nepal or other developing countries the disposal of municipal solid waste (MSW) has the potential to impact the environment negatively. The main concern is to prevent the contamination of soil and water by the leachates that originates in the decomposition of the solid waste inside landfills (Kjeldsen et al., 2002). The volume and chemical composition of leachates depends on the water that infiltrates in the landfill, and on the chemical reactions between the solid and liquid phases, including dissolution, precipitation, ion exchange and biochemical processes. Leachates migration from inside the landfill cell to the vadose zone is prevented by low permeability liners (Petrov and Rowe, 1997; Guyonnet et al., 2005; Touze-Foltz et al., 2006 Francisca, 2010), which usually have multiple layers of compacted clay,

granular filters and geosynthetics. Compacted clays or mixtures of local soils with clay are frequently used to achieve very low hydraulic conductivity barriers and prevent subsurface contamination. The hydraulic conductivity can be further reduced by the addition of Bentonite to local soils to attain the values specified by international regulations (kb10−7 cm/s) (Kayabali, 1997; Goldman et al., 1998). The ability of compacted soil liners to restrict the movement of water and contaminants depends on particle size, void ratio, specific surface, degree of saturation, and fluid properties (Vukovid and Soro, 1992; Foged and Baumann, 1999). Soil fabric, compaction energy and thixotropy are also relevant properties (Daniel and Benson, 1990; Benson and Trast, 1995). Different particle associations created during compaction generate either flocculated or dispersed soil fabrics, and are of fundamental importance in the soil hydraulic conductivity (Mitchell et al., 1965). In the past two decades, several studies were conducted to evaluate how soil and liquid properties control the hydraulic conductivity of soil liners (Mitchell et al., 1965; Mitchell and Jaber, 1990; Gleason et al., 1997; Schmitz, 2006). In general, the hydraulic conductivity of soils decreases with increasing fine particle content (Sivapullaiah et al., 2000). At high mechanical stress levels and in the case of highly compacted soils, electrical forces have negligible effect on soil behavior and soil fabric is slightly affected by the chemical properties of the permeating liquid (Mitchell and Soga, 2005). However, hydraulic behavior of fine soils with high porosity and freshly compacted soils is highly influenced by the interaction between the pore fluid and mineral particles.

2. Theoretical background

Environmental and public health trouble connected with the dispersal of sewage on land have been experienced for the year's dawn of the 20th century. Instances of land procedure of sewage are increasing because this disposal process removes some of the contaminants 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 Jamal et al 1994). 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 application 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.(Jamal et al 1994).

3. Governing Equation

Nomenclature

C - Concentration

K_d - Decay

K - Permeability

θ	-	Porosity
S	-	Physiochemical
D	-	Dispersion
V		Velocity
X	-	Distance
T	-	Time

$$K\frac{\partial c}{\partial t} + K_d S\frac{\partial c}{\partial t} = D\frac{\partial^2 c}{\partial X^2} - V\frac{\partial c}{\partial X} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Applying physical splitting techniques on equation (1)

Equation (1) developed in appliance of the influential variables including the physiochemical properties interaction on the several conditions, this condition are were decay phase express its function under the influences of soil formation conditions with Edwardsiella transport in homogeneous velocity and permeability. Mathematical equations were generated denoted by mathematical symbols expressing the parameters as presented in the nomenclature. Physical split techniques were applied that descretized the variables to express their functions in the system. Introducing the splitting application is denoted with a constant C_1. Boundary values were introduced to determine the limit of distance and time including the initial concentration of the solute.

$$K\frac{\partial c_1}{\partial t} = K_d\frac{\partial c_1}{\partial t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$\left.\begin{array}{l} t = 0,\quad x = 0 \\ C_{(o)} = 0 \\ \left.\dfrac{\partial c_1}{\partial t}\right| t = 0 \end{array}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

$$K\frac{\partial c_2}{\partial t} = D\frac{\partial^2 c_2}{\partial X^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

$$\left.\begin{array}{l} t = 0,\quad x = 0 \\ C_{(o)} = 0 \\ \left.\dfrac{\partial c_2}{\partial t}\right| = 0 \\ t = 0 \end{array}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

$$K\frac{\partial^2 c_3}{\partial t} = -\frac{V\partial c_3}{\partial X} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

$$\left.\begin{array}{l} t = 0 \\ C_{(o)} = 0 \end{array}\right| \; t = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (7)$$

$$D\frac{\partial^2 c_4}{\partial X^2} = -V\frac{\partial c_4}{\partial X} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (8)$$

$$\left.\begin{array}{l} x = 0 \\ t = 0 \\ C_{(o)} = 0 \end{array}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (9)$$

$$\left.\frac{\partial c_4}{\partial X}\right| \; x = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (10)$$

Applying direct integration on (2)

$$K\frac{\partial c}{\partial t} = K_d C + K_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (11)$$

Again, integrate equation (11) directly, yield

$$KC = K_d Ct + K_1 t \quad K_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (12)$$

Subject to equation (3), we have

$$KC_o = K_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (13)$$

And subjecting equation (11) to (3)

$$at \left.\frac{\partial c_1}{\partial t}\right| = 0 \quad C_{(o)} = C_o$$
$$t = 0$$

Yield

$$0 = K_d C_o + K_2$$

$$\Rightarrow K_2 = -K_d C_o \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (14)$$

So that, put (13) and (14) into (13), we have

$$KC_1 = K_d C_1 t - K_d C_o t + KC_o \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (15)$$

$$KC_1 - K_d C_1 t = KC_o - K_d C_o t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (16)$$

$$\Rightarrow \quad C_1 \left(K - K_d t\right) = C_o \left(k - K_d t\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (16)$$

The procedure of this conceptual formation is carried out by expressing the variables through mathematical symbols and it resultant is to establish their functions at different setting in terms of relations to monitor the behaviour of the contaminants at various conditions in soil and water environments. This expression continued from equation (2) to equation (16) where a constant concentration in the system was determined.

$$\Rightarrow \quad C_1 = C_o \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (17)$$

Hence equation (16) entails that at any given distance, *x*, we have constant concentration of the contaminant in the system. Now we consider equation (4) which is the progressive phase of the system.

$$K\frac{\partial c_2}{\partial t} = D\frac{\partial^2 c_2}{\partial X^2} \quad \ldots\ldots\ldots\ldots\ldots \quad (4)$$

Approach this system using the Bernoulli's method of separation of variables

i.e. $C_2 = XT$ $\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$ (18)

i.e. $K\frac{\partial c_2}{\partial t} = XT^1$ $\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$ (19)

$$\frac{\partial^2 c_2}{\partial X^2} = X^{11}T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (20)$$

Put (19) and (20) into (18), so that we have

$$KXT^1 = DX^{11}T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (21)$$

i.e. $\frac{KT^1}{T} = \frac{DX^{11}}{X} = -\lambda^2$ $\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$ (22)

Hence $\frac{KT^1}{T} + \lambda^2 = 0$ $\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$ (23)

$$X^{11} + \frac{\lambda^2}{V} = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (24)$$

And

$$DX^{11} + \lambda^2 T = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (25)$$

From (24) $$T = ACos\ \frac{\lambda}{K}t + B\,Sin\ \frac{\lambda}{K}x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (26)$$

And (19) gives:

$$T = C\ell^{\frac{-\lambda^2}{V}t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (27)$$

Progressive phase of the Edwardsiella migration process were measured, this were expressed in equation (18) applying the split method from equation (4), deriving the expression using the Bernoulli's method of separation of variable, it was mathematically established, whereby a steady symbol was equated by integrating equations (19) and (20) into equation (18). Hence, evaluating the solution by integrating the constant from equations (22) to (26) into equation (19) gives a model established in exponential phase of the Edwardsiella transport, which is a model at equation (27).

By substituting (25) and (26) into (18) we get:

$$C_2 = \left[ACos\ \frac{\lambda}{\sqrt{K_d}}t + B\,Sin\ \frac{\lambda}{\sqrt{K_d}}x\right]C\ell^{\frac{-\lambda^2}{K}t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (28)$$

Subject equation (28) to condition in (5), so that we have

$$C_o = AC \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (29)$$

Equation (29) becomes:

$$C_2 = C_o\ell^{\frac{-\lambda^2}{D}t}\ Cos\frac{\lambda}{\sqrt{k}}x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (30)$$

Again at $\left.\frac{\partial c_2}{\partial t}\right| = 0, \quad x = 0$

$$t = 0, B$$

Equation (30), becomes:

$$\frac{\partial c_2}{\partial t} = \frac{\lambda}{\sqrt{K}}C_o\ell^{\frac{-\lambda^2}{D}t}\ Sin\frac{\lambda}{K}x \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (31)$$

i.e. $$0 = -C_o\frac{\lambda}{\sqrt{K}}\ Sin\frac{\lambda}{\sqrt{K}}0 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (31)$$

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

Base on this condition substituting equations (25) and (16) into equation (18) developed an establishment to ensure an expression determine the relation with developed model in equation (18). This development represents a model in equation (8). Further expression was developed from equations (28), (29) to (31), initial concentration equating other variables with a constant that were established in equation (22). Due to the behaviour of the microbial deposition and its movement by applying a plug flow procedure, an assumption was made base on the behaviour of the microbes that were integrated in the system, thus substrate utilization were assumed to deposit in some formation on the microbial transport in soil and water environment that denotes (NKP).

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

$$0 = -C_o \frac{\lambda}{\sqrt{K}} Sin \frac{\lambda}{\sqrt{K}} B \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (32)$$

$$\Rightarrow \frac{\lambda}{\sqrt{K}} = \frac{n\pi}{2}, n,1,2,3 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (33)$$

$$\Rightarrow \lambda = \frac{n\pi\sqrt{K}}{2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (34)$$

So that equation (30) becomes

$$C_2 = C_o \ell^{\frac{-n^2\pi^2 V}{2D}t} Cos \frac{n\pi\sqrt{K}}{2\sqrt{K}} x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (35)$$

$$C_2 = C_o \ell^{\frac{-n^2\pi^2 K}{2D}t} Cos \frac{n\pi}{2} x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (36)$$

We consider equation (6)

$$K \frac{\partial c_3}{\partial t} = -V \frac{\partial c_3}{\partial X} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

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

$$C_3 = X^1 T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (37)$$

$$\frac{\partial c_3}{\partial t} = XT^1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (38)$$

$$\frac{\partial c_3}{\partial X} = X^1T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (39)$$

Again, we put (38) and (39) into (37), so that we have

$$VXT^1 = VX^1T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (40)$$

i.e. $$\frac{KT^1}{T} = \frac{VX^1}{X} = -\lambda^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (41)$$

Hence $$\frac{KT^1}{T} + \lambda^2 = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (42)$$

i.e. $$X^1 + \frac{\lambda^2}{V}X = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (43)$$

And $$KT^1 + \lambda^2 T = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (44)$$

From (44) $$X = ACos\frac{\lambda}{\sqrt{V}}X + BSin\frac{\lambda}{\sqrt{V}}X \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (45)$$

And (38) give

$$T = C\ell^{\frac{-\lambda^2}{K}t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (46)$$

Putting in the substrate utilization established in equation (32), an expression to monitor as well as determine the behaviour and movement of the microbes were considered, this is when there is substrate deposition in the formation, those region when there is substrates deposited in the soil formation were expressed from equations (32) to (36). In further procedures, through the splitting application, velocity and distance were thoroughly integrated to display their functions, this base on the pressure from formation characteristics on microbial transport system at various formations. These proceed with the application of separation of variables whereby, from equation (37) to (45) developed a model where velocity and time were equated with other variables denoted as constant expressed in the model in equation (46).

By substituting (45) and (46) into (37), we get

$$C_3 = \left(ACos\frac{\lambda}{\sqrt{V}}x + BSin\frac{\lambda}{\sqrt{V}}x\right)C\ell^{\frac{-\lambda}{K}t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (47)$$

Subject (47) to conditions in (9), so that we have

$$C_o = AC \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (48)$$

$\therefore$ Equation (48) becomes:

$$C_3 = C_o \ell^{\frac{-\lambda^2}{K}t} Cos \frac{\lambda}{\sqrt{V}} x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (49)$$

Again, at $\left.\frac{\partial c_3}{\partial t}\right| = 0, \quad t = 0$

$$t = 0, B$$

Equation (49), becomes:

$$\frac{\partial c_3}{\partial t} = \frac{\lambda}{\sqrt{K}} C_o \ell^{\frac{-\lambda^2}{D}t} Sin \frac{\lambda}{V} x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (50)$$

i.e. $0 = \frac{-C_o \lambda}{\sqrt{K}} Sin \frac{\lambda}{V} 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (51)$

Subject to these relation, substitution of equations (45) and (46) were integrated into a developed model it generated a comparative model at equation (47). Expressing these relations with boundary values it is found within the limit time, from equations (48) and (49) the expressed boundary values of time produced equation (50) whereby initial concentration were denoted at zero in equation (51).

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

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

$$0 = -C_o \frac{\lambda}{\sqrt{K}} Sin \frac{\lambda}{\sqrt{V}} B \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (51)$$

$$\Rightarrow \frac{\lambda}{\sqrt{V}} = \frac{n\pi}{2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (52)$$

$$\Rightarrow \lambda = \frac{n\pi\sqrt{V}}{2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (53)$$

So that equation (30) becomes

$$C_3 = C_o \ell^{\frac{-n^2\pi^2 K}{4D}t} Cos \frac{n\pi\sqrt{V}}{2\sqrt{V}} x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (54)$$

$$\Rightarrow C_3 = C_o \ell^{\frac{-n^2\pi^2 K}{4V}t} \; Cos \frac{n\pi}{2} x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (55)$$

Now, we consider equation (8), which is the steady flow rate of the system

$$\frac{D\partial^2 c_4}{\partial X^2} = -V\frac{\partial c_4}{\partial X} \quad \ldots\ldots\ldots\ldots \quad (8)$$

Using Bernoulli's method, we have

$$C_4 = XT \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (56)$$

$$\frac{\partial c_4}{\partial X^2} = X^{11}T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (57)$$

$$\frac{\partial c_4}{\partial X} = X^{1}T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (58)$$

Put (57) and (58) into (8), so that we have

$$DX^{11}T = -VX^{1}T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (59)$$

i.e. $$\frac{DX^{11}}{X} = \frac{VX^{1}}{X} = \varphi \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (60)$$

$$\frac{DX^{11}}{X} = \varphi \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (61)$$

$$\frac{-VX^{1}}{X} = \varphi \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (62)$$

$$X = A\frac{\varphi}{D}X \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (63)$$

And $$X = B\ell\frac{-\varphi}{V}X \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (64)$$

Put (63) and (64) into (56), gives

$$C_4 = A\ell^{\frac{\varphi}{V}x} \; B\ell^{\frac{-\varphi}{V}x} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (65)$$

$$C_4 = AB\ell^{(x-x)}\frac{\varphi}{V} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (66)$$

Subject equation (66) and (67) yield

$$C_{(4)} = (o) = C_o \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (67)$$

So that, equation (68) becomes

$$C_4 = C_o \ell^{(x-x)} \frac{\varphi}{V} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (68)$$

Looking at substrate again, establishing relation with velocity of transport on the system, the derived solutions were derived to produces different mathematical expression that were denoted as a constant in equation (55). An assumption was integrated on a microbial deposition at this phase on steady state flow rate, this were split condition of equation (8) was expressed applying Bernoulli's method also. These expressions were from equations (56) to (66) whereby a combination of various variables were integrated representing it as a constant under the influence of velocity of transport subject to equations (66) and (67),developed yield a relation to reintegrate initial concentration under the influence of steady state flow condition. These expressions were integrated to yield equation (68).

Now assuming that, at the steady flow, there is no NKP for substrate utilization, our concentration here is zero, so that equation (68) becomes

$$C_4 = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (69)$$

Therefore solution of the system is of the form

$$C = C_1 + C_2 + C_3 + C_4 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (70)$$

We now substitute (17), (36), (55) and (69) into (70), so that we have the model of the form

$$C = C_o + C_o \ell^{\frac{-n^2\pi^2K}{2D}t} \bullet \frac{n^2\pi^2V}{4D}x \; Cos \frac{n^2\pi^2}{4}x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (71)$$

$$\Rightarrow C = C_o \left[1 + \ell^{\frac{-n^2\pi^2K}{2D}t} \bullet \frac{n^2\pi^2V}{4D}x \; Cos \frac{n^2\pi^2}{4}x\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (72)$$

Putting in mind the variables integrated at various phase influenced by formation variation including the behaviour of the Edwardsiella, there are some region of the formation that substrate may not deposit, the transport process may not experience substrate utilization, this yield zero concentration in equation (69) as expressed above. The split concept at various conditions of the system were established at equation (70) whereby equations (17), (36), (55) and (69) were integrated into equation (70) to generate a final model equation at equations (71) and (72). This

developed concept consider all these variables in the system that will monitor the physiochemical interaction with Edwardsiella transport on homogeneous velocity and permeability in the study environments

Conclusion

Modeling of Edwardsiella transport in homogeneous velocity and permeability influenced physiochemical deposition has been thoroughly expressed. Physiochemical are other substances that deposit through natural origin or man-made activities; such substances are known to be metallic elements including substrate deposition (NKP) etc. These are deposited in the soil and water environment. The microbial transport process is influenced by these physiochemical properties whereby interactions are expressed through the behaviour of the microbial migration in progressive phase, or lag phase including decay phase. This circumstance may be found reflecting through other influences such as formation characteristics that develop more dynamic behaviour of the microbial concentration to groundwater aquifers. The developed model will monitor the behaviour of the microbes. The concept was to ensure that results from those formation and physiochemical influences are integrated on transport evaluation; this will ascertain monitoring the rates and migration process of concentration at different strata of microbial deposition in soil and water environment.

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