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Original article

Mathematical modeling to monitor physiochemical interaction with e. coli transport in homogeneous fine sand on the application of colloid filtration method in port harcourt, Niger delta of Nigeria

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ABSTRACT

Excessive usage of different types of chemical constituents through the activities of man has caused a lot of pollution in soil and water environment. The deltaic environment are not left behind, in fact it is an area to be taken as the worst condition in research of groundwater pollution transport in developing nation. This has reflected on high concentration of different types of pollution sources influenced by the activities of man as industrialized environment. Formation characteristics that reflect the deltaic nature of the soil 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 E.coli under the influence of physiochemical deposition at various formations. The model will definitely monitor the behaviour of E. coli transport under the influence of these chemical properties in soil and water environment.

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. 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 change. 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 (Vuković 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

According to John et al (2011) Agriculture chemical are normal agric tools used to protect agricultural products. But the excessive usage of the material generates a lot of soil and groundwater pollution. Most parts of the world generate their economic growth in agriculture, developed nations around the globe has developed some concepts to reduce the rate of chemical pollution emanating from agricultural process. Developing nations like Nigeria has not realized the negative impact from this source of pollution are very high. Although much agricultural activities are not practiced, but if government policies on agricultural reforms are implemented, then the rate of this source of pollution will be very high. The deltaic nature of the soil will generate high concentration of agricultural source of pollution as this will be a serious threat to groundwater in deltaic environment.

The reason for this prediction is because the stratification of the soil is deltaic in nature where the rate of porosity are high and deposition of shallow aquifers. More so, the formations of the soil are predominant with homogeneous formation. Agricultural practices are done within the surface of the soil, but the deltaic natures of the soil are where the rate of pollution rely on. In this context it is imperative that such study of monitoring the rate of pollution is carried out. The result will predict the rate of pollution from the surface to ground water aquifers, the migration of this contaminant will be determined in some factors based on the formation characteristics of the soil in the study area. So many models have been developed to simulate and predict the fate

and transport of agricultural chemicals. (John et al, 2011). The most famous model is based on convection dispersion equations and considers such mechanism as convection dispersion, sorption and degradation. The transport of solute, including herbicides has been widely studied under field laboratory condition in both disturbed and undisturbed bed soil columns. The sorption and degradation of herbicides are included in the studies. Van Genuchten (1981), Van Genuchten and Wagenet (1989), Gamerdinger et al (1991).

3. Governing mathematical equation

3.1. Nomenclature

C	-	Concentration
P_b	-	Bulk density
θ	-	Porosity
S	-	Physiochemical
D	-	Dispersion
V		Velocity
X	-	Distance
T	-	Time

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

Applying physical splitting techniques on equation (1)

Equation (1) expresses the application of determining the physiochemical properties interaction with E.coli transport in homogeneous fine sand on the application of colloid filtration method. Mathematical equations were developed denoted by mathematical symbols, the expressing the parameters are presented in the nomenclature. Physical split techniques were applied that descretized the variables to express their thorough functions in the system. Introducing the splitting application is denoted with a constant C_1-C_3, Boundary values were introduced to determine the limit of distance and time including the initial concentration of the solute.

$$\frac{P_b}{\theta}S\frac{\partial c_1}{\partial t}=P_b\frac{\partial c_1}{\partial t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

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

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

$$\left.\begin{aligned} &t=0,\quad x=0\\ &C_{(o)}=0\\ &\left.\frac{\partial c_2}{\partial t}\right|\ =0\\ &\qquad t=0 \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

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

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

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

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

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

Applying direct integration on (2)

$$V\frac{\partial c}{\partial t} = \frac{P_b}{\theta}C + K_1 \quad \text{.....} \quad (11)$$

Again, integrate equation (11) directly, yield

$$VC = \frac{P_b}{\theta}Ct + K_1 t \;\; K_2 \quad \text{.....} \quad (12)$$

Subject to equation (3), we have

$$VC_o = K_2 \quad \text{.....} \quad (13)$$

And subjecting equation (11) to (3)

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

$$t = 0$$

Yield

$$0 = \frac{P_b}{\theta}C_o + K_2$$

$$\Rightarrow K_2 = -\frac{P_b}{\theta}C_o \quad \text{.....} \quad (14)$$

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

$$VC_1 = \frac{P_b}{\theta}C_1 t - \frac{P_b}{\theta}C_o t + VC_o \quad \text{.....} \quad (15)$$

$$VC_1 - \frac{P_b}{\theta}C_1 t = VC_o - \frac{P_b}{\theta}C_o t \quad \text{.....} \quad (16)$$

The splitting techniques proceeds expressing the variables through mathematical symbols, it is derived to express their functions at various conditions in terms of interactions to determine the behaviour of the solute 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.

$$\Rightarrow \quad C_1\left(V - \frac{P_b}{\theta}t\right) = C_o \left(V - \frac{P_b}{\theta}t\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (16)$$

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

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.

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

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

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

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

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

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

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

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

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

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

And

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

From (24) $T = ACos\ \frac{\lambda}{V}t + BSin\ \frac{\lambda}{V}x$ ..... (26)

And (19) gives:

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

Exponential phase of the microbial transport were considered that were expressed in equation (18) through the split method from equation (4), deriving the expression using the Bernoulli's method of separation of variable, it was mathematically expressed whereby a constant was equated by putting equations (19) and (20) into equation (18). Hence, expressing the solution by integrating the constant from equations (22) to (26) into equation (19) gives a model that expressed the exponential phase of the microbial transport, which is a model at equation (27). By substituting (25) and (26) into (18) we get:

$$C_2 = \left[ACos\ \frac{\lambda}{\sqrt{V}}t + BSin\ \frac{\lambda}{\sqrt{V}}x\right]C\ell^{\frac{-\lambda^2}{V}t} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (28)$$

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

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

Equation (29) becomes:

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

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

Again at $t = 0, B$

Equation (30), becomes:

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

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

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

Subject to the relation by substituting equations (25) and (16) into equation (18) an expression to determine the relation with the developed model in equation (18) were generated it represents a model in equation (8). Further expressions were developed from equations (28), (29) to (31), this expressed initial concentration equating other parameters with a constant that were expressed in equation (22). Due to the behaviour of the microbial migration applying a plug flow integrated, an assumption were made in the system where the 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), as the equation were expressed in this form.

$$0 = -C_o \frac{\lambda}{\sqrt{V}} Sin\frac{\lambda}{\sqrt{V}}B \quad \text{..... (32)}$$

$$\Rightarrow \frac{\lambda}{\sqrt{V}} = \frac{n\pi}{2}, n,1,2,3 \quad \text{..... (33)}$$

$$\Rightarrow \lambda = \frac{n\pi\sqrt{V}}{2} \quad \text{..... (34)}$$

So that equation (30) becomes

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

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

We consider equation (6)

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

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

$$C_3 = X^1 T \quad \text{..... (37)}$$

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

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

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

$$VXT^1 = VX^1T \quad \text{..... (40)}$$

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

Hence $$\frac{VT^1}{T} + \lambda^2 = 0 \quad \text{..... (42)}$$

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

And $$VT^1 + \lambda^2 T = 0 \quad \text{..... (44)}$$

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

And (38) give

$$T = C\ell^{\frac{-\lambda^2}{V}t} \quad \text{..... (46)}$$

Integration of the substrate utilization from equation (32), an expression to determine the behaviour of the microbes when there is substrates on a certain region of the soil were expressed from equations (32) to (36). In further expression, on splitting application, velocity and distance were thoroughly integrated to display their functions on the influence of the 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 equate other variables as constant were expressed in the model in equation (46).

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

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

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

$$C_o = AC \quad \text{..... (48)}$$

$\therefore$ Equation (48) becomes:

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

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

$$t = 0, B$$

Equation (49), becomes:

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

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

Subject to the relation, substitution of equations (45) and (46) were integrated into a developed model that generated a comparative model at equation (47). Expressing the relations where boundary values were integrated

within the limit of 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).

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

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

$$0 = -C_o \frac{\lambda}{\sqrt{V}} \; Sin \frac{\lambda}{\sqrt{V}} B \quad \text{..... (51)}$$

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

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

So that equation (30) becomes

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

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

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

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

Using Bernoulli's method, we have

$$C_4 = XT \quad \text{..... (56)}$$

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

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

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

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

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

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

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

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

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

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

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

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

Subject equation (66) and (67) yield

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

So that, equation (68) becomes

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

Considering substrate again, in relation to velocity of transport on the system the expressions were derived to generate different interactions that were denoted as a constant in equation (55). An assumption was considered on a microbial system to be on steady state flow rate whereby the 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 expressed as a constant under the influence of velocity of transport subject to equations (66) and (67) 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

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

Therefore solution of the system is of the form

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

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

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

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

Considering a condition as assumed when the transport process did not experience substrate utilization, this yield zero concentration and equation (69) were expressed to be zero. The split method at various conditions of the system were expressed 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 expression developed considering all the variables in the system will be able to monitor the physiochemical interaction with E.coli transport on homogeneous fine sand through the application of colloid filtration method in the study location.

4. Conclusion

Modeling of physiochemical interaction with e.coli transport in homogeneous fine sand applying colloid filtration theory has been thoroughly expressed. Physiochemical constituents are other influences that deposit through natural origin or man-made activities; these are known to be metallic elements 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 exponential phase, in lag phase or in decay phase. These conditions reflect other influences such as formation characteristics that develop more dynamic behaviour of the microbial concentration to groundwater aquifer. The

developed model will monitor the behaviour of the microbes applying the colloid filtration theory. It will generate a result that will be integrated on transport evaluation and monitoring of microbial concentration in soil and water environment.

References

Glatstein, F.F.M., 2010. D.A. Long term hydraulic conductivity of compacted soils permeated with landfill leachates Applied Clay Science 49 187–193

Low, C.S., 2002. Appropriate Microbial Indicator Tests for Drinking Water in enveloping Countries and Assessment of Ceramic Water Filters Submitted to the Department of Civil and Environmental Engineering in Partial Fulfillment of the Requirements for the Degree of Master of Engineering in Civil and Environmental Engineering at the Massachusetts Institute of Technology

Metcalf, Eddy, 1991. *Wastewater Engineering: Treatment, Disposal and Reuse.* McGraw Hill Book Co., Singapore.

Madigan, M.T., Martinko, J.M., Parker, J., 2000. *Brock Biology of Microorganisms, 9th Edition.* Prentice Hall, NJ.

World Health Organization (WHO) 1993a. *Guidelines for Drinking Water Quality, 2nd ed. Vol. 1 - Recommendations*. Geneva

World Health Organization (WHO) 1996. *Guidelines for Drinking Water Quality, 2nd ed. Vol. 2 – Health criteria and other supporting information.* Geneva.

Kjeldsen, P., Barlaz, M.A., Rooker, A.P., Baun, A., Ledin, A., Christensen, T.H., 2002. Present and long-term composition of MSW landfill leachates: a review. Critical Reviews in Environment Science and Technology 32 (4), 297–336.

Guyonnet, D., Gaucher, E., Gaboriau, H., Pons, C.-H., Clinard, C., Norotte, V., Didier, G., 2005. Geosynthetic clay liner interaction with leachates: correlation between permeability, microstructure, and surface chemistry. Journal of Geotechnical and Geoenvironmental Engineering 131 (6), 740–749

Touze-Foltz, N., Duquennoi, C., Gaget, E., 2006. Hydraulic and mechanical behavior of GCLs in contact with leachates as part of a composite liner. Geotextiles and Geomembranes 24, 188–197.

Petrov, R., Rowe, R., 1997. Geosynthetic Clay Liner (GCL) — chemical compatibility by hydraulic conductivity testing and factors impacting its performance. Canadian Geotechnical Journal 34, 863–885

Kayabali, K., 1997. Engineering aspects of a novel landfill liner material: bentoniteamended natural zeolite. Engineering Geology 46 (2), 105–114.

Goldman, L.J., Greenfield, L.I., Damle, A.S., Kingsbury, G.L., Northeim, C.M., Truesdale, R.S., 1998. Design, Construction, and Evaluation of Clay Liners for Waste Management Facilities. USEPA,Washington D.C. EPA/530/SW- 9/007F.

VanGulck, J.F., Rowe, R.K., Rittmann, B.E., Cooke, A.J., 2003. Predicting biogeochemical calcium precipitation in landfill leachate collection systems. Biodegradation 14 (5), 331–346.

Foged, N., Baumann, J., 1999. Clay membrane made of natural high plasticity clay: leachate migration due to advection and diffusion. Engineering Geology 54, 129–137

Daniel, D.E., Benson, C.H., 1990. Water content-density criteria for compacted soil liners. Journal of Geotechnical Engineering 116 (12), 1811–1830.

Benson, C.H., Trast, J.M., 1995. Hydraulic conductivity of thirteen compacted clays. Clays and Clay Minerals 43 (6), 669–681.

Mitchell, J.K., Hooper, R., Campanella, R., 1965. Permeability of compacted clay. Journal of Soil Mechanics and Foundation Division 91 (4), 41–65.

Mitchell, J.K., Jaber, M., 1990. Factors controlling the long-term properties of clay liners. Waste containment systems: construction, regulation and performance. ASCE.

Geotechnical Special Publication 26, 84–105.

Gleason, M.H., Daniel, D.E., Eykholt, G.R., 1997. Calcium and sodium Bentonite for hydraulic containment applications. Journal of Geotechnical and Geoenvironmental Engineering 123 (5), 438–445.

Sivapullaiah, P.V., Sridharan, A., Stalin, V.K., 2000. Hydraulic conductivity of bentonite– sand mixtures. Canadian Geotechnical Journal 37 (2), 406–413.

Schmitz, R.M., 2006. Can the diffuse double layer theory describe changes in hydraulic conductivity of compacted clay? Geotechnical and Geological Engineering 24, 1835–1844.