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Research article

M0DELING THE DEPOSITION POTASSIUM IN LATERITIC SOIL ON BATCH SYSTEM APPLICATION INFLUENCING E. COLI TRANSPORT

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Abstract

Modeling the deposition of potassium and E.coli on batch system application in homogeneous lateritic soil formation influenced by porosity has been expressed. The model was developed in phases, microbial and potassium deposition was monitored in exponential phase considering the concentration with respect to time and velocity of transport. Subject to the relation, porosity was integrated in the expression due to predominant influence of such parameters in the study location. Homogeneous stratification was confirmed through hydrogeological studies. Based on these factors, the model equations were modified considering the system as a batch based on the uniformity of the soil stratification. The final derived model integrates all the models in phases considered base on the behaviour of potassium and E.coli deposition in lateritic soil formation. This final expressed model will definitely monitor the deposition of the substrate and microbes in homogenous lateritic soil formation influenced by porosity in the study area.

Keywords: m0deling potassium, lateritic soil, batch system application, and E. coli transport

1. Introduction

To recapitulate, *E. coli* microorganisms have often been establish in focally polluted soil and water , are easy to count, and are hydrophilic and powerfully unconstructively charged. These properties make this bacterium a useful indicator of fecal pollution of soil and water, especially in developing countries lacking adequate laboratory capital. In calculation, some *E. coli* strains are enteropathogenic. Viruses may be considered more critical to soil and water quality than *E. coli*. Because of their lesser size, stability, and unconstructive charge, they may be migrated even further through the soil, and because of their infectiousness they symbolize a major threat to public health. However, the discovery and enumeration of viruses, including Bacteriophages requires more technical skills than needed for *E. coli*. The migration of E.coli and deposition of potassium in accumulation in porous media may be normally described by the advection dispersion sorption (ADS) equation (De Marsily, 1986). Several expressions of the ADS equation have been applied for the transport of colloids in general (Herzig et al., 1970; Yao et al., 1971; Corapcioglu and Haridas, 1984, 1985; Murphy and Ginn, 2000; Schijven, 2001) and, more particularly, for the transport of *E. coli* and Thermotolerant coliforms (Pang et al., 2003; Powelson and Mills, 2001; Matthess and Pekdeger, 1981 and 1985; Matthess et al., 1985, 1988. To suitably explain the dynamic effects of colloid deposition and possible blocking effects, the colloid transport equation is expressed in terms of particle number concentration rather than mass concentration (Sun et al., 2001; Johnson et al., 1996) along with terms for attachment, detachment, straining, and inactivation or die-off (Bhattacharjee et al., 2002). Straining is defined as the trapping of bacteria in pore throats that are too small to allow passage, and it results from pore geometry. Matthess and Pekdeger (1988) where *N* is the coordination number or the number of contact points between grains. Foppen et al. (2005) determined the pore volume available for straining from modeling high concentration *E. coli* breakthrough curves, from geometrical considerations based on Herzig et al. (1970) and from a pore size density function, and concluded that pore volumes determined with those methods were in reasonable agreement. Neumann (1983) developed geometrically derived contact efficiency due to straining, based on Hall (1957, Jan, 2007).

2. Theoretical background

Modeling the deposition of potassium in lateritic soil under applying batch system were found necessary because the lateritic source in the upper layer of soil formation that have much interaction with the organic soil, lateritic soil are normally homogeneous in stratification and content some percentage of clayey properties in there deposition since the batch is something acting within a region thus implies that they are not migrating from one environment to another, the uniformity of the lateritic, develop the concept of assuming that the deposition of potassium and E.coli are within a region, then something must happen at those uniform region of the formation. The applications of batch system develop several variations of the substrate generating different behaviour including the microbes E.coli. The uniformity of the formation developed a condition were the substrate and the microbes deposited within the region are not migration to another region due the rate plasticity of the percentage of clayey content in lateritic soil this formation are impermeable layer thus an inhibitor for transportation of the substrate microbes may not possibly the microbes to migrate to other soil formations. Modeling of potassium and E.coli deposition under the influence of batch is essential because concentrations of most microbes are normally deposit high concentration in some formation. The developed mathematical equation will be a useful tool to predict the rate potassium and behavior of E.coli in lateritic soil formation.

More so soil dilapidation processes comprise serious difficulties on a universal basis, with important ecological, social and financial consequences. As the world inhabitants Increases, so does the require to guard the soil as a imperative resource, mainly for food making, The soil is a active intermediate, constituting the habitat of plentiful biodiversity, with unique hereditary patterns where one can find the maximum amount and variety of living organisms, which serve as a nutrient reservoir. One gram of soil in good situation can have 600 million microorganisms belonging to 15,000 or 20,000 dissimilar species. These standards decrease to 1 million bacteria encompassing from 5000 to 8000 species in wasteland soils. Depending on the quantity of natural matter there in the soil, the biological activity eliminates pathogenic agents, decomposes organic matter and other contaminants into simpler components (regularly less toxic), and contributes to maintaining the corporeal and biochemical properties essential for soil fruitfulness and structure. Nevertheless, soil is not an inexhaustible resource and awareness of this, allied to knowledge is require maintaining or growing the capability of this agro-ecosystem, directing its multiple functions in an adequate way, and is escalating, as also changes in the generally perception of its significance as an ecological constituent. Alterations in the substance situation of cultivated soils, such as the concentrations and Types of ions in answer in the soil, variations in pH and in the critical flocculation concentration of the particles, can cause modifications in the dispersion of the clay fraction, degrading the original soil fraction. The sodium ion, being monovalent, increases the width of the diffuse double layer on the surface of the clays, reducing the attractive forces between them with a consequent increase in particle dispersion [Celia and Elisabeth 2011] the expression of the précised microbes and the deposition of substrate are stated below.

3. Governing Equation

$$K\,C_{(x)}\frac{\partial V_{(x)}}{\partial t} = \frac{V\partial C_{(x)}}{\partial t} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (1)$$

The expressions in equation (1) govern the deposition of potassium and E.coli in lateritic soil formation; this is application of batch system because the geological systems from the hydrological study were confirmed to be homogenous lateritic in the study location. The developed mathematical equation measured important variables that influence the system influence the deposition of potassium and E.coli pollute developing high concentration of these two parameters in lateritic soil. The governing equation were derived to integrate the influential parameters in the system and express their functions that aid the deposition of potassium and E.coli in the formation

$$\frac{V\partial C_{(x)}}{\partial t} = K\,C_{(x)}\frac{\partial V_{(x)}}{\partial t} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (2)$$

$$\frac{V\partial C_{(x)}}{\partial t} = -K\,C_{(x)}\frac{V_x}{t} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (3)$$

$$\left(\frac{V}{V_x}\right)\frac{\partial C_{(x)}}{\partial (x)} = -\frac{Kdt}{t} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (4)$$

$$V/V = \int 1/C_{(x)} \ \partial C_{(x)} = -K\int \frac{\partial t}{t} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (5)$$

$$V/V_{(x)} \left[\ln C_{(x)} = -K \ln \frac{t_o}{t}\right] \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (6)$$

$$\ln \frac{C_{(x)}}{C_{(x)o}} = -K\frac{V_{(x)}}{V} \ln \frac{t}{t_o} = \ln\left(\frac{t}{t_o}\right) - K\frac{V_x}{V} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (7)$$

$$\frac{C_{(x)}}{C_{(x)_o}} = \left(\frac{t}{t_o}\right) - \frac{KV_x}{V} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (8)$$

$$\frac{C_{(x)}}{C_{(x)_o}} = \ell^{-K\ln\left(t/t_o\right)V_x/V} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (9)$$

$$C_{(x)} = C_{(x)_o}\ell^{-K\ln 1/t\, V_x/V} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (10)$$

$$C_{(x)} = \beta\,\ell^{-K\ln 1/t}\, Vx/V \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (11)$$

$$\boxed{\beta = C_{(x)_o}\ell\frac{V_{(x)}}{tv}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (12)$$

This expressed model is considered to monitor the deposition of potassium and microbial concentration with respect to velocity of transport and time. The concentration is at initial point of pollution discharge of the biological waste. Constant deposition unifies constant generation of these concentrations with respect to time through velocity of transport. The expressed model in (12) considered the microbial transport through influence of initial point of discharge and velocity of transport.

The model can be applied to monitor the potassium deposition and E. coli on a batch system influenced by porosity.

Integrating the parameter in the equation it becomes

$$C_{(x)} = \beta\,\ell^{nVt} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (13)$$

The geological settings in the area are predominant with homogeneous in lateritic formation, the formation characteristics found to develop high percentage of transport influenced by degrees of porosity and void ratio in the study area including environmental factors, Moreso, High rain intensities increase the degree of soil porosity and saturation. The expressed parameters were integrated into the mathematical expression to yield equation 13

Taking Laplace transform of (13), gives

$$C_{(o)} = \frac{\beta}{nV+S} \qquad \text{.......................................} \qquad (14)$$

$$\Rightarrow \qquad C_{(o)}\left[nV+S\right] = \beta$$

$$C_{(o)}\, nV + C_{(o)}\, S - \beta = 0 \qquad \text{.......................................} \qquad (15)$$

The expressed equations in 13 were transform into Laplace in other for the influential variable to express there functions and also relate with other variables in the system. These derived expressions yield the equation in 15.

Applying quadratic expression on (15), it becomes

$$C_{(x)} = \frac{-S \pm \sqrt{S^2 + 4\beta nV}}{2nV} \qquad \text{.......................................} \qquad (16)$$

Looking at the deposition of potassium and E.coli in an exponential direction, quadratic expression was applied. These is because of the nature of the formation, the formation deposited homogenous, this type of formation under study deposit low permeability but due high rain intensities the deposition of the substrate and the microbes accumulated and generate high concentration in lateritic, therefore high rain intensities increase degree of saturation and produce more deposition of potassium and increase the microbes in the formation. Therefore the deposition of potassium and E.coli in lateritic soil will be on exponential phase, base on these factors quadratic function were find suitable to express the behaviour of the system at this phase

Now $S = nV$ substitute it in equation (16) so that we can have

$$C_{(x)} = \frac{-nV \pm \sqrt{n^2V^2 + 4\beta nV}}{2nV} \qquad \text{.......................................} \qquad (17)$$

Therefore, the general solution can be expressed as

$$C_{(x)} = A\exp\left[\frac{-nV+\sqrt{n^2V^2+4\beta nV}}{2nV}\right]t + \exp\left[\frac{-nV+\sqrt{n^2V^2+4\beta nV}}{2nV}\right]t \quad \ldots\ldots\ldots \quad (18)$$

Subjecting (18) to the following boundary and initial conditions:

At $x = 0$, $C_{(o)} = 0$ and $t = 0$, so that we can have

$0 = A + \beta$, i.e. $A = -\beta$

If $A = 1 \Rightarrow \beta = -1$

And our equation (18) can be expressed thus,

Boundary conditions were established, this is to determine the limits at which the microbes can migrate within the region in homogeneous lateritic soil formation. Such expressions were considered and the boundary values were stated above, the boundary values were integrated in the derived equation stated bellow.

$$C_{(x)} = \exp\left[\frac{-nV+\sqrt{n^2V^2+4\beta nV}}{2nV}\right]t - \exp\left[\frac{-nV-\sqrt{n^2V^2+4\beta nV}}{2nV}\right]t \quad \ldots\ldots\ldots \quad (19)$$

Thus, we convert $\frac{\ell^{x} - \ell^{-x}}{2} = Sin\,x$

So that we can rewrite our equation (19) as

$$\boxed{C_{(x)} = 2\,Sin\,x\left[\frac{nV+\sqrt{n^2V^2+4\beta nV}}{2nV}\right]t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (20)$$

The expression in (20) is the finally developed model to monitor the deposition of potassium and E.coli in homogenous lateritic soil formation, the model considered some parameters relevant to the system, the parameters are base on the geological formation through hydrogeological studies of the area, the parameters considered are found to play major roles influencing the deposition of potassium and E.coli migration in the soil formation. The developed mathematical models also considered the exponential of potassium and microbial in this phase, this condition are imperative because the stratification of the formation deposit homogeneous stratum, thus the develop model expressed the application of batch system in the study area.

4. Conclusion

Predicting the presence of potassium and E.coli in lateritic soil formation has been found in other microorganisms in homogeneous formation. Numerous microbes in fecal Coliform family has been confirmed to be microbial indicator of fecal pollution but the most effective one applied to indicate the presence of fecal Coliform in groundwater is from the group E. coli. These microbes are in the family of fecal coliform including. The deposition of potassium which is substrate utilization to the microbes in lateritic soil formation definitely should displayed variables behaviour in the formation. In such homogenous formation, there is no doubt that microbes of such types deposit a high rate of concentration due to constant regeneration from indiscriminate biological deposition of waste generation. Homogenous settings were related to batch system since the stratification of the soil is predominantly homogenous. This concept was applied to ensure that the microbial transport and the substrate deposited in such homogenous formations are monitored based on its level of stratification deposition. Formations in such formation were found to deposit high degree of porosity influenced by high degree of velocity, the level of deposition from potassium and E.coli can be expressed on the degree of micropores through the predominant homogeneous stratification in the soil. High level of environmental factors displayed lost of influence through change in climatic conditions under the influence of deltaic environment. The developed mathematical model that expressed these influential parameters is to monitor the deposition of potassium and E.coli in lateritic soil influenced by porosity. Finally, experts will find it very important in monitoring including the assessment of high concentration of potassium and E.coli in the study location.

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