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Research article

MODELING DISSOLVED POTASSIUM INFLUENCED BY VELOCITY AND VOID RATIO ON DISPERSION RATE OF FUNGI IN DEPOSITED SILTY FORMATION OF ABOLUMA AREA, RIVERS STATE OF NIGERIA

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Abstract

Dissolved potassium are found to deposit in the study locations, lots of influences were observe in the formation, but the paramount formation characteristics are from an observed investigation confirmed the predominant of high degree of void rate and velocity of flow including dispersion rate through these variables in the system, the deposited strata silty and fine sand formation in aboluma were found to deposit dissolved potassium and fungi concentration through base on high degree of deposited void ratio and velocity of flow, these condition implies that the formation if deposit unconfined bed may experience high concentration of potassium and fungi, the study found the deposition of potassium an exponential phase of fungi through the deposition of potassium that is substrate utilization to microbes. Such condition made need a base line that can be applied to monitor or prevent the deposition of potassium and fungi, mathematical model was find suitable to develop a model that will prevent the dissolved potassium and fungi in silty and fine sand formation.

Keywords: modeling dissolved potassium, velocity, fungi and silty formation

1. Introduction

A major current scientific challenge is scaling from the functional properties of organisms to processes at the ecosystem and global levels (Enquist et al. 2003; Torsvik and Ovreas 2002; Zak et al. 2006). Microbial respiration is a process that has particular importance in the ecosystem and global scales, representing about half of total CO2 flux from soils (Hanson et al. 2000). Furthermore, effects of human-induced climate change on soil microbial communities and their metabolic activities could create potentially devastating feedbacks to the Earth's biosphere (Meir et al. 2006). Biomass made up of fast-growing species respires faster than an equal amount of biomass made up of slow-growing species. Microbes with low growth yields (biomass produced per unit substrate consumed) convert a larger fraction of substrate into CO2 during growth, and so respire faster than efficiently growing organisms. It has been observed that there is an inevitable thermodynamic trade-off between growth rate and yield among heterotrophic organisms (Pfeiffer et al. 2001). Past authors have proposed that two opposing ecological strategies exist at either end of this spectrum: a fast-growing, low yield competitive strategy and a slow growing high yield cooperative strategy (Kreft and Bonhoeffer 2005; Pfeiffer et al. 2001). For microbes, the cooperative, slow, efficient growth strategy is more successful in spatially structured environments such as biofilms (Kreft 2004; Kreft and Bonhoeffer 2005; MacLean and Gudelj 2006; Pfeiffer et al. 2001). With over a billion individual cells and estimates of 104–105 distinct genomes per gram of soil (Gans et al., 2005; Tringe et al., 2005; Fierer et al., 2007b, David et al 2008), bacteria in soil are the reservoirs for much of Earth's genetic biodiversity. This vast phylogenetic and functional diversity can be attributed in part to the dynamic physical and chemical heterogeneity of soil, which results in spatial and temporal separation of microorganisms (Papke and Ward, 2004 *Katherineel al 2011*). Given the high diversity of carbon (C) – rich compounds in soils, the ability of each tax on to compete for only a subset of resources could also contribute to the high diversity of bacteria in soils through resource partitioning (Zhou et al., 2002). Indeed, Waldrop and Firestone (2004) have demonstrated distinct substrate preferences by broad microbial groups in grassland soils and C resource partitioning has been demonstrated to be a key contributor to patterns of bacterial co-existence in model communities on plant surfaces (Wilson and Lindow, 1994).

2. Theoretical background

Velocity and Void depend on the stratification micropores of the formation that deposit at different structure and strata, the degree of void and velocity in soil determine the tortuosity or longitudinal flow path of the formation, this evaluate the level of flow path of fluid under rate of velocity including void ratio that varies according to structural setting of the soil under the influence of geological historical, high variation rate of velocity and void ratio are deposit in soil are base on this condition in developing various percentage of these parameters, degree void and velocity of flow in silty formation can never deposit the same with that of coarse and fine sand formations. The flows under the influence of velocity through tortuosity will definitely experiences vary, the state mean that the hydraulic conductivity abound to be express variation, subject to this relation, the dispersion of fluid flow through velocity will also express comparable variations under the pressure of variation of void and velocity through tortuosity, the flow of potassium in like manner generate its rate of transport under the influence of the structural stratification of the void and degree of velocity, the deposition of potassium in most cases are solute to fluid in soil, the deposition can at any formation of the soil, the formation of the soil determine the rate concentration. Mores the structural deposition of the formation influence the variation of migration under the law of plug flow, such condition in the deposition of fungi develop into focus of concern in the transport behaviour from one stratum to another, the rate of influence are determined by the degree of deposition of the potassium in the formation, in like manner to fluid flow through velocity are under the influence of void ratio the through the rate of tortuosity in the strata, dispersion influence are recorded in the formation base on the rate void ratio and velocity of flow under the deposition of the formation, this condition reflect the geologic history in the study area. Potassium deposition in soil are determine on numerous setting, but high concentration of fungi are influence by the rate of potassium deposition in the formation, the micronutrients is a substrate to fungi, therefore there will be increase in fungi population in the formation, to monitor the rate of potassium deposition under the influences of void ratio, velocity of flow and dispersion influences, mathematical model were found imperative to monitor the deposition of the potassium in soil water environment. These conditions determine the rate of void ratio and dispersion influence on its velocity of flow in the study area. The developed model was generated from a formulated equation to monitor the rate of void ratio and dispersion on phosphorous deposition influence on salmonella in the study area, the express governing equation is stated bellow.

3. Governing equation

$$V\frac{\partial^2 c}{\partial t^2} = \frac{\partial cs}{\partial x}\phi_z C_s + Ds\frac{\partial cs}{\partial x} - M_b\frac{\mu_o}{\gamma_o}\frac{\partial c}{\partial x} + \frac{\partial cs}{\partial t}\frac{Cs}{K_{Ao}+Cs} + \frac{\partial cs}{\partial x}\frac{Cs}{K_A+C_A} \quad \ldots\ldots \quad (1)$$

The governing equation express the influences of

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

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

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

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

$$\frac{\partial cs}{\partial t} = SC_{(t)} - C_{(t)} \quad \ldots\ldots\ldots\ldots \quad (6)$$

$$\frac{\partial cs}{\partial x} = SC_{(x)} - C_{(x)} \quad \ldots\ldots\ldots\ldots \quad (7)$$

Equation (1) to (7) were transform into Laplace, the expression is to convert the parameters to the structure were it can be functional to express their various subject relation at these various function in the system, the transformation application are necessary because it simplify the parameters function at their various areas mathematically in the system, the expression also connect the activities of the parameters that is establish to monitor the behaviour of the microelement under the influence of void ratio, velocity and dispersion of fungi in the system.

$$V\left[S^2C_{(t)} - SC_{(t)} - SC_{(0)}\right] + \phi zCs\left[SC_{(z)} - C_{(0)}\right]Ds\left[SC_{(z)} - C_{(0)}\right] -$$

$$M_b\frac{\mu_o}{\gamma_o}\left[SC_{(z)} + C_{(0)}\right] + \frac{Co}{Ko+Cs}\left[SC_{(t)} + C_{(0)}\right] + \frac{CA}{KA+CA}\left[SC_{(z)} + C_{(0)}\right] \quad \ldots\ldots\ldots\ldots \quad (8)$$

$$V\left[S^2C_{(t)} - C_{(t)} - C_{(0)} + \phi zCs\right]\left[SC_{(z)}{}^2 - 2SC_{(z)}\left(C_{(0)}\right)^2\right]\left[M_b\frac{\mu_o}{\gamma_o} + 2SC_{(z)}C_{(0)} - \left(C_{(0)}\right)^2\right] \quad (9)$$

Equating (9) into time t, we have

$$V\left[S^2C_{(t)} - SC_{(t)} - SC_{(0)}\right] + \phi zCs\left[SC_{(z)}{}^2 - 2SC_{(z)}\left(C_{(0)}\right)^2\right] - \quad \ldots\ldots\ldots\ldots \quad (10)$$

$$M_b\frac{\mu_o}{\gamma_o}\left(SC_{(z)}\right)^2 - 2SC_{(z)}C_{(0)} + \left(C_{(0)}\right)^2 + \frac{Cs}{Ko+Cs}\left(SC_{(z)}\right)^2 - 2SC_{(z)}C_{(0)} + \left(C_{(0)}\right)^2 \quad \ldots \quad (11)$$

Rearranging

(11) yield $a^2 - 2ap + p(a-b)^2$

Equation (8) to (11) show a relationship at various parameters by excising there a variety of role in other to descretize it into a variety of area the parameters activities are more rigorous, the role of the parameters are express in different circumstances, such position implies that the parameters activities may not be concurrently in the system, these is base on the variation of the formation that influences all the parameters in the system, such situation implies that the parameters are influenced by the variation of the soil structural depositions, the expression from equation (8) to(11) were able to differentiate various parameters in accordance with the considered variations of the soil strata in the system, the expression were able to differentiates these parameters in line with their various function base on different condition considered in the study.

$$\left[1 + \frac{Cs}{Kso+Cs}\right]\left[SC_{(t)}\right]^2 - \left[1 + \frac{Cs}{Kso+Cs}\right]2SP_{(z)}C_{(0)} + \left[1 + \frac{Cs}{Kso+Cs}\right]\left[C_{(0)}\right]^2 \quad \ldots\ldots\ldots\ldots \ (12)$$

$$\left[\left(SC_{(z)}\right)^2 - 2SC_{(x)}C_{(0)} + \left(C_{(0)}\right)^2\right]1 + \frac{Cs}{Kso+Cs} \quad \ldots\ldots\ldots\ldots \quad (13)$$

$$\left[\left(SC_{(t)}\right)^2 - 2SC_{(t)}C_{(0)} + \left(C_{(0)}\right)^2\right]1 + \frac{\frac{Cs}{KAo+CA}}{\frac{Cs}{Ks+Cs}} \quad \ldots\ldots\ldots\ldots \quad (14)$$

$$\left[SC_{(t)}\,C_{(0)}\right]^2 - \frac{\frac{CA}{KAo+CA}}{\frac{Cs}{Ks+Cs}} \qquad \ldots\ldots\ldots\ldots \quad (15)$$

Equation (12) to (15) express advance on the behavior of the parameters at different state, but at this stage the concentration of the microbes fungi were paramount in the system, because the behaviour of fungi are resolute by the rate of void ratio, dispersion velocity and deposition of potassium in the formation, therefore the concentration were thoroughly expressed in the system from equation (12) to (15) to monitor the behaviour with respect to time and distance travelled.

$$SC_{(x)} - C_{(0)} = \sqrt{\frac{\frac{CA}{KAo+CA}}{\frac{Cs}{Ks+Cs}}} = \pm 1\sqrt{\frac{\frac{CA}{KAo+CA}}{\frac{Cs}{Ks+CA}}} \qquad \ldots\ldots\ldots\ldots \quad (16)$$

$$SC_{(x)} = C_{(0)} \pm 1\sqrt{\frac{\frac{CA}{KAo+CA}}{\frac{Cs}{Ks+Cs}}} \qquad \ldots\ldots\ldots\ldots \quad (17)$$

$$SC_{(x)} = C_{(0)} + 1\sqrt{\frac{\frac{CA}{KAo+CA}}{\frac{\frac{Cs}{Ks+Cs}}{S}}} \qquad \ldots\ldots\ldots\ldots \quad (18)$$

F(x) when $x > 0 \quad C_{(o)} = P_0$

$$SC_{(x)} = \frac{C_0}{S} + \sqrt{\frac{\frac{CA}{KAo+CA}}{\frac{\frac{Cs}{KA+CA}}{S}}} \qquad \ldots\ldots\ldots\ldots \quad (19)$$

Hence, in any direction of *x*, we have

$$C_{(x)} = \ell^{\frac{C_0}{S}} \left[ACos \sqrt{\frac{\frac{CA}{KAo+CA}}{\frac{\frac{Cs}{Ks+Cs}}{S}}} + BSin \sqrt{\frac{\frac{CA}{KAo+CA}}{\frac{\frac{Cs}{Ks+CA}}{S}}} \right] x \quad \ldots\ldots\ldots\ldots (20)$$

$$\Rightarrow C_{(x)} = \ell^{C_0 t} \left[ACos \sqrt{\frac{\frac{CA}{KAo+CA}}{\frac{\frac{Cs}{Ks+CA}}{S}}}\, t + BSin \sqrt{\frac{\frac{CA}{KAo+CA}}{\frac{\frac{Cs}{Ks+CA}}{S}}} \right] x \quad \ldots\ldots\ldots\ldots (21)$$

To monitor the structure under exponential phase quadratic expressions were well appropriate , the parameters were establish to pressure the concentration of fungi , therefore mathematical expression of quadratic equations were functional to express the parameter in exponential phase, the micronutrients is substrate to fungi, this situation is where there is boost in microbial inhabitants, so at this situation there no propensity of degradation of the microbes, other influential parameters in the system are in continuous process thus influencing the deposition of potassium and fungi in the study area, therefore the approach of applying quadratic expression were suitable in the derived mathematical expression.

Again, we consider (10), so that we have

$$V\left[S^2 C_{(t)} - SC_{(t)} - SC_{(0)}\right] + \phi z Cs\left[SC_{(z)}{}^2 - 2SC_{(z)}\left(C_{(0)}\right)^2\right]$$

$$V\left[S^2 C_{(t)} - SC_{(t)} - C_{(0)}\right] = -\phi z Cs\left[SC_{(z)}{}^2 - 2SC_{(z)}\left(C_{(0)}\right)^2\right] \quad \ldots\ldots\ldots\ldots (22)$$

$$\frac{S^2 C_{(t)} - SC_{(t)} - C_{(0)}}{\left(SC_{(t)} - C_{(0)}\right)^2} = \frac{\phi z Cs}{V} \quad \ldots\ldots\ldots\ldots (23)$$

$$SC_{(t)} - C_{(0)} \neq 0 \quad \ldots\ldots\ldots\ldots (24)$$

Considering the LHS of the numerator of (23) gives

$$C_{(t)} = \frac{S \pm \sqrt{S^2 + 4S^2{}_{(o)}}}{2S^2} \quad \ldots\ldots\ldots\ldots (25)$$

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$$C_{(t)} = \frac{1}{2S} \frac{\pm\sqrt{1+4_{(o)}}}{2S} \quad \ldots\ldots\ldots\ldots \quad (26)$$

When $t > 0 \quad C_{(o)} = C_0$

So that $C_{(t)} = \frac{1}{2S} \frac{\pm\sqrt{1+C_o}}{2S}$

$$C_{(t)} = A\ell^{\frac{1}{2}\left(1+\sqrt{1+C_o}\right)t} + B\ell^{\frac{1}{2}\left(1-\sqrt{1+C_o}\right)t} \quad \ldots\ldots\ldots\ldots \quad (27)$$

Since the denominator of the LHS of (23) has equal Roots

$$P_{(t)} = -\frac{\phi z Cs}{V}(C+Dt)\ell^{(t\ -P_o)t} \quad \ldots\ldots\ldots\ldots \quad (28)$$

Combining equation (27) and (28), we have

$$C_{(t)} = -\frac{\phi z Cs}{V}(C+Dt)\ell^{(1\ +\ C_o)t} + A\ell^{\frac{1}{2}\left(1+\sqrt{1+C_o}\right)t} + B\ell^{\frac{1}{2}\left(1-\sqrt{1+C_o}\right)t} \quad \ldots\ldots\ldots\ldots \quad (29)$$

The expression from equation (22) to (29) were to express the parameters at various area where they are more influential on the deposition of potassium and fungi in the formation, these equations were able to descretize the parameters from equation (10), the expression in equation ten were recalled in other to express the activities of parameters at various level, there various role of influence on the system were expressed at different condition were they influence the deposition of potassium and dispersion through velocity of flow in the system\, subject to this relation, the behaviour of the micronutrients has displayed the consequences through the various activities and function of the parameters. The behaviour of potassium are is influenced by the depended variables in the system; the expression from this dimension integrated the parameters by denoting through mathematical symbols, the express equation in (29) shows that the deposition of potassium and concentration of fungi are with respect to time, the influence from void ratio and velocity of flow developed the spread of the potassium and fungi in the study area, the expression with respect to time are stated below.

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

$$P_{(x,v)} = A\ell^{\frac{1}{2}\left(1+\sqrt{1+C_o}\right)\frac{x}{v}} + B\ell^{\frac{1}{2}\left(1-\sqrt{1+C_o}\right)\frac{x}{v}} - \frac{\phi z Cs}{V}(C+Dt)\ell^{(1\ +\ C_o)\frac{x}{v}} \quad \ldots\ldots\ldots\ldots \quad (30)$$

Development of the final model equation shows how the concentration of fungi and the deposition of potassium considered with respect to distance , the concluding expressed model velocity of transport were considered, the velocity of transport were express in the system were other influential parameters are denoted by other mathematical symbol the major parameters that determine the deposition of potassium and fungi is void ratio and velocity of flow the soil, it is the tortuosity are established which determine the flow path in the soil formations, the parameter were expressed as the dominant variables in the final model expression. The structure of the soil from this dimensions are thoroughly expressed in the final model equation, the model show the rate of exponential phase, because an increase in degree of void ratio and velocity of flow determine the rate of tortuosity in soil formation the condition may definitely increase the rate velocity of flow in fluid on soil formations, therefore the influence of void ratio are subject to increase dispersion influence of fungi deposition in the study location.

4. Conclusion

The rate of velocity and void ratio in soil has been thoroughly express in the derived model equation, this condition are reflected on velocity of flow through the formation characteristics from degree of void ratio, this depend on the soil structural deposition through the geologic history in the study location. The deposition of the micronutrients in the system are determined on the degree of void ratio that reflect on the velocity of flow in the soil, the degree of void ratio in the study location are confirmed through standard experiment of void ratio to be in a very high degree , such condition are reflected on the rate tortuosity that experience high degree also in the system, the expression in this condition generate high velocity of flow, the condition implies that the transport of fungi and potassium will be very speedy beneath the influence of high degree of void ratio deposition and velocity of flow in the study area. The area under study is in deltaic environment, from the investigation carried out the rate of void are very high at every part of the study area, this condition implies that speedy migration of micronutrients abound to be experienced in the soil formations. The expressed final model will able to streamline the behaviour of the substrate deposition and the migration of fungi in the formation, the expression from the final model shows that there is the tendency of continue increase of fungi in the study area, this impression are from the fact that there is high deposition of potassium in the formation such condition is of serious concern in soil and water environment, the developed model will definitely monitor the degree of void ratio including the rate of velocity and the deposition of potassium on the influence of fungi in the study area.

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