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Research article

MODELING VOID RATIO AND DISPERSION OF CARBON INFLUENCE ON CRYPTOSPORIDIUM DEPOSITION IN SILTY FORMATION UNDER PROGRESSIVE PHASE IN COASTAL AREA OF OKRIKA, RIVERS STATE OF NIGERIA

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Abstract

Modeling void ratio and dispersion of carbon influence on cryptosporidium deposition in silty formation under progressive phase in coastal area of Okirika has been thoroughly expressed. Geologic process by which soils are formed described various limits on the size of soil particles and the mechanical analysis of the soil in natural occurrence since it consists of three phases solid. Water and air have a relationship with their structure deposition including their plasticity. Subject to this relation, the volume of relationship that is commonly used for the three phases in soil elements is void ratio, porosity and degree of saturation. This condition expresses the influence of dispersion rate of cryptosporidium dispersion. Thus, stratification of the formation based on these relationships between porosity. Void ratio and degree of saturation has been found to play serious roles in this condition. Formation characteristics such as the void ratio are determined by disintegration of the rock mass under porous condition subjecting it to intercede of the soil matrix. Disintegration of this porous sedimentary rock determines the void deposition which influences the dispersion rate of the microbes. These actions in order to monitor or determine the dispersion rate in the study location, mathematical model were established to ensure that such kinds of determinants are observed. The models were formulated through the variables that influenced the system subjecting them to fast dispersion of the microbes under the influence of void ratio.

Keywords: Modeling, void ratio and dispersion, cryptosporidium and progressive phase.

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1. Introduction

The size and composition of the soil microbial community is a function of net primary production, plant carbon (C) allocation, rhizosphere activity, and litter substrate quality (Smith and Paul, 1990; Fisk and

Fahey, 2001; Myers et al., 2001), and is controlled through complex interactions with plants (Zak et al., 2000; Bohlen et al., 2001; Butler et al., 2004). Changes in atmospheric CO_2 concentration and nitrogen (N) deposition rates alter both the quality and quantity of above- and belowground plant. litter inputs to soil (Aber et al., 1993; Canadell et al., 1996), which in turn can affect belowground microbial community structure and function (Phillips et al., 2002; Frey et al., litter inputs to soil (Aber et al., 1993; Canadell et al., 1996), which in turn can affect belowground microbial community structure and function (Phillips et al., 2002; Frey et al.,2004; Waldrop et al., 2004). Understanding the mechanisms controlling belowground C processes is useful in predicting future changes in soil C stores in response to climate and land-use change (Pendall et al., 2004). Altering root and coarse woody debris (CWD) inputs to soil is one method to examine the feedbacks between plants, microbes, and soil organic matter (SOM) dynamics (Nadelhoffer et al., 2004). In a Douglas-fir forest, 7 y of CWD additions and litter and root exclusion have produced significant changes in annual soil CO_2 efflux (Sulzman et al., 2005). 2004; Waldrop et al., 2004). Understanding the mechan- isms controlling belowground C processes is useful in predicting future changes in soil C stores in response to climate and land-use change (Pendall et al., 2004). Altering root and coarse woody debris (CWD) inputs to soil is one method to examine the feedbacks between plants, microbes, and soil organic matter (SOM) dynamics (Nadelhoffer et al., 2004). In a Douglas-fir forest, 7 y of CWD additions and litter and root exclusion have produced significant changes in annual soil CO2 efflux (Sulzman et al., 2005). The efficiency with which microbes convert assimilated soil carbon into microbial biomass has been called the microbial growth efficiency (Y), carbon-use efficiency, or substrate-use efficiency. This physiological characteristic of the microbial biomass strongly influences overall soil organic carbon (SOC) budgets and carbon sequestration in ecosystems (Six et al. 2006). Since C:nutrient ratios in microbial biomass vary over relatively narrow ranges, Y also contributes to regulation of nitrogen (and other nutrient) mineralization and immobilization in soils (Six et al., 2006). A shift to different groups of active bacteria or fungi could lead to different community growth efficiencies. At higher moisture contents, there also is potential for the microbial population to shift from a population dominated by aerobes toward one where facultative anaerobic microorganisms dominate activity (Sommers et al., 1981). Since anaerobic growth is inherently less efficient than aerobic growth, microbial growth efficiencies integrated across the entire soil community would likely decrease in very wet soils. Second, as soils dry out, substrate supply becomes increasingly limited by slow diffusion rates along the increasingly tortuous paths defined by thin water films (Papendick and Campbell, 1981; Stark and Firestone, 1995). Lower rates of substrate supply mean that a greater proportion of the substrate will be used for mainte- nance energy requirements, less will be available for growth, and Y will be lower. Thirdly, a decrease in water availability may cause a change in the physiology of microbes as they adjust to more desiccating conditions (Stark and Firestone, 1995). For example, one microbial response to water stress is the accumulation of intracellular solutes for osmoregulation (Harris, 1981). Microbial growth may be hindered biochemically by a high intracellular concentration of solutes, or growth efficiency may be lowered because of costs of osmoregulation (Harris, 1981 Justin, et al 2006).

2. Theoretical background

The dispersion rate of contaminant has been examine through the degree of void ratio of soil at different formation, this expression were found through the rate fast dispersion in silty formation in soil and water environment, such condition were found to have develop several rates of concentration of cryptosporidium in the study area, carbon deposition were found also to been under the influence of this state base on the rate dispersions in the study location, high concentration of carbon in the environment were confirmed to have been influenced by this conditions, the deposition of carbon were found to increase microbial population in the formation, structural stratification of the formation are found to deposit homogeneous system. These were found from the geologic history of the study location, the degree of void ration at different strata were also found to deposit high micropores generating high degree of hydraulic conductivity in the formations, such development influence the migration of cryptosporidium in the formation, thus carbon deposition, the development of the governing equation will definitely showcase the behaviuor of carbon under the influence of theses microbes in the study location.

Governing equation

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

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

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

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

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

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

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

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

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

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

Equating (9) into time *t*, we have

$$V\left[S^2C_{(t)} - SC_{(t)} - SC_{(0)}\right] + qzCs\left[SC_{(z)}{}^2 - 2SC_{(z)}\left(C_{(0)}\right)^2\right] - \qquad (10)$$

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

Rearranging (11) yield

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Considering the LHS of the numerator of (23) gives

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

$$\ldots\ldots\ldots\ldots \quad (25)$$

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

$$\ldots\ldots\ldots\ldots \quad (26)$$

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

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

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

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

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

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

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

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

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

Equation (30) expressed the final model equation that will monitor dispersion rate of cryptosporidium under the influence of void ratio of the soil. Subject to this relation, stratification of the formation is found to be paramount on dispersion rate of cryptosporidium in soil and water environment. The final models are expressed to determine the rate of dispersion and void ratio disposition on migration of cryptosporidium to aquiferous zones.

Conclusion

Stratification of the formation are influenced through the disintegration of the porous sedimentary rock mass into intercedes reflecting on geologic history in the study location. This expression reveals the disintegration of sediments under the influence of soil matrix developing variations of void ratios at different strata. Microbial depositions are structured to be influenced by the stratification of the formation. Subject to this relation, mathematical model of such microbes are expressed on the variables that streamline the migration process of cryptosporidium deposition in the study location. The study expressed the progressive condition of the microbes under the influence of dispersion coefficient through void ratio deposition in soil matrix. Practicing engineers will find this mathematical application favourable to determine the relationship of dispersion and void ratio deposition in soil and water environment.

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