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Research article

MODELING POROSITY AND DISPERSION INFLUENCE ON ENTERIC VIRUS GROWTH RATE FROM NITROGEN DEPOSITIOIN SILTY AND FINE SAND FORMATION IN ELEME, RIVERS STATE OF NIGERIA

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Abstract

Modeling porosity and permeability influences on enteric virus growth rate from nitrogen deposition has been expressed. The model were to monitor the deposition of enteric virus under the influence of nitrogen in silty and fine sand formation, the degree of porosity and permeability of the soil were the paramount determinant on the behaviour of nitrogen and transport process of enteric virus in the study area. Half concentration of nitrogen in some formation were considered in the system, because the concentration of the substrate in some formation of the soil deposit slight concentration, geological setting express some roles of experienced variations in the deposition of enteric virus and nitrogen in the study location. To evaluate the behaviour of these two parameters, mathematical modeling approach were find suitable to generate better solution in monitoring the deposition and migration rate of enteric virus in soil and water environments. The developed model were derived to express various parameters that influence the system in the study locations, the governing equation derived expressed models in phases and finally produced the model that express activities of enteric virus and nitrogen deposition in the study area.

Keywords: modeling porosity, dispersions, enteric virus and nitrogen in fine sand and formation

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1. Introduction

Soil biogeochemical cycles are characterized by complex dynamics, acting at different spatial and temporal scales. They are impacted by vegetation and hydro-meteorological forcing and, in turn, exert various feedbacks on the ecosystems, atmosphere, and climate dynamics. Various models have been proposed in the past to investigate these dynamics (e.g. Parton et al., 1988; Hunt et al., 1991; Gusman and Marino, 1999; Melillo et al., 1995; Benbi and

Richter, 2002; Schimel and Weintraub, 2003; Schimel and Bennett, 2004, Manzoni el al 2004 resulting in a deeper understanding of soil biogeochemistry under a broad variety of climatic and ecological conditions. However, given the difficulty of modeling the biological components and the high variability of the hydro meteorological forcing, our ability to model and predict soil Previous theoretical investigations focused mostly on the linear analyses of soil nutrient cycles, providing useful assessments of the effects of model parameters on ecosystem processes (e.g. Bolker et al., 1998; Katterer and Andr`en, 2001; Baisden and Amundson, 2003). Plant litter decomposition is regulated by a suite of interacting hierarchically organized factors, including climate, soil mineralogy, nutrient status, resource quality, and the activity of soil organ-isms (Lavelle et al. 1993; Adair et al. 2008; Wall et al. 2008). As temporal and spatial scales decrease, the importance of resource quality and the decomposer community as regulators of decompo-sition increases. Many studies demonstrate a strong relationship between the chemical composition of substrates and their decom-position rates (e.g. Meentemeyer 1978; Aerts 1997). The impact of the soil community on contemporary decomposition and mineral-ization rates is also amply supported (Setälä et al. 1991; Bradford et al. 2002; Wardle 2002; Heemsbergen et al. 2004; Carrillo et al. 011). However, whether and how these factors manifest via historical legacies is not well understood. The chemical composition of organic matter inputs to soil can affect soil chemical variables (Bulluck et al. 2002; Tirol-Padre et al. 2007). It has also been shown that the chemical composition of plant litter influences the structure of the soil microbial (Schutter and Dick 2001) and faunal (Parmelee et al. 1989; Hansen and Coleman 1998) communities. These changes in the chemical and biotic environment in soil may have direct impacts on future soil function. However, the link between the change brought about in the soil environment by the chemical quality of plant material and its legacy on soil processes has not been addressed by many studies. Whether legacies on function arise mainly via changes in the soil biota or the chemical environment in soil is a matter of debate. Wardle (2002) proposed that plant species indirectly affect ecosystem processes by their influence on soil community structure. This suggests that historical legacies of plant litter occur mainly via the soil community. Strickland et al. (2009a,b Yolima 2012) found evidence that plant species can modify the soil community to influence decomposition.

2. Theoretical background

The spread of enteric virus in point of discharge is of serious concern in the study area; the sources of the spread are form several condition under the influence of numerous influences from soil and water environment, this condition has develop different threat of soil and water pollution in the study location, the dispersion influence on the deposition of nitrogen are from several geological variation including geochemistry and geomorphology of the formation, the dispersion influences in study location are determined by the formation characteristics in the study area, the rate of dispersion influences on the deposition of nitrogen are from the rate permeability in the study location nitrogen is a substrate that deposit at any stratum of the formation, the deposition of nitrogen will definitely generated high deposition of microbial pollution in the study area. The concentration of solute from microbes in the study will increase base on the rate deposition of nitrogen in the formation , the degree of permeability deposit influence in the system including the micropores in the strata thus developed tortuosity, this

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numerous influence in the strata develop high velocity of transport from the flow paths in the formation, the study is in the deltaic environment, the geological history of formation deposit several formation variation in soil structural deposition, this condition were found to influence the degree of permeability in the formations, the formation soil strata variation are determined by these stated conditions, to predict the deposition of nitrogen and determine the rate dispersions of nitrogen under the influence of dispersion, mathematical model were develop to monitor the rate of dispersion influence on enteric virus in soil and water environment. The model were derived through the formulated equation to solve the deposition of nitrogen under the influence of dispersion in the study locations, the model were derived by considering several condition that are found to influence the system, the model developed are base on the stated parameters in the system. The expressed equations are stated below.

3. Governing Equation

$$\phi\frac{\partial c^2}{\partial t^2} = V\frac{\partial}{\partial z} + D\frac{\partial c}{\partial z} - K\frac{\partial c}{\partial z} + K_o\frac{\partial c}{\partial t} + K_n\frac{\partial c}{\partial z} \qquad \ldots\ldots\ldots\ldots \qquad (1)$$

The rate of formation characteristics are the influential variables that play major roles in the deposition of nitrogen. Geological formations are very influential condition on the deposition of microelements, the concentration of nitrogen are determined by the rate of deposition of the enteric virus in any stratum of the soil, the condition were they are express as partial depositions are fo8und in some stratum of the soil, this implies that there serious is variation of nitrogen deposition in soil and water environment, in this note the governing equation was formulated to monitor the deposition of nitrogen through the rate of dispersion in soil and water environments,

Nomenclature

ϕ	=	Porosity
V	=	Void Ratio
D	=	Dispersion number
K	=	Permeability
$K_A o$	=	Half concentration of substrate of Nitrogen
K_n	=	Half concentration of substrate of Nitrogen Under aerobic respiration
T_1	=	Time of concentration
X	=	Distance
C	=	Concentration of enteric virus.

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

$$\frac{\partial c}{\partial z} = SC_{(z)} - C_{(z)} \qquad \ldots\ldots\ldots\ldots \qquad (3)$$

$$\frac{\partial c}{\partial z} = SC_{(z)} - C_{(z)} \quad \ldots\ldots\ldots\ldots \quad (4)$$

$$\frac{\partial c}{\partial z} = SC_{(z)} - C_{(z)} \quad \ldots\ldots\ldots\ldots \quad (5)$$

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

$$\frac{\partial c}{\partial t} = SC_{(t)} - C_{(t)} \quad \ldots\ldots\ldots\ldots \quad (7)$$

The expression from equation (1) to (7) shows the transformation of the variables that express the deposition of nitrogen in different formation, the parameters were transform mathematically to a product through mathematical symbol thus by expressing the parameters function in discretizing it to a certain level were the parameters can display their various function as a product of this system, the transformation of the variable streamline the various function under the influence of formation characteristics in soil and water environment. Various deposition expression different concentration of nitrogen under the influence of high degree of porosity deposited in the study locations the variation of porosity of the soil played some major roles in the depositions of nitrogen partially in some formation of the soil, several condition of the on the concentration of nitrogen were expressed in the system this is by showing how the formation has developed several parameters that increase the deposition of nitrogen in the stratum.

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

$$\left[SC_{(t)} - C_{(0)}\right] + K_n\left[\left(SC_{(z)} - C_{(0)}\right)\right] \quad \ldots\ldots\ldots\ldots \quad (8)$$

$$\phi\left[S^2C_{(t)} - C_{(t)} - C_{(0)}\right] + V\left[SC_{(z)}{}^2 - 2SC_{(z)}\left(C_{(0)}\right)^2\right]K + 2SC_{(z)}C_{(o)} \quad \ldots\ldots\ldots\ldots \quad (9)$$

$$C_{(o)} + K_n\left(SC_{(z)}\right)^2 - 2Sc_{(z)}\left(C_{(o)} - C_{(o)}\right)^2$$

Equating (9) into time t, we have

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

$$-K\left(SC_{(z)}\right)^2 - 2SC_{(z)}C_{(0)} + \left(C_{(0)}\right)^2 + K_o\left(SC_{(z)}\right)^2 - 2SC_{(z)}C_{(0)} + \left(C_{(0)}\right)^2 \quad \ldots\ldots\ldots \quad (11)$$

Equation (8) to (11) compare a variety of variables by excising there various function in other to descretize it into various area the parameters behaviors are more harsh, the role of the parameters are stated in different conditions, such circumstances implies that the parameters behaviour may not be concurrently in the system, these are base on the variation of the formation that influences all the parameters in the system, such circumstances 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 harmony with the considered variations of the soil strata in the system, the expression were able to differentiates these parameters in line with there various function base on different condition considered in the study.

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

$$(1+K_o)(SC_{(t)})^2 - (1+K_o)\,2S_{(t)}\,C_{(0)} + (1+K_o\,C_{(0)})^2 \qquad \text{…………} \quad (12)$$

$$\left[(SC_{(t)})^2 - 2SC_{(t)}\,C_{(0)} + (C_{(0)})^2\right](1+K_o) \qquad \text{…………} \quad (13)$$

$$(SC_{(t)})^2 - 2SC_{(t)}\,C_{(0)} + (C_{(0)})^2\,\frac{K_n}{(K_o)} \qquad \text{…………} \quad (14)$$

$$\left[SC_{(z)} - C_{(0)}\right]^2 - \frac{K_n}{(1+K_o)} \qquad \text{…………} \quad (15)$$

Equation (12) to (15) articulate further on the behavior of the parameters at dissimilar circumstance, but at this phase the concentration of the microbes enteric virus were paramount in the system, because the behaviour of enteric virus are determined by the rate of void ratio, this dispersion deposition of nitrogen 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.

$$SC_{(x)} - C_{(0)} = \sqrt{\frac{K_n}{C(1+K_o)}} = \pm 1\sqrt{\frac{K_n}{C(1+K_o)}} \qquad \text{…………} \quad (16)$$

$$SC_{(x)} = C_{(0)} = \sqrt{\frac{K_n}{C(1+K_o)}} \qquad \text{…………} \quad (17)$$

$$C_{(z)} = C_{(0)} + 1\sqrt{\frac{K_n}{C(1+K_o)}} \qquad \text{…………} \quad (18)$$

F(x) when $x > 0$ $C_{(o)} = C_0$

$$C_{(z)} = \frac{C_0}{C} + 1\sqrt{\frac{\frac{K_n}{C(1+K_o)}}{C}} \qquad \text{…………} \quad (19)$$

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

$$C_{(z)} = \ell^{\frac{C_0}{C}} \left[ACos \sqrt{\frac{K_n}{\frac{C(1+K_o)}{C}}} + BSin \sqrt{\frac{K_n}{\frac{C(1+K_o)}{C}}} \right] z \qquad \ldots\ldots\ldots\ldots \quad (20)$$

$$\Rightarrow C_{(z)} = \ell^{C_0 t} \left[ACos \sqrt{\frac{K_n}{C(1+K_o)}} t + BSin \sqrt{\frac{K_n}{C(1+K_o)}} \right] z \qquad \ldots\ldots\ldots\ldots \quad (21)$$

To observe the system under exponential phase, application of quadratic expressions were fine appropriate , the parameters express the rate of influence on the concentration of enteric virus , therefore mathematical expression of quadratic equations were applied to express the parameter in exponential phase, nitrogen are deposited partially in some formations but microelement is substrate to enteric virus, this condition is were there is increase in microbial population, so at this condition there no tendency of degradation of the microbes, microelements may experience slight concentration depending on the formation in the study area, other influential parameters in the system are in continuous process they are also influencing the deposition of nitrogen and enteric virus in the study location, therefore the approach of applying quadratic expression were suitable in the derived mathematical expression.

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

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

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

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

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

Considering the LHS of the numerator of (23) gives

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

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

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

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

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

$$C_{(t)} = -\frac{V}{\phi}(C+Dt)\ell^{(t - C_o)t} \qquad \text{...........} \quad (28)$$

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

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

The developed express equation from (22) to (29) were to explain the parameters at various area, they are more influential on the deposition of nitrogen and enteric virus 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 this were they influence the deposition of enteric virus and dispersion in the system\, subject to this relation, the behaviour of the microelements has displayed the penalty through various behavior and purpose of the parameters. The activities of nitrogen is influenced by the independent variables in the system; the expression from this dimension integrated the parameters by denoting through mathematical symbols, the express equation in (29) shows the deposition of nitrogen and concentration of enteric virus are with respect to time, the influence from void ratio developed the spread of the nitrogen and enteric virus in the study area, the expression are with respect to time.

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

$$C_{(z,v)} = A\ell^{\frac{1}{2}\left(1+\sqrt{1+C_o}\right)\frac{z}{v}} + B\ell^{\frac{1}{2}\left(1-\sqrt{1+C_o}\right)\frac{z}{v}} - \frac{V}{\phi}(C+Dt)\,\ell^{(1 - C_o)\frac{z}{v}}$$

The final express model displayed it rate of concentration of enteric virus and the deposition of substrate, it is under the circumstance of distance. The final expressed model consider velocity of transport, the velocity of transport were express in the system including other influential parameters denoted by other mathematical symbols, The major parameters that determine the deposition of nitrogen and enteric virus is permeability and porosity of the soil, tortuosity are found to established, this determine the flow path in the soil formations, the parameters were expressed as the supreme variables in the final model expression. The formation from this dimensions are thoroughly expressed in the final model equation, the model shows the rate of exponential phase, because an increase in degree of permeability and porosity determine the rate of flow path of the soil formation, the condition may definitely increase rate velocity of flow of fluid in soil formations, therefore the influence of porosity and permeability are subjected to increase of dispersion influence of enteric virus deposition in the study location.

4. Conclusion

The permeability and porosity in soil has been examined to be the paramount parameters that determine the dispersion of enteric virus from nitrogen, the derived model equation, express the behaviour of the substrate and enteric virus base on the soil structural deposition through the geologic history in the study location. The depositions of the substrates in the system are depending on the degree of permeability and porosity of the soil. The degree of porosity and permeability in the study location are confirmed through standard experiment of the two parameters, both parameters deposit high degree in the formation. Such condition are reflected on the rate tortuosity that experience high degree velocity of transport in the system, the expression in this condition generate high velocity of flow, the condition implies that the transport of enteric virus and nitrogen will be very fast under the influence of high degree of porosity and permeability deposition in the study area. The area under study is in deltaic environment, from the investigation carried out, the rate of porosity are very high at every part of the study area, this condition implies that fast transport of nitrogen abound to be experienced in the formations. The expressed final model will be able to make more efficient solution on the behaviour of the substrate deposition and the migration of enteric virus in the formation, the expression from the final model shows that there is the tendency of continue increase of enteric virus in the study area, this impression implies that there will high deposition of nitrogen in the formation, such condition is of serious concern in soil and water environment, the developed model will definitely monitor the degree of porosity and permeability and the deposition of nitrogen on the influence of microbes in the study location.

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