World Journal of Soil, Water and Air Pollution
Vol. 1, No. 2, December 2014, pp. 1- 9
Available online at http://www.wjswap.com

Research article

ALLUVIA INFLUENCES ON PSEUDOMONAS TRANSPORT IN PREDOMINANT SILTY FORMATION ON AQUITARD RECHARGE, WARRI DELTA STATE, NIGERIA

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Abstract

The behaviour of Pseudomonas transport in deltaic formation in warri delta State Nigeria has been thoroughly expressed, the examination of alluvia influences on the migration of Pseudomonas is to determine the level of impact from the microbes in such deltaic environment, this implies that the study were to express the rate of concentration in silty formation were homogeneous setting may have pressure the migration and deposition of the contaminant. Development of mathematical model were found imperative due to the tendency of predominant formation characteristics variables in homogeneous silty formation, the express model will definitely predict the rate of Pseudomonas Concentration in silty formation under the influences of alluvia deposition in such deltaic formation.

Keywords: Alluvia Influences, Pseudomonas Transport, Silty Formation and Aquitard Recharge.

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1. Introduction

There are many different microbes that may be of concern in source waters or within the distribution system. Developing a monitoring scheme for each would be an impossible task; therefore, another approach is needed. The food and beverage industry has used the “hazard analysis critical control point” (HACCP) approach to determine the key points within the manufacturing chain where contamination can be measured and prevented. A similar concept can be used by water utilities, to prioritize the key contamination points within the treatment and distribution system

[1,2,19]. This approach allows utilities to focus their resources on monitoring these points and correcting any deviations from acceptable limits. The latest edition of the World Health Organization (WHO) *Guidelines for Drinking-Water Quality* [4] incorporates such an approach, providing guidance on the development of a water safety plan. The plan is developed using a water safety framework, which combines HACCP principles with water quality management and the multiple barrier concept. Most strains of bacteria, including actinomycetes, and also fungi produce siderophores under iron limitation conditions. Siderophores are non-porphyrin, nonprotein compounds that bind iron and their synthesis is repressed when this element is abundant [17]. The requirement of bacterial cells is not high and averages about 3 10-7 M, but the rhizosphere does not contain sufficient free iron (III) ions to allow their survival [7,9]. These chelators, secreted by microorganisms, also play a particularly important role in regulating the amount of assimilable iron in the rhizosphere of plants, by increasing the concentration of available iron in the immediate vicinity of the plant roots. Siderophores secreted by bacteria of the genus Pseudomonas are the focus of particularly intense studies. It is thought that the synthesis of siderophores by these bacteria is one of the main factors inhibiting the growth and development of bacterial and fungal pathogens [3,4,and 5]. Fluorescing strains of this bacterium secrete pyoverdin, which is also known as pseudobactin, a yellow-green pigment that is capable of chelating iron. *Pseudomonas* strains can also secrete other siderophores, the best known of which is pyochelin, a siderophore with lower affinity for iron (III) ions than pyoverdin and probably has no biological activity with regard to plant pathogens. In terms of structure, pyochelins are derivatives of salicylic acid [8]. Pyoverdins comprise a group of siderophores with similar structure, which contain a cyclic or linear oligopeptide linked to dihydroxychinone chromophore and dicarboxylic acid or amide. Differentiation within this group of compounds involves the peptide component of a siderophore. Pyoverdins differ from other siderophores in exceptionally strong affinity for iron (III) ions and high stability of the complexes formed [9, 12 and 13]. The literature indicates that the secretion of siderophores can be regulated by a number of factors, including carbon source in the growth medium and temperature [10, 14]. However, the results of studies carried out so far point to the homogeneity of the mechanisms determining the level of pyoverdin secreted by bacteria belonging to the genus *Pseudomonas*. In the soil, the natural habitat of these bacteria, there are several variable factors that can modify the level of released pyoverdin. For this reason the objective of these studies was to compare the ability of six different strains of *Pseudomonas* bacteria isolated from the rhizosphere of winter wheat to synthesize siderophores under various culture conditions. In recent years growing interest in the agriculture has been observed in non-pathogenic rhizospheric strains of bacteria with properties that would allow their use as biopesticides [14, 16]. Biopesticides can be an excellent alternative for the plant protection chemicals, that are both costly and damaging for the environment. The research demonstrates that their efficiency is very high. Particularly useful as the biospecimen are the natural, non-pathogenic rhizospheric microorganisms capable of secondary metabolite synthesis, including the siderophores, which have a favorable influence on the plants. Especially great attention is paid to the *Pseudomonas* strains, which synthesize the pyoverdine, because of its significant biological activity [15, 16 and 17].

2. Theoretical background

It has been unambiguously verified that water of good quality is vital to sustainable socio-economic growth. Aquatic ecosystems are endangered on a universal scale by a diversity of contaminants as well as destructive land-use or water-management practices. Some inconvenience encompass present for a long time but have only recently reached a critical level, while others are newly emerging. Gross organic contamination leads to interruption of the oxygen balance and is frequently accompanied by severe pathogenic contamination. Accelerated eutrophication results from enhancement with nutrients from a variety of origins, mainly household sewage, agricultural overflow and agro-industrial effluents. Lakes and impounded rivers are particularly affected. Agricultural land use without ecological safeguards to avoid over-application of agrochemicals is causing prevalent decline of the soil/water ecosystem as well as the underlying aquifers. The major problems connected with agriculture are salinisation, nitrate and pesticide pollution, and corrosion leading to elevated concentrations of suspended solids in rivers and streams and the siltation of impoundments. Irrigation has engorged the land area obtainable for crop production but the consequential salinisation which has occurred in several areas has caused the deterioration of previously fertile soils. Direct contamination of surface waters with metals in discharges from mining, smelting and industrial developed is a long-standing phenomenon. However, the release of airborne metallic contaminants has now reached such magnitude that long-range atmospheric transport causes pollution, not only in the vicinity of industrialised regions, but also in more remote areas. Similarly, moisture in the atmosphere combines with some of the gases produced when fossil fuels are burned and, falling as acid rain, causes acidification of surface waters, especially lakes. Contamination of water by synthetic organic micro pollutants results either from direct discharge into surface waters or after transport through the atmosphere. Today, there is trace contamination not only of surface waters but also of groundwater bodies, which are susceptible to leaching from waste dumps, mine tailings and industrial production sites.

The amount of the human activities that pressure the environment has improved dramatically through the past few decades; global ecosystems, freshwater and marine environments and the atmosphere are all pretentious. Large-scale mining and fossil fuel burning have started to interfere measurably with natural hydro geochemical cycles, resulting in a new generation of environmental problems. The scale of socio-economic activities, urbanisation, industrial operations and agricultural production, has reached the point where, in addition to interfering with natural processes within the same watershed, they also have a world-wide impact on water resources. As a result, very complex inter-relationships between socio-economic factors and natural hydrological and ecological conditions have developed [1996 UNEP/WHO].

$$K \frac{hA}{L} \frac{\partial c}{\partial t} = \Delta V \frac{\partial^2 c}{\partial z^2} + h_{(x)} \frac{\partial c}{\partial z} + \Delta \phi \frac{\partial^2 c}{\partial z^2} \qquad \text{...............................} \qquad (1)$$

The governing equation developed is base on the system that are evaluated by determining the behaviour of the pollutant in soil and water environment, mathematical expression are formulated in accordance with the parameters that pressure the behaviour of the contaminant, these are base on groundwater contained beneath the surface of the rocks, this implies that soil is conceptually simple and convenient, the behaviour of transport system of contaminant express the reality in practice including complexity that has been pictured out thus confusion that do arise. The water beneath the ground surface includes that contained in the soil thus intermediate unsaturated zone below the

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soil, these comprise the capillary fringe that is below the water table, these condition express the behaviour of pollution transport from pseudomonas been influences by the deposition of hydrological setting in the deltaic environment.

Nomenclature

h	=	Fluid flow at vertical level
K	=	Permeability
A	=	Cross sectional area
L	=	Length
T	=	Time
Q	=	Porosity
c	=	Concentration
V	=	Velocity
z	=	Depth
$h_{(x)}$	=	Fluid at short distance

$$K\frac{hA}{L}\frac{\partial c}{\partial t} = \left[\Delta V + \Delta\phi\right]\frac{\partial^2 c}{\partial z^2} + h\frac{\partial c}{\partial z} \quad \text{..............................} \quad (2)$$

$$K\frac{hA}{L}\frac{\partial c}{\partial t} = \left[\Delta V + \Delta\phi\right]\frac{\partial^2 c}{\partial z} \quad \text{..............................} \quad (3)$$

$$K\frac{hA}{L}\frac{\partial c_1}{\partial t} = h\frac{\partial c}{\partial z} \quad \text{..............................} \quad (4)$$

$$\left[\Delta V + \Delta\phi\right]\frac{\partial^2 c_3}{\partial z^2} = -h\frac{\partial c_3}{\partial z} \quad \text{..............................} \quad (5)$$

The solution is of the form $c = (t, z) = c_1(t, z) + c_2(t, z) + c_3(t, z)$

Let $c = T, Z$ .... (6)

$$\frac{\partial c_1}{\partial t} = T^1 Z \quad \text{..............................} \quad (7)$$

$$\frac{\partial c}{\partial z} = TZ^1 \quad \text{..............................} \quad (8)$$

$$\frac{\partial^2 c}{\partial z^2} = TZ^{11} \quad \text{..............................} \quad (9)$$

Consider (3)

$$K\frac{hA}{L}T^1 Z = \left[\Delta V + \Delta\phi\right]TZ^{11} = \beta^2 \quad \text{..............................} \quad (10)$$

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$$K\frac{hA}{L} = \beta^2 \qquad \text{(11)}$$

$$\int\frac{dT}{T} = \int\frac{\beta^2}{K\frac{hA}{L}}dt \qquad \text{(12)}$$

$$Ln\,T = \frac{\beta^2}{K\frac{hA}{L}} + c \qquad \text{(13)}$$

$$\boxed{T = A\ell^{\frac{\beta}{K\frac{hA}{L}}t}} \qquad \text{(14)}$$

The deposition of pseudomonas consider time of migration, the migration process are determined by the degree of the soil permeation, such formation influences are known to determine the migration rate of the contaminant in the study location, the relation between time and permeability are evaluated in the expression generated from derived solution, the behaviour under exponential phase express fluid flow in stratum under short distance with respect to time on distances travel

Considering this expression again $[\Delta V + \Delta\phi] = \beta^2$

$$[\Delta V + \Delta\phi]Z^{11} = \beta^2 \qquad \text{(15)}$$

$$c = B\ell^{\frac{\beta^2}{\Delta V+\Delta\phi}Z} + D\ell^{\frac{\beta^2}{\Delta V+\Delta\phi}Z} \qquad \text{(16)}$$

Combine (14) and (16) gives

$$c_1(t,z) = \left(B\ell^{\frac{\beta}{\Delta V+\Delta\phi}Z} + D\ell^{\frac{\beta}{\Delta V+\Delta\phi}Z}\right)A\ell^{\frac{\beta^2}{K\frac{hA}{L}}t} \qquad \text{(17)}$$

The expressed model at these phase compared two different condition established to predict the behaviour of the microbes in some certain region of the formation, these condition streamline the system to identify the behaviour that pressure the microbes at those region of the soil, in line with these condition, comparative evaluation between fluid flow, velocity, degree of porosity detailed there functions to express the pressure in the transport condition of pseudomonas in soil and water environment.

Consider equation (4)

$$K\frac{hA}{L}\frac{\partial c_2}{\partial t} = h\frac{\partial c_2}{\partial z}$$

$$K\frac{hA}{L}T^1Z = hZ^1T$$

$$K\frac{hA}{L}\frac{T^1}{T} = h\frac{Z^1}{Z} = \gamma \qquad \text{..............................} \qquad (18)$$

$$h\frac{Z^1}{Z} = \gamma \qquad \text{..............................} \qquad (19)$$

$$\int\frac{dT}{T} = \frac{\gamma}{K\frac{hA}{L}}\int dt \qquad \text{..............................} \qquad (20)$$

$$Ln\,T = \frac{\gamma}{K\frac{hA}{L}} + \varphi \qquad \text{..............................} \qquad (21)$$

$$T = C\ell^{\frac{\gamma}{K\frac{hA}{L}}t} \qquad \text{..............................} \qquad (22)$$

Considering $h\frac{Z^1}{Z} = \gamma$

$$\int\frac{dz}{z} = \int \gamma v dz \qquad \text{..............................} \qquad (23)$$

$$Ln\,z = \gamma hz + b \qquad \text{..............................} \qquad (24)$$

$$z = \Delta\ell^{\gamma h} \qquad \text{..............................} \qquad (25)$$

Combine (22) and (25), gives;

$$c_2 = (t, z) = ab\ell^{\left(\frac{1}{K\frac{hA}{L}} + h\right)t} \qquad \text{..............................} \qquad (26)$$

The migration of the microbes in porous medium has lot of several influences, therefore the deposition of pseudomonas including its behaviour are observed in various direction, these implies that if the migration process must be predicted, several conditions must considered in the derived solution. Vertical direction of flow were considered in these phase precisely, linear migration under vertical flow direction may take places, these condition

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are influenced by disintegration of the grains between the intercedes of the soil, fracture from the deposition of sedimentary rock may developed linear transport base on the nature of the fracture in the porous rock, these deposition are observed in some locations of the deltaic environment, therefore, the phase of the derived solution monitor the concentration at theses phase.

Consider equation (5)

$$[\Delta V + \Delta\phi] Z^{11} T = -hZ^{1} T$$

$$[\Delta V + \Delta\phi] \frac{Z^{11}}{Z} = -h\frac{dz}{dz} = \theta^2 \quad \text{.................................} \quad (27)$$

$$[\Delta V + \Delta\phi] \frac{d^2 z}{dz^2} = \theta^2 \quad \text{.................................} \quad (28)$$

$$Z = E\,Cos \frac{\theta}{\sqrt{\Delta V + \Delta\phi}} z + F\,Sin \frac{\theta}{\sqrt{\Delta V + \Delta\phi}} z \quad \text{.................................} \quad (29)$$

Also $h\frac{dz}{dz} = +\theta^2$

$$\int \frac{dz}{dz} = h\theta^2 \int dz \quad \text{.................................} \quad (30)$$

$$Ln\,z = h\theta^2 z + d \quad \text{...............................} \quad (31)$$

$$z = D\ell^{h\theta^2} \quad \text{...............................} \quad (32)$$

Combining (29) and (30) yield

$$c_3 = (t,z) = \left(E\,Cos \frac{\theta}{\sqrt{\Delta V + \Delta\phi}} z + F\,Sin \frac{\theta}{\sqrt{\Delta V + \Delta\phi}} z \right) G\ell^{h\theta^2} \quad \text{......................} \quad (33)$$

The migration of pseudomonas in silty formation May experiences change in velocity and porosity on direction of flow, such condition were at these level of derived solution considered to monitor the deposition of pseudomonas on change of velocity, porosity on fluid flow at vertical direction, the expression monitored the deposition under these influences on variation of depth in the formation, the behaviour of the system in line with these condition observed their various relation in terms of formation characteristics at vertical direction of flow.

Therefore, combined equations (17), (26) and (33) give

$$c(t,z) = c_1(t,z) + c_2(t,z) + c_3(t,z)$$

$$c_1(t,z) = \left(B\ell^{\frac{\beta}{\Delta V + \Delta\phi}Z} + D\ell^{-\frac{\beta}{\Delta V + \Delta\phi}Z} \right) A\ell^{\frac{\theta^2}{K\frac{hA}{L}}t} +$$

$$ab\ell^{\left(\frac{1}{K\frac{hA}{L}}+h\right)}\gamma + \left(E\,Cos\frac{\theta}{\sqrt{\Delta V + \Delta\phi}}z + F\,Sin\frac{\theta}{\sqrt{\Delta V + \Delta\phi}} \right) G\ell^{h\theta^2}z \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (34)$$

The deposition pseudomonas in silty formation at aquifer recharge horizon has been thorough expressed in the derived solution, several condition base on the stratification through the geological setting were observed on the system, formulation of the system through these parameters developed the governing equation, the derivation of the expression were expressed in various phase to monitor the migration and its behaviour at under the influence of the lithological of the formation, the derived solution generated several model integrated together to produced the final derived model that will monitor and predict the concentration of pseudomonas in silty soil.

4. Conclusion

The behaviour of pseudomonas in aquitard recharge in warri has been expressed, the behaviour of the contaminant deposition were investigated in the study location, the migration process were confirm to be pressured by coefficient of permeability in the formation with high degrees of predominant in the formation, on physical process the lithology of the formation confirm the level of predominant of silty deposition, these implies that silty formation may deposit low permeability and that will cause accumulation of pseudomonas in the silty formation. Subject this condition, it has reflected the behaviour of Groundwater influences on the migration process of pseudomonas, this refers only to water in the saturated zone beneath the water table, and the total water column beneath the earth's surface is usually called subsurface water. In practice, of course, the saturated and unsaturated zones are connected, and the position of the water table fluctuates seasonally, from year to year and with the effects of groundwater abstraction. These conditions affect the deposition of pseudomonas in it variation of deposition at various formation. Appreciating this characteristic is particularly imperative in relation to protecting groundwater from pollutants originating from activities at the surface. Such pollutants can either be retained in the soil or they may be carried downwards by infiltrating water, depending on the physicochemical properties of both the soil material and of the pollutants.

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