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Research article

MODELING AMMONIA AND CHROMIUM DEPOSITION INFLUENCED BY VOID RATIO AND DISPERSION IN HOMOGENEOUS SILTY AND FINE SAND FORMATION IN SEMI CONFINED BED AT AHOADA, RIVERS STATE OF NIGERIA

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Abstract

Ammonia and chromium deposited fine sand formation in the study location, these investigation were confirm through hydrogeological studies carried out to monitor the rate of physiochemical reaction at various homogeneous strata in deposited fine sand formation, the study location are predominantly deposit heterogeneous formation, but few location were presently investigated to deposition slight homogeneous fine sand strata, it was also discovered to deposit semi confined bed through experienced over burden pressure in the formation. Void ratio deposited high percentage; these are reflected on the rate of dispersions influences of ammonia and chromium deposition, the physiochemical interaction from ammonia and chromium were thoroughly assessed, these expressed parameters established lots of pressured that are reflected on ammonia and chromium migration process in soil and water environments. Base on this factors mathematical modeling approach were found suitable to express various rate of deposition and migration of ammonia and chromium in the study location. The derived model from the governing equation were approached by various mathematical system, the derived solution considered different dimension that has cause lots of solute migration to semi confined bed in the study area.

Keywords: modeling ammonia and chromium, void ratio, dispersion and semi confined bed

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1. Introduction

Bacterial adhesion is imperative in a variety of ecological applications together with microbial biofouling and *in-situ* bioremediation. When situation permit, attached bacterial cells may survive for lingering periods and biofilms, i.e., powerless microbial cell colonization on a surface, can be formed. Biofilms have been familiar as a potential source of pollution, though biofilms arrangement may also be valuable for biofouling [Momba et al 2000] and biodeterioration [Chavant, et al 2000, Eluozo and Nwaoburu, 2013]. Bacterial adhesion and surface colonization are interrelated with bacterial surface physicochemical properties [Sinet et al, 2002 Flint,et al 1997 Rosenberg,1991, Eluozo and Nwaoburu, 2013, Bornaet and Rouxhxt, 2000], which ascribes to the surface molecular composition in terms of proteins, polysaccharides and hydrocarbon-like compounds [Barker et al, 2002]. Bacterial strains with diverse cell surface properties show diverse adhesion kinetics and affinity for substrate [Gottenbos et al, 2002]. Bacterial surface physicochemical properties and as a result their adhesion can be influenced by growth situation (Briandet et al. 1999). For example, [Gottenbos et al, 2002] it is found that incubation temperature impacted the hydrophobicity of *C. parapsilosis* strain 294 through contact angle measurements of strains deposited on lawns of yeasts [Busalmen and Sanchez, 2001]. [Doyle et al, 1980] It observed a low adhesion density of cells grown in the logarithmic state and a high adhesion density of cells grown in the stationary state by examining the adhesion of *Lactococcus lactis* on polystyrene [Doyle et al, 1980]. Bacterial adherence to substrate is also influenced by pH and ionic strength of the electrolyte solution [Doyle et al 1980, Pelletier et al,.1997 Vander et al,2001]. Bacterial surface physico-chemical properties can be chemically modified to stimulate bacterial adhesion to substrate [, Whitetle 1991, Bornaet, et al 2001]. Besides, several extracellular structures (lipopolysaccharides, flagella and membrane proteins) also impact the modulation of the adhesion of bacteria to substrate [Bornaet et al 2001, Gomez et al 2002, Whitetle 1991and Pelletier et al,.1997]. The United States Environmental Protection Agency [Arnold et al 1998] estimated that 45 percent of the rivers, 54 percent of the lakes, and 54 percent of the estuaries, among 32 percent of U.S. waters assessed, are threatened or polluted [Arnold et al 1998]. The nation’s waters are still threatened by pollutants such as sediment, bacteria, nutrients, and metals in spite of more than 30 years cleanup efforts. Non-point source (NPS) pollution transported by precipitation and runoff from both urban and agricultural areas is the most significant source of water quality problem in the United States [USEPA, 2000]. NPS pollution is difficult to monitor and control because the pollutants are generated over an extensive area of land and enter receiving water bodies in a diffused manner. NPS pollution is low in concentration and high in total load, while point source pollution generally high in concentration and low in total load. Therefore, NPS pollution abatement is usually focused on land and runoff management practices. Agricultural activities may introduce sediments, nutrients, pesticides, and other organic matter to the water bodies. It is reported that agriculture is the most widespread source of pollution in impaired rivers and lakes [USEPA, 2000,]. Pesticides mainly originate from agricultural activities. Over 76% of the 1.2 billion pounds of pesticides’ active ingredients used in the United States during the 90s were used in agricultural areas [Arnold et al 1998]. It is estimated that the annual amount of pesticide (active ingredient) used in the U.S. is about 20% of the total amount used in the world [Arnold et al 1998]. Growing evidence shows that pesticides exist in the environment, such as atmosphere, surface, and ground water, far from the areas of their application. About

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50% of the U.S. population, primarily in urban areas, relies on streams and reservoirs for drinking water. Surface waters are vulnerable to pesticide contamination because runoff from source areas, including agricultural and urban areas, can carry pesticides into streams [Eluozo and Nwaoburu, 2013].

surface water problems by pesticides have been investigated because of their acute effects, more attention has been given to soil and ground water contamination by pesticides because ground water is a major source of drinking water in Western Europe and the United States [Arnold et al 1998,and Van den and Va Denlinden,1994]. Furthermore, continued contamination of surface water resources has increased our dependence on ground water to meet growing water needs. Contamination of soil and ground water by NPS pollutants is serious, because areal extent of contamination is usually large and effective Remediation is very difficult [4]. Ground water and surface water quality were examined as part of the National Water Quality Assessment (NAWQA) Program by the U.S. Geological Survey in 1991. The results of the NAWQA study of pesticides in surface water indicated that more than 95% of the samples collected from 58 rivers and streams across the U.S. contained at least one pesticide or pesticide byproduct (Larson et al., 1999). Results from the first set of ground water/land use studies conducted in the first 20 NAWQA study units during 1993-1995 indicated that the concentration and frequency of pesticide detection was closely related to the use and properties of pesticides and land use categories [Woolheriser, et al 1990, Kolpin, et al 1998]. Overall, the results of the national study demonstrated that pesticides were commonly detected in shallow ground water of both agricultural and urban areas, with about 54% of 1034 sites sampled containing one or more pesticide compounds. However, agricultural areas showed higher frequency of pesticide detection in ground water than urban areas (Kolpin et al., 1998

2. Theoretical background

Semi confined beds are structural formations that are deposited in Ahoada East, Rivers State of Nigeria. The formations develop semi confine through slight overburden pressures deposited in homogenous fine sand. This formation that deposits slight overburden pressure are from sombrero structural setting under the influence of Benin formation transiting from Ahoada river..it it predominated by sombrero formation known to develop its strata structured by lacustrine deposition. Such geological origins were always known to deposit heterogeneous structure even if it lies under Benin formation. Discovering slight overburden pressure that structure the homogeneous in some region of Ahoada settlements were confirmed from hydrogeological studies to deposit homogeneous fine sand overburden by deltaic clay. These were influenced by high degree of void ratio that established an interaction with dispersion rate under the influence of the micropores of deposited strata. Ammonia and chromium were found to deposit in semi confined beds from deposited fine sand. Such physiochemical depositions were found to establish a reaction. These conditions subject the deposition of ammonia to establish a fluctuation of inhibition by chromium. Subject to this interaction, the established reactions between the two parameters leads to fluctuation in the water quality of semi confined beds. Dispersion influence was found to deposit through high percentage of void ratio in the strata dispersing ammonia and chromium in semi confined beds. These has generated high spread of the contaminants in some regions where semi confined beds are deposited. Subject to these challenges, better solutions to prevent

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further migration or dispersion of this contaminant should be developed. In line with these factors, mathematical model approach was found suitable to express different influences and ways of preventing such pollution. These factors are considered where a system that captured these conditions was considered and it produced the governing equations stated below.

3. Governing equation

$$V\frac{\partial Cs}{\partial t} = \frac{\partial Cs}{\partial z} q_z C_s + Ds\frac{\partial Cs}{\partial z} - M_b\frac{\mu_o}{\gamma_o}\frac{\partial Cs}{\partial z} + \frac{\partial Cs}{\partial t}\frac{Cs}{K_{So}+Cs} + \frac{\partial Cs}{\partial z}\frac{C_A}{K_{Ao}+C_A} \quad \ldots\ldots\ldots \quad (1)$$

The expressed governing equations were formulated from the system, it considered all the factors influencing the deposition of ammonia and chromium in semi confined beds in some part of Ahoada region. Geological influence of Sombrero was found to deposit few areas predominant with homogeneous fine sand and semi confined beds. Moe so, ammonia and chromium were found to deposit in homogeneous fine sand of semi confined aquiferous zone. These factors are expressed in the developed governing equation stated above.

$$V\frac{\partial Cs_1}{\partial t} = M_b\frac{\mu_o}{\gamma_o}\frac{\partial Cs_1}{\partial z} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$\left.\begin{array}{l} x = 0 \\ Cs_{(o)} = 0 \\ \frac{\partial Cs_1}{\partial t}\Big| t = 0,\ B \end{array}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

$$V\frac{\partial Cs_2}{\partial t} = D_s\frac{\partial Cs_2}{\partial z}\frac{C_A}{K_{Ao}+C_A} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

$$\left.\begin{array}{l} x = 0 \\ t = 0 \\ Cs_{(o)} = 0 \\ \frac{\partial Cs_2}{\partial t}\Big| t = 0,\ B \end{array}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

$$V\frac{\partial Cs_3}{\partial t} = \frac{\partial Cs_3}{\partial t}\frac{Cs_o}{K_{so}+C_o} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

$$\left.\begin{array}{l} t = 0 \\ Cs_{(o)} = 0 \\ \frac{\partial Cs_3}{\partial t}\Big| t = 0,\ B \end{array}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (7)$$

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$$V\frac{\partial Cs_4}{\partial t} = D_s\frac{\partial Cs_4}{\partial z} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (8)$$

$$\left.\begin{array}{l} t = 0 \\ x = 0 \\ Cs_{(o)} = 0 \\ \frac{\partial Cs_4}{\partial t}\Big| t = 0,\ B \end{array}\right\} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (9)$$

$$V\frac{\partial Cs_5}{\partial t} + \frac{\partial Cs_5}{\partial z}q_z\,Cs \qquad \ldots\ldots\ldots\ldots\ldots\ldots \ (10)$$

$$\left.\begin{array}{l} t = 0 \\ x = 0 \\ Cs_{(o)} = 0 \\ \frac{\partial Cs_5}{\partial t}\Big| t = 0,\ B \end{array}\right\} \qquad \ldots\ldots\ldots\ldots\ldots \quad (11)$$

$$M_b\frac{\mu_o}{\gamma_o}\frac{\partial Cs_6}{\partial z} = \frac{\partial Cs_6}{\partial t}\frac{C_A}{K_{Ao} + C_A} \quad - = 0 \qquad \ldots\ldots\ldots\ldots\ldots \quad (12)$$

$$\left.\begin{array}{l} x = 0 \\ Cs_{(o)} = 0 \\ \frac{\partial Cs}{\partial t}\Big| t = 0,\ B \end{array}\right\} \qquad \ldots\ldots\ldots\ldots\ldots \quad (13)$$

Applying direct integration on (2)

$$\frac{\partial Cs_1}{\partial t} = M_b\frac{\mu_o}{\gamma_o} + K_1 \qquad \ldots\ldots\ldots\ldots\ldots \quad (14)$$

Again, integrate equation (14) directly yield

$$VCs = M_b\frac{\mu_o}{\gamma_o} + K_1 + K_2 \qquad \ldots\ldots\ldots\ldots\ldots \quad (15)$$

Subject to equation (3) we have

$$Cs_{(o)} = K_2 \qquad \ldots\ldots\ldots\ldots\ldots \quad (16)$$

Subjecting equation (15) to (3)

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At $\left.\frac{\partial Cs_1}{\partial t}\right|_{t=0} = 0 \quad Cs_{(o)} = Cs_o$

Yield

$$O = VCs_o = K_2$$

$$K_2 = VC_o \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (17)$$

So that we put (16) and (17) into (15), we have

$$Cs_1 = VCs_1 t - M_b \frac{\mu_o}{\gamma_o} Cst + Cs_o \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (18)$$

$$Cs_1 = V = Cs_o - M_b \frac{\mu_o}{\gamma_o} Cst \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (19)$$

$$\Rightarrow Cs_1 \left[Cs_1 - Vt\right] = Cs_o \left[Cs_1 - M_b \frac{\mu_o}{\gamma_o}\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (20)$$

$$\Rightarrow Cst = Cs_o \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (21)$$

$$V \frac{\partial Cs_2}{\partial t} = \frac{\partial Cs_2}{\partial z} \frac{C_A}{K_{Ao} + C_A} \quad \ldots\ldots\ldots (4)$$

We approach this system using the Bernoulli's method of separation of variables.

i.e. $Cs_2 = ZT \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (22)$

$$\frac{\partial Cs_2}{\partial t} = ZT^1 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (23)$$

$$\frac{\partial Cs_2}{\partial z} = Z^1 T \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (24)$$

Put (23) and (24) into (25), so that we have

$$VZT^1 = \frac{C_A}{K_{Ao} + C_A} Z^1 T \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (25)$$

$$VZT^1 \frac{VT^1}{T} = \frac{C_A}{K_{Ao} + C_A} \frac{Z^1}{Z} = -\lambda^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (26)$$

Hence $\frac{VT^1}{T} = -\lambda^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (27)$

$$\frac{C_A}{K_{Ao} + C_A} Z^1 + \lambda^2 Z = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (28)$$

From (27) $T = ACos \frac{\lambda}{V} t + B \; Sin \frac{\lambda}{V} z \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (29)$

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$$T = Cs\ell^{\frac{-\lambda^2}{V}t} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (30)$$

And (28) gives

By substituting (28) and (29) into (22) we get

$$Cs_2\left[ACos\frac{\lambda}{\sqrt{V}}t \ + B\,Sin\frac{\lambda}{\sqrt{V}}z\right]Cs\ell^{\frac{-\lambda^2}{\sqrt{V}}t} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (31)$$

$$Cs_o = Ac \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (32)$$

Equation (31) becomes

$$Cs_2 = Cs_o\ell^{\frac{\frac{-\lambda^2}{C_A}t}{K_{Ao}+C_A}} \ Cos\frac{\lambda}{V}z \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (33)$$

Again at $\left.\frac{\partial Cs_2}{\partial t}\right| \begin{matrix} = 0, \ z = 0 \\ t = 0, \ B \end{matrix}$

Equation (33) becomes

$$\frac{\partial Cs_2}{\partial t} = \frac{\lambda}{V}Cs_o\ell^{\frac{\frac{-\lambda^2}{C_A}t}{K_{Ao}+C_A}} \ Sin\frac{\lambda}{V}z \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (34)$$

i.e. $0 = Cs_o\frac{\lambda}{\sqrt{V}} \ Sin\frac{\lambda}{V}0$ $\quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (35)$

$Cs_o\frac{\lambda}{\sqrt{V}} \neq 0$ Considering NKP

$$0 = -Cs_o\frac{\lambda}{V} \ Sin\frac{\lambda}{V}B \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (36)$$

$$\Rightarrow \lambda = \frac{n\pi\sqrt{V}}{2} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (37)$$

So that equation (33) becomes

$$Cs_2 = Cs_o\,\ell^{\frac{\frac{-n^2\pi^2V}{C_A}}{2\,K_{Ao}+C_A}} \ Cos\frac{n\pi\sqrt{V}}{2\sqrt{V}}z \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (38)$$

$$Cs_2 = Cs_o\,\ell^{\frac{\frac{-n^2\pi^2V}{C_A}}{2\,K_{Ao}+C_A}} \ Cos\frac{n\pi}{2}z \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (39)$$

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We consider equation (6)

$$V\frac{\partial Cs_3}{\partial t} = \frac{\partial Cs_3}{\partial z}\frac{Cs}{Ks_o + Cs} \quad \ldots\ldots\ldots\ldots \quad (6)$$

We approach the system by applying Bernoulli's method of separation of variables.

$$Cs_3 = ZT \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (40)$$

$$\frac{\partial Cs_3}{\partial t} = ZT^1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (41)$$

$$\frac{\partial Cs_3}{\partial z} = Z^1 T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (42)$$

Again, we put (41) and (42) into (40), so that we have

$$VZT^1 = \frac{Cs}{Ks_o + Cs_3} Z^1 T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (43)$$

$$\text{i.e. } \frac{VT^1}{T} = \frac{Cs}{Ks_o + Cs_3}\frac{Z^1}{Z} - \lambda^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (44)$$

Hence $\frac{VT^1}{T} = -\lambda^2$ ………………… (45)

$$\text{i.e. } \frac{Cs}{Ks_o + Cs} Z^1 + \lambda^2 z = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (46)$$

From (46) $T = ACos\frac{\lambda t}{V} Z + BSin\frac{\lambda z}{V}$ ………………… (47)

And (46) gives

$$T = Cs_o \ell^{\frac{-\lambda^2}{V}t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (48)$$

By substituting (47) and (48) into (40), we get

$$Cs_3 = \left[ACos\frac{\lambda}{V} z + BSin\frac{\lambda}{\sqrt{V}} z \right] Cs\ell^{\frac{-\lambda^2}{V}t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (49)$$

Subject (54) to condition in (6) so that we have

$$Cs_o = Ac \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (50)$$

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$$Cs_3 = Cs_o \ell \frac{-\lambda^2}{V} t \; Cos \frac{\lambda}{\sqrt{V}} Z \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (51)$$

Again at $\frac{\partial Cs_3}{\partial t} \Big| \; t = 0, \; B$

Equation (51) becomes

$$\frac{\partial Cs_2}{\partial t} = \frac{\lambda}{\sqrt{V}} Cs_o \ell^{\frac{\frac{-\lambda^2}{Cs}}{Ks_o + Cs}} \; Sin \frac{\lambda}{V} z \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (52)$$

i.e. $0 = -Cs_o \frac{\lambda}{\sqrt{V}} \; Sin \frac{\lambda}{V} 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (53)$

$Cs_o \frac{\lambda}{\sqrt{V}} \neq 0$ Considering NKP

Which is the substrate utilization for microbial growth rate (population) so that

$$0 = -Cs_o \frac{\lambda}{V} \; Sin \frac{\lambda}{V} B \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (54)$$

$$\Rightarrow \frac{\lambda}{\sqrt{V}} = \frac{n\pi}{2} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (55)$$

$$\Rightarrow \lambda = \frac{n\pi\sqrt{V}}{2} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (56)$$

So that equation (57)

$$Cs_3 = Cs_o \ell^{2\frac{\frac{-n^2\pi^2 V}{C_A}}{K_{Ao} + C_A}} \; Cos \frac{n\pi\sqrt{V}}{2\sqrt{V}} z \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (57)$$

$$\Rightarrow Cs_3 = Cs_o \ell^{\frac{-n^2\pi^2 V}{2V} t} \; Cos \frac{n\pi}{2} z \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (58)$$

The formation of Sombrero defines the structural strata under the influence of void ratio and dispersion of ammonia and chromium. Ammonia, as a substrate was considered in the system to be predominant in some regions of the strata where an inhibition from chromium may experience inactivity. Such conditions expressed the tendency of contaminant growth rate that may be found in any deposited stratum of the formation. Based on these factors, substrate utilization were considered in the system through the modified governing equation expressed on the process of the derived solution as stated in equation (58) above.

Now we consider equation (8)

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$$V\frac{\partial Cs_4}{\partial t} = Ds\frac{\partial Cs_4}{\partial z} \quad \ldots\ldots\ldots\ldots \quad (8)$$

Using Bernoulli's method of separation of variables, we have

$$Cs_4 = ZT \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (59)$$

$$\frac{\partial Cs_4}{\partial t} = ZT^1 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (60)$$

$$\frac{\partial Cs_4}{\partial Z} = Z^1T \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (61)$$

Put (60) and (61) into (8), so that we have

$$VZT^1 = -DsZ^1T \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (62)$$

i.e. $$\frac{VT^1}{T} = Ds\frac{Z^1}{Z} = \varphi \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (63)$$

$$Ds\frac{Z^1}{Z} = \varphi \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (64)$$

$$T = A\frac{\varphi}{V}z \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (65)$$

And $$Z = B\ell^{\frac{-\varphi}{V}z} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (66)$$

Put (65) and (60) into (59), gives

$$Cs_4 = A\ell^{\frac{\varphi}{Ds}z} \bullet B\ell^{\frac{-\varphi}{Ds}z} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (67)$$

$$Cs_4 = AB\ell^{(x-t)}\frac{\varphi}{Ds} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (68)$$

Subject equation (67) to (8) yield

$$Cs_4 = (o) = C_o \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (69)$$

So that equation (69) becomes

$$Cs_4 = Cs_o\ell^{(x-t)}\frac{\varphi}{Ds} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (70)$$

Now, we consider equation (9)

$$V\frac{\partial Cs_5}{\partial t} = \frac{\partial Cs_5}{\partial z}q_zC_s \quad \ldots\ldots\ldots\ldots \quad (9)$$

Apply Bernoulli's method, we have

$$Cs_5 = ZT \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (71)$$

$$\frac{\partial Cs_5}{\partial t} = ZT^1 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (72)$$

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$$\frac{\partial Cs_5}{\partial Z} = Z^1 T \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (73)$$

Put (72) and (73) into (9), so that we get

$$VXT^1 = -Z^1 T q_z C_s \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (74)$$

i.e. $\frac{VT^1}{T} = \frac{Z^1}{Z} q_z C_s = \phi$ ……………… (75)

$$\frac{VT^1}{T} = \phi \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (76)$$

$$\frac{Z^1}{Z} = \phi \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (77)$$

$$T = \frac{A\phi}{V} T \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (78)$$

And $Z = B\ell \frac{-\phi}{q_z C_s} Z$ ……………… (79)

Put (78) and (79) into (71), gives

$$Cs_5 = A\ell^{\frac{\phi}{q_z C_s}t} \bullet B\ell^{\frac{-\phi}{q_z C_s}t} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (80)$$

$$Cs_5 = AB\ell^{(x-t)} \frac{\phi}{q_z C_s} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (81)$$

Subject equation (83) and (84) into (74) yield

$$Cs_5 = (o) = Cs_o \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (82)$$

So that equation (81) and (82) becomes

$$Cs_5 = (o) = Cs_o \ \ell^{(t-x)} \frac{\phi}{q_z C_s} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (83)$$

Now, we consider equation (11) which is the steady flow rate of the system

$$M_b \frac{\mu_o}{\gamma_o} \frac{\partial Cs_6}{\partial z} = \frac{\partial Cs_6}{\partial z} \frac{C_A}{K_{Ao} + C_A} \quad \ldots\ldots \quad (11)$$

Applying Bernoulli's method of separation of variables, we have

$$Cs_6 = ZT \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (84)$$

$$\frac{\partial Cs_6}{\partial t} = ZT^1 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (85)$$

$$\frac{\partial Cs_6}{\partial Z} = Z^1 T \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (86)$$

Put (85) and (86) into (11), so that we have

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$$M_b \frac{\mu_o}{\gamma_o} Z^1 T = -\frac{C_A}{K_{Ao} + C_A} Z^1 T \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (87)$$

i.e. $$M_b \frac{\mu_o}{\gamma_o} \frac{Z^1}{Z} = \frac{C_A}{K_{Ao} + C_A} \frac{Z^1}{Z} = \alpha \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (88)$$

$$M_b \frac{\mu_o}{\gamma_o} \frac{Z^1}{Z} = \alpha \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (89)$$

$$\frac{C_A}{K_{Ao} + C_A} \frac{Z^1}{Z} = \alpha \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (90)$$

$$Z = A \frac{\alpha}{M_b \frac{\mu_o}{\gamma_o}} Z \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (91)$$

And $$Z = B\ell^{\frac{\alpha}{\frac{C_A}{K_{Ao} + C_A}} Z} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (92)$$

Put (91) and (92) into (84) gives

$$Cs_6 = A\ell^{\frac{\alpha}{M_b \frac{\mu_o}{\gamma_o}}} B\ell^{\frac{\alpha}{M_b \frac{\mu_o}{\gamma_o}}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (93)$$

$$Cs_6 = AB\ell^{(x-x)} \frac{\alpha}{M_b \frac{\mu_o}{\gamma_o}} x \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (94)$$

Subject equation (93) and (94) into (94) yield

$$Cs_6 = (o) = C_o \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (95)$$

So that equation (96) becomes

$$Cs_6 = Cs_o \, \ell^{(x-x)\frac{\alpha}{M_b \frac{\mu_o}{\gamma_o}}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (96)$$

Fluid flow depositions are influenced by structural stratification setting of the formation. Sombrero developing from lacustrine deposition, it is structured under the influence of its geological setting that develops predominant of homogeneous formation in some region of Ahoada. The expressed condition develops lots of formation characteristics influence including climatic influence predominant in deltaic environment. The slight deposited homogenous formation in the study location experienced constant flow of ammonia and chromium under the influence of steady rate of flow in the formation. These expressions developed the condition of steady state flow on the derived solution stated above.

Now, assuming that at the steady flow there is no NKP for substrate utilization, our concentration is zero so that equation (96) becomes

$$Cs_6 = 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (97)$$

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Therefore, solution of the system is of the form

$$Cs = Cs_1 + Cs_2 + Cs_3 + Cs_4 + Cs_5 + Cs_6 \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (98)$$

We now substitute (20), (39), (58), (70), (83) and (96) into (98), so that the model is of the form

$$C = Cs_o + Cs_o\, \ell^{\frac{-n^2\pi^2 V}{2\frac{C_A}{K_A + C_A}}} Cos\frac{n\pi}{2}Z + Cs_o\, \ell^{\frac{-n^2\pi^2 V}{2V}}\, Cos\frac{\sqrt{V}}{2}Z +$$

$$Cs_o\, \ell^{(x-t)}\frac{\phi}{Ds} + Cs_o\, \ell^{(t-x)}\frac{\phi}{q_z C_s} + Cs_o\, \ell^{(t-x)}\frac{\alpha}{M_b\frac{\mu_o}{\gamma_o}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (99)$$

$$\Rightarrow Cs = Cs_o\; 1 + \ell^{\frac{-n^2\pi^2 V}{2\frac{C_A}{K_A + C_A}}} Cos\frac{n\pi}{2} + \ell^{\frac{-n^2\pi^2 V}{2V}} + Cos\frac{n\pi}{2} +$$

$$\ell^{(t-z)}\frac{\phi}{q_z C_s} + \ell^{(t-x)}\frac{\phi}{M_b\frac{\mu_o}{\gamma_o}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (100)$$

The expression in (100) is the derived final equation from the governing equation stated in (1) above. These expressions are derived to generate this model at (100) considering all the influential parameters that pressured the deposition of ammonia and chromium in semi confined beds. Environmental factors were considered in the system, which may have been insignificant in the governing equation, but are integrated in the study. Such conditions were expressed on the parameters from formation characteristics that are influenced by high rain intensities. This notion was thoroughly articulated in the system that generated the governing equation as expressed above. All the influential parameters are expressed in the derived solution to produce the final model equation for the study.

4. Conclusion

Ammonia and chromium has been confirmed to deposit in some region of Ahoada influenced by Sombrero through lacustrine deposition. Semi confined beds were confirmed to develop in the slight region of Ahoada, depositing homogenous fine sand and void ratio. Dispersion influences were monitored based on high degree of void ratio where ammonia and chromium are deposited in fine sand formation. The study is imperative because Sombrero are predominant of heterogeneous formation and were not found to deposit semi confined beds, but the study carried out in some regions generated semi confined and high dispersing rate of ammonia and chromium under the influence of homogenous fine strata. Experts in this developed model will definitely apply this guided baseline to monitor such pollution transport in prevention of quality aquiferous zone in the study location.

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