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Research article

MODELING ACCUMULATION OF IONIC CONTENT IN AQUIFEROUS ZONE INFLUENCED BY PERMEABILITY AND SEEPAGE VELOCITY IN KAIAMA, BAYELSA STATE OF NIGERIA

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Abstract

Accumulation of ionic content were found to have predominant in Kaiama Bayelsa state of Nigeria, the deposition of the mineral has cause lots of water the rate of accumulation has not be determined in the study location, the deposition of ionic content has been expressed from hydrogeological studies carried out, this were found to be one of the highest deposited content in the entire state, such condition implies that the development of quality water through well construction and design will face lots of challenges in the study location, the settlers will definitely face quality water challenges due to the ugly scourge. The condition of water quality in Kaiama is a serious threat human settler in the area as most of them has serious been affected by water related disease from the pollution sources. The condition of ionic content at high degree of concentration has a serious threat to water engineers due to lack of through information that can be applied in the design and construction of water well in the study area, this challenging condition can be solved if there is a lay down conceptual frame work that will be a guild which must be to applied in ensuring that such pollution are prevented in the design and construction of water well in the study area. Base on this factors, mathematical model to monitor and predict the rates of ionic content were find appropriate to ensure that solution to this crisis are solved in the deposition of ionic content in the study area, the expressed derived solution that develop this model will definitely be a guild to water well engineers and scientists in the construction of water well in Kaiama.

Key words: modeling, ionic content, i aquiferous zone and permeability and seepage velocity

1. Introduction

The regional geology has been mapped and described by Wells and O'Brien (1994a and 1994b bread 2005) and is also summarized by Whitaker and Green (1978). Early work on the volcanic rocks wasp documented by Stevens (1968), and more detailed geologic information and mapping in the study area provided by Willey (1992). The regional geomorphology was interpreted by Ollier and Harworth (1994). The area is dominated by two main rock units: a near-horizontal to gently dipping Middle Jurassic sedimentary sequence of the Moreton-Clarence Basin, part of the Great Artesian Basin, and the mid-Tertiary Main Range Volcanics (MRV), extending up to 50 km westward from Toowoomba. These strata unconformable overlie a concealed basement of Palaeozoic rocks, the New England Orogen (**I**brahim,2006, Bread, 2005, Bread, et al, 2005, Briggs, 2008).The primary environmental issue facing the whole world, in terms of subsurface environment, is the protection of good quality groundwater and the clean-up or remediation of already contaminated groundwater resources (**I**brahim,2006).. Before 1976, US citizens had used open dumping of wastes which invariably resulted into soil contamination, groundwater pollution, and adverse health hazards, including cancer in children traceable to contamination by industrial chemicals. This led to public outcry and environmental regulations promulgated by both federal and state governments. In a developing country like Nigeria where the practice of waste containment is nonexistent, deadly health hazards from soil or groundwater pollution by harmful elements like mercury (Hg), potassium (K), sodium (Na), zinc (Zn), lead (Pb), etc are a reality especially when the country steps into proper development of her natural mineral resources To impede the transport processes of these contaminants, compacted clay liners are normally used as an integral component of the lining systems to cover landfills, municipal and hazardous waste impoundments, and also to cap new or old waste disposal units (Daniel and Benson, 1990; Albrecht and Benson, 2001 Shackelford, 1994, 2000). Considering advection as a major transport process, the most significant factor affecting the performance of compacted clays is hydraulic conductivity. Apart from hydraulic conductivity, diffusion is a very important transport mechanism especially if the seepage velocity is or approaches zero (Shackelford and Daniel, 1991, Shackelford, 1990, 1993). Contaminants travel along the pathway of least resistance, and narrow permeable channels usually govern their movement. Defining these transport pathways is of paramount importance, and is difficult using traditional methods of drilling and sampling because the volume explored is small, sampling is slow, and the cost of sampling is often prohibitive.

2. Theoretical background

Accumulation of ionic content has been found to deposit at a highest concentration in the study area. Kaiama was confirmed through hydrological studies carried out to deposit high ionic content precisely in aquiferous formation. These depositions are attributed to the geologic history of the study area. The stratification of the formation deposits homogeneous and heterogeneous under the influence of formation variables. Ionic content are found in every aquiferous formations, seepage velocity influence the migration of the ionic content through regeneration of the contaminant in soil where the velocity are very low. Those formations are also where the hydraulic conductivity is found to deposit low percentage. Precisely, these formations are known as slight lateritic and clay formations. Such formations within those two formations develop high accumulation of ionic content under the influence of predominance of montmorillonite in the study formation. Kaiama deposits a shallow aquiferous zone with high rate of permeability expressing constant seepage velocity, including deposition of other minerals in the strata. Accumulation of ionic contents is also developed through the industrialization of man-made activities under the influence of exploitation of other minerals that are found to create wealth or generate revenue in the country. The rate of ionic content express this sources under the influences of hydrological studies that carried all this details, but the solution to these problem in terms of developing quality ground water in such complex formation were not done, such condition has made the abstraction of ground of quality become very difficulty in the study location. The circumstances call for better solution that will develop conceptual frame work for construction of quality water borehole in the study location. The solution for this ugly scourge will generated better construction method by establishment of mathematical model that will monitor and predict the deposition of ionic content in the study location.

3. Governing equation

$$\frac{Vi\,\partial C}{\partial xi} = K_I \frac{qi}{\varepsilon} = K_I \frac{h}{\varepsilon}\frac{\partial C}{\partial xi} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

The governing equation expresses the accumulation of ionic content in aquiferious zone influenced by permeability and seepage velocity in Kaiama Bayelsa State, the expressed equation were modified base on the variables that are influential to that system in other to solve the deposition of ionic content in the study location, the governing equation are modified to determine the level of ionic content in the stratification of the formation.

$$\frac{\partial C}{\partial x} = SC_{(x)} - C_{(0)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$\frac{\partial C}{\partial xi} = SC_{(x)} - C_0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

$$C = C_o \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

To express the variable in terms relating themselves to each other in the system , the parameters was transform to Laplace, this mathematical method was applied I so that principal parameters in the system express its function inline with the achievement of ensuring that the level of deposition are determined in soil and water environment

Substituting equations (2), (3) and (4) into equation (1) yield

$$Vi\left[SC_{(x)} - SC_{(x)} - C_{(0)}\right] - \frac{qi}{\varepsilon} - K_I \frac{h}{\varepsilon}\left[SC_{(x)} - C_{(x)}\right] - C_{(0)} \quad \ldots\ldots\ldots\ldots \quad (5)$$

$$Vi\ SC_{(t)} - ViSC^{1}{}_{(t)} - C_{(0)} - \frac{qi}{\varepsilon} K_I \frac{h}{\varepsilon} SC_{(0)} + \frac{qi}{\varepsilon} K_I \frac{h}{\varepsilon} C_{(0)} - C_{(0)} \ldots\ldots\ldots\ldots\ldots \quad (6)$$

Considering the following boundary condition at $t = 0, C^{1}{}_{(0)} = C_0 = 0$ .... (7)

We have

$$C_{(x)} \left(ViS - Vs - \frac{qi}{\varepsilon} K_I \frac{h}{\varepsilon} S \right) = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (8)$$

$$C_{(t)} \neq 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (9)$$

But considering the boundary condition

At $t > 0, C^{1}{}_{(0)} = C_{(0)} = C_o$ .... (10)

Equation [10] is the established boundary condition in the system, the condition considered as boundary values shows the condition where the period that it will be greater than zero and concentration from the initial level of deposition remain in constant level as initial concentration under the influences of constant regeneration of formation influence such low permeability in some deposited formations.

$$SC_{(x)} - \frac{qi}{\varepsilon} \frac{Kih}{\varepsilon} S_{(x)} - Vi\,Sc_o + Vi\,C_o + \frac{qi}{\varepsilon} K_I \frac{h}{\varepsilon} C_o \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (11)$$

$$\left[ViS - \frac{qi}{\varepsilon} K_I \frac{h}{\varepsilon} S \right] C_{(x)} = \left[Vi\,S + Vi + \frac{qi}{\varepsilon} K_I \frac{h}{\varepsilon} \right] C_o \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (12)$$

$$\frac{C_{(x)} = Vi\,S + Vi\,\frac{qi}{\varepsilon} K_I \frac{h}{\varepsilon}}{ViS - \frac{qi}{\varepsilon} K_I \frac{h}{\varepsilon} S} C_o \quad \ldots\ldots\ldots\ldots\ldots \quad (13)$$

Subject to this relation, quadratic function were find suitable in the system to detailed the expressed parameter at another considered condition, the system applied the concept to monitor the deposition of ionic content in another soil structural stratification, this is base on the formation characteristics variables that may be found in the study location, such condition call for the application of quadratic expression so that it can monitor the deposition of ionic content in the study area , further more the expression of seepage velocity in the formation may develop several change in concentration in some condition, but application of this method will ensure that the system accommodate every condition in the deposition under the influences of seepage velocity in the study area.

Applying quadratic expression, we have

$$S = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (14)$$

Where $a = Vi$, $b = \dfrac{qi}{\varepsilon}$, $c = K_I \dfrac{h}{\varepsilon}$

$$S = \frac{\frac{qi}{\varepsilon} - \sqrt{\frac{qi}{\varepsilon}^2 + 4ViK_I \frac{h}{\varepsilon}}}{2Vi} \quad \ldots\ldots\ldots\ldots \quad (15)$$

$$S_1 = \frac{\frac{qi}{\varepsilon} - \sqrt{\frac{qi}{\varepsilon}^2 - 4ViK_I \frac{h}{\varepsilon}}}{2Vi} \quad \ldots\ldots\ldots\ldots \quad (16)$$

$$S_2 = \frac{\frac{qi}{\varepsilon} + \left[\sqrt{\frac{qi}{\varepsilon}^2 + 4ViK \frac{h}{\varepsilon}}\right]}{2Vi} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (17)$$

$$S_1 = \frac{\frac{qi}{\varepsilon} + \left[\sqrt{\frac{qi}{\varepsilon}^2 + 4ViK_I \frac{h}{\varepsilon}}\right]}{2Vi} S_2 + \frac{\frac{qi}{\varepsilon} - \left[\sqrt{\frac{qi}{\varepsilon}^2 + 4ViK_I \frac{h}{\varepsilon}}\right]}{2Vi} \ell^{\frac{\left[\frac{qi}{\varepsilon} + \sqrt{\frac{qi}{\varepsilon}^2 + 4ViK_I \frac{h}{\varepsilon}}\right]^{\frac{L}{v}}}{2Vi}} + \frac{\left[-\frac{qi}{\varepsilon} - \frac{qi}{\varepsilon}\sqrt{\frac{qi}{\varepsilon}^2 + 4ViK \frac{h}{\varepsilon}}\right]}{2Vi} \quad \ldots\ldots\ldots\ldots \quad (18)$$

Applying inverse of the equation, we obtain

$$C_{(x)} = \left[\frac{Vi}{x} + Vi + \frac{qi}{\varepsilon}\right] C_o \, \ell^{\frac{\left[\frac{qi}{\varepsilon} + \sqrt{\frac{qi}{\varepsilon} + 4ViK \frac{h}{\varepsilon}}\right]^x}{2Vi}} + \ell^{\frac{\left[\frac{qi}{\varepsilon} - \sqrt{\frac{qi}{\varepsilon} + 4ViK_I \frac{h}{\varepsilon}}\right]^x}{2Vi}} \quad \ldots\ldots\ldots \quad (19)$$

Application of inverse Laplace were also find necessary because the concentration may not be uniform in terms of deposition at a\t every deposition in soil structural deposition in study area. The deposition of ionic con content should have slight variation due to different void ration within the intercedes of the soil, soil structural depositions are base on the disintegrations of the porous rock generating a structure strata at different depths to ground water aquifers the application is suitable because concentration will definitely vary as concentration of ionic content at a particular formation will be greater one in another strum. Application of inverse Laplace transformation is very necessary to predict the rate of inverse at some depositions which may be reflected in the system simulation

But if $x = \dfrac{t}{v}$

$$\left[C\,[t,v] = {Vi}\big/{t/v} + Vi + \frac{qi}{\varepsilon}\right]C_o \ell^{\frac{\left[\frac{qi}{\varepsilon}+\sqrt{\frac{qi^2}{\varepsilon}+4ViK_I\frac{h}{\varepsilon}}\right]^{\frac{t}{v}}}{2Vi}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (20)$$

Considering the following boundary condition at

$$t = 0, C^1{}_0 = 0, C_0 = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (21)$$

$$C_{(x)} = \left[\frac{Vi}{x} + Vi + \frac{qi}{\varepsilon}\right]C_o\, \ell^{\frac{\left[\frac{qi}{\varepsilon}+\sqrt{\frac{qi^2}{\varepsilon}+4ViK_I\frac{h}{\varepsilon}}\right]^{\frac{t}{v}}}{2Vi}+\frac{\left[\frac{qi}{\varepsilon}\sqrt{\frac{qi^2}{\varepsilon}+4ViK_I\frac{h}{\varepsilon}}\right]^{\frac{t}{v}}}{2Vi}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (22)$$

At $C^1{}_{(0)} = t \neq 0$

Again $C_{(0)} = C_{(0)}$

So that $C_O = \left[Vi + \frac{qi}{\varepsilon}\right]C_o\,[1+1]\,i.e.\,0 = \left[0 + \frac{qi}{\varepsilon}\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (23)$

$$\Rightarrow \quad \frac{qi}{\varepsilon} + \frac{qi}{\varepsilon} = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (24)$$

So that we have

$$C_{(x)} = \left[2\frac{Vi}{x}\right]C_o\, \ell^{\frac{\left[\frac{qi}{\varepsilon}\sqrt{\frac{qi^2}{\varepsilon}+4VK_I\frac{h}{\varepsilon}}\right]^{\frac{t}{v}}}{2Vi}+\frac{\left[\frac{qi}{\varepsilon}-\sqrt{\frac{qi^2}{\varepsilon}+4ViK\frac{h}{\varepsilon}}\right]^{\frac{t}{v}}}{2Vi}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (25)$$

Application sunsidal expression were introduces because the depositions reflects inverse transformation of the system, the expressed suncidal application is to motivate the inverse application to streamline the system since the deposition of ionic content at accumulated stage may vary in concentration at high deposition in the formation, these conditions are base on the structural strategraphic of the formations under the influences of geologic history..

However, $e^x + e^{-x} = 2Cos\,x$ therefore, we have

$$\boxed{C_{(x)}\left[2\frac{Vi}{t}\right]C_o\; Cos\,\frac{\left[\frac{qi}{\varepsilon}\sqrt{\frac{qi}{\varepsilon}+4ViK_I\frac{h}{\varepsilon}}\right]^{\frac{t}{v}}}{2Vi}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (26)$$

The developed model from the derived equation has expressed as the model that will monitor the deposition of ionic content in the study location. The expressed model considered different condition that cause the accumulation of ionic content in the study location as expressed in the system. The accumulations of ionic content deposition have lots causes from different dimension, therefore it imperative that the system ensure that those conditions are thoroughly expressed in the system. therefore the development of the derived solution were expressed considering all the influences develop to accumulation of this ionic content in the formation, the final expressed model will definitely predict the rate of accumulation and deposition of ionic content in the study area.

4. Conclusion

Modeling accumulation of ionic content in aquiferous zone influenced by permeability and seepage velocity as been thoroughly expressed. The depositions of ionic content are base various condition of the soil including the activities of man in the study area. But the most influential is the stratigarphy deposition of the formation, the influence from the formation are through the formation characteristics of the formation such variation of void ratio including permeability and porosity of the formation, the application of mathematical model were find appropriate to ensure that various condition of the formation including the influences from manmade activities are through expressed in the derived solution. This is ensuring it generates model from different mathematical approach. Expressing the method was to ensure the rates of ionic content in the formation that degrade ground water aquifer are thoroughly predicted through the developed model. The developed model in the study will definitely predict the deposition ionic content in the study location.

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