International Journal of Sustainable Energy and Environment
Vol. 1, No. 5, June 2013, PP: 103 –110, ISSN: 2327- 0330 (Online)
Available online at www.ijsee.com

Research article

MODELING THE DEPOSITION OF ADSORPTION RATE OF CARBON INFLUENCE BY POROSITY IN SEMICONFINED BED IN OKIRIKA, RIVERS STATE OF NIGERIA

Eluozo, S. N[1]. . Nwaoburu A .O[2]

[1]Subaka Nigeria Limited, Port Harcourt, Rivers State of Nigeria
[1]Director and Principal Consultant Civil and Environmental Engineering, Research and Development

E-mail: Soloeluozo2013@hotmail.com
E-mail: solomoneluozo2000@yahoo.com
[2]Department of mathematics, Faculty of science Rivers State University of science and technology Nkpolu, Port Harcourt

---

Abstract

Modeling the adsorption rate of carbon influenced by porosity in semi confined bed has been carried out in okirika. The model was develop through the governing equation to monitor the rate of adsorption in coastal area of okirika, several studies has been done but proof abortive, base on these situation, mathematical model were find suitable to find better solution in this dimension, the model were develop considering those influential challenging condition in the coastal location, the rate of porosity were confirmed to determine the rate of adsorption in the formation, the developed model express the rate of porosity in the stratification of the soil, the study were able to showcase environmental influence in the express model, because it reflect on the rate of adsorption in the study location, this is through high rain intensities that increase degree of saturation of the soil. The develop model is imperative because it has showcase the rate of influence in the model, so the expressed model with all this influential parameters will definitely predict the rate of adsorption under the influence of porosity variation in the study area.

Keywords: modeling deposition, deposition of carbon, porosity and semiconfined bed

---

1. Introduction

Diverse amounts of heavy metals may be found everywhere; in soils, water, sediments, plants [szefer,1997,glasby,1998,szefer,1998,szefer,1995,szefer,1995], even the Arctic [pacyna,1994]. The emission sources of these xenobiotics have been studied for several years in order to reduce pollution. Chemicals like heavy metals once introduced to the environment by one particular method may spread to various environmental components, which may be caused by the nature of interactions occurring in this natural system. Heavy metals may chemically or physically interact with the natural compound, which changes their forms of existence in the environment. In general they and precipitate [Dube et al 2000]. Heavy metals may be bound or sorbed by particular natural substances, which may increase or decrease mobility. Studying the dissipation of heavy metals is called speciation [hulaniki.2000]. Literature study shows that the speciation may be understood in different ways and in various aspects, but in all cases when we generally talk about different forms of existence of studied compounds we talk about speciation [8-10]. In general two forms of speciation are distinguished by environmental scientists: chemical and physical [Hulanki, 2000, kot and namiesnik, 2000]. However chemical speciation may be distinguished further, it is said about group speciation, distribution speciation, individual speciation and many more [Hulanki, 2000, kot and Namiesnik, 2000].

Groundwater is the main resource of drinking water in many parts of the world. Contamination resulting from industry, urbanization and agriculture poses a threat to the groundwater quality [Amadi, 2009]. The task of balancing groundwater protection and economic activities is challenging. Therefore, understanding the effects of different water management strategies and the role of climate change is essential for the sustainable use of coastal groundwater resources [Prasad and Narayana, 2004]. According to Olobaniyi and Owoyemi [2006], the coastal regions of the world are the most densely populated areas in the world. More than one third of the world's populations are living within 100 km of the coastline [Hughes, et al., 1998]. At the same time, the coastal regions provide about one third of the world's ecosystem services and natural capital [Aris, et al., 2007]. Such growth is accompanied by increasing demand for water supply leading to the over-exploitation of the aquifer system and excessive drainage for land reclamation purposes. Contamination of the groundwater by natural means (seawater intrusion) and through anthropogenic means (human activities) cannot be ruled out in the area. The study is aimed at evaluating the quality of groundwater from the coastal plain-sand aquifer Port-Harcourt area with the view of determining its suitability for domestic, irrigational and industrial purposes. The heavy industrial and human activities in the area lead to the present study. The aquifer system in the area is largely unconfined, highly porous and permeable and the possibility of anthropogenic interference cannot be completely ignored, hence the need for this study. Port-Harcourt, the 'garden-city and treasure base of the nation' is situated about 60 km from the open sea lies between longitude 6o55'E to 7o10'E of the Greenwich meridian and latitude 4o38'N to 4o54'N (Fig. 1) of the Equator, covering a total distance of about 804 km2 [Akpokodje 2001]. In terms of drainage, the area is situated on the top of Bonny River and is entirely lowland with an average elevation of about 15 m above sea level [Nwankwoala, 2005]. The topography is under the influence of tides which results in flooding especially during rainy season [Nwankwoala and Mmom, 2007]. Climatically, the city is situated within the sub-equatorial region with the tropical monsoon climate characterized by high temperatures, low pressure and high relative humidity all the year round. The mean annual temperature, rainfall and relative humidity are 30oC, 2,300 mm and 90% respectively (Ashton-Jones, 1998). The soil in the area is mainly silty-clay with interaction of sand and gravel while the vegetation is a combination of mangrove swamp forest and rainforest [Teme, 2002].

2. Theoretical Background

Semi confined bed develop a higher hydrostatic pressure more than unconfined aquifers, this condition are reflected on the stratification of the formation, such formation deposit either homogeneous or heterogeneous formations, this expression are confirm in hydrogeological studies, but the deposition of other substance like minerals, are harmful or harmless, they are not detailed on hydrogeological studies, most risk assessment carried out are not thoroughly done to expressed detailed studies of the most mineral in the soil formation. These condition develop several threat to formation were ground water aquifer are deposited, the deposition of carbon were investigated in the coastal area of okirika, the formation deposition slight thickness of sand stone that develop over burden pressure in the study area, despite this geological setting formation characteristics from porosity were confirmed to displayed several influence in most strata in the study area. The adsorption of carbon were found to develop numerous influence on between the organic and fine coarse formation, low permeability are attributed to such experience, including low porosity, this condition developed high accumulation of carbon from organic to fine coarse sand, the study confirmed these condition and fine it imperative that better solution should be applied, this to monitor this accumulation of this substance in semi confined formation in the coastal area of okirika. Development of mathematical model were fine suitable in the study, to ensure that thorough established system are develop that can determine the rate of adsorption in semi confined aquifers, the formation also develop crystallized aquiferous formation in the study area, this condition were all considered through mathematical symbols were an expressed equation were develop, the study streamlined various causes of carbon adsorption in coastal area of okirika.

3. Governing equation

$$\theta m \frac{\partial Cs}{\partial t} = K \frac{\partial Cs}{\partial X}\left[C^{\omega}{}_{p} - C^{\omega}{}_{p}\right] \qquad \ldots\ldots\ldots\ldots\ldots.. \quad (1)$$

Applying Laplace transformation into equation (2)

$$\frac{\partial Cs}{\partial t} = S^1 C_{(t)} - C_{(o)} \qquad \text{...............} \qquad (2)$$

$$\frac{\partial Cs}{\partial t} = S^1 C_{(x)} - C_{(o)} \qquad \text{...............} \qquad (3)$$

$$Cs = C_o \qquad \text{...............} \qquad (4)$$

The expressions from [1] to [4] applied Laplace transformation, this concept were to transform the product to the level the parameters can express their various function on deposition of the adsorption in semi confine bed, such condition in coastal formation has variations that should be streamlined in the deposition system. Transforming the parameters is imperative because the functionalities of the parameters will be thoroughly streamlined in the system.

$$\theta m \left[S^1 C_{(t)} - C_{(o)} \right] - K \left[SC_{(t)} - C_{(x)} \right] - C^{\varpi}{}_{p} - C^{\varpi}{}_{p} \qquad \text{...............} \qquad (5)$$

$$\theta m \left[SC_{(t)} - \theta m S_{(t)} - C_{(o)} - K\, SC_{(x)} + K\, C_{(o)} - C^{\varpi}{}_{p} - C^{\varpi}{}_{p} \right] \qquad \text{...............} \qquad (6)$$

Considering the following boundary condition at

$$t = 0,\; C^1{}_{(o)} = C^1{}_{(o)} = 0 \qquad \text{...............} \qquad (7)$$

$$C_{(t)} - \theta m S^1 - \theta m S - KS = 0 \qquad \text{...............} \qquad (8)$$

$$C_{(t)} \neq 0 \qquad \text{...............} \qquad (9)$$

But considering the boundary condition at

$$t = 0,\; C^1{}_{(o)} = C_{(o)} = 0 \qquad \text{.............} \qquad (10)$$

The concept from [5] to [10] evaluated the parameters that express the rate of adsorption in semi confined bed, the rate of accumulation of the substance were descretize in the system, the influential parameters express themselves with each others, the rate accumulation show the low rate of porosity in the formation between the organic and the silty formation in the study area. The boundary values shows there various limit in the system base the types of formation, including the rate of variation in soil stratification in coastal area of okirika

$$\theta m\, S^1 C_{(t)} - K\, SC_{(x)} - C^{\varpi}{}_{p} - C^{\varpi}{}_{p}\, C_{(x)} = \theta m\, SC_{(o)} + \theta m\, C_o + KC_o \qquad \text{................} \qquad (11)$$

$$\left[\theta m\, S^1 - KS - C^{s}{}_{\omega} - C^{s}{}_{\omega} \right] C_{(t)} = \left[\theta m\, S + \theta m + K \right] C_o \qquad \text{................} \qquad (12)$$

$$C_{(t)} = \frac{\theta m\, S + \theta m + K}{\theta m\, S + \theta m\, S - C^{s}{}_{\omega} - C^{s}{}_{\omega}} C_o$$

Applying quadratic equation, we have

The rate of accumulation of substance between the organic and silty formation in semi confined bed were thoroughly evaluated, the application of quadratic expression were suitable because the expression were to monitor exponential level of adsorption in the system, the expressions shows how the boundary condition were integrated with the parameters in the to express their various limitation and functions in the study location.

International Journal of Sustainable Energy and Environment
Vol. 1, No. 5, June 2013, PP: 103 –110, ISSN: 2327- 0330 (Online)
Available online at www.ijsee.com

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

$$\frac{-\mathrm{K} \pm \sqrt{\mathrm{K}^2 + 4\theta m\, C^{\omega}{}_p - C^{\omega}{}_p}}{2\theta m} \qquad \ldots\ldots\ldots\ldots\ldots.. \quad (15)$$

$$C_{(t)} = A \exp\left[-K + \frac{\sqrt{-\mathrm{K} + 4\theta m\, C^{\omega}{}_p - C^{\omega}{}_p}}{2\theta m}\right] t \left[\exp\left[-\mathrm{K} + \frac{\sqrt{-\mathrm{K}^2 + 4\theta m\, C^{\omega}{}_p - C^{\omega}{}_p}}{2\theta m}\right]\right] x \quad (16)$$

Subject equation (16) to the following boundary conditions and initial values conditions

$$x = 0,\ C_{(o)} = 0 \qquad \ldots\ldots\ldots\ldots\ldots \quad (17)$$

The expression progress as the parameters were subjected to correlations with other parameters it continue to express their functions at various conditions under the influence of formation variation in the system, the expression in the system interact with other variation on their boundary values, this is base on the condition of the formation in the system. The major influence is porosity, such condition are express in the deposition of carbon in the strata, the degree of porosity varies , the degree of porosity in organic and silty formation in semi confined bed, they are found to express porosity are very low compared to the coarse and gravel formations. This implies that at coastal formations, the adsorption rate are mostly deposited from the organic to silty formation, the rate of void ratio were also found to be very low in those formation, such formation deposit boundary values that are more influential to their parameters, because it determine the rate of change in the adsorption rate of the formation.

So that particular solution will be of this form

$$C_{(t)} = \exp\left[-K + \frac{\sqrt{-\mathrm{K} + 4\theta m\, C^{\omega}{}_p - C^{\omega}{}_p}}{2\theta m}\right] t \left[\exp\left[-\mathrm{K} + \frac{\sqrt{-\mathrm{K}^2 + 4\theta m\, C^{\omega}{}_p - C^{\omega}{}_p}}{2\theta m}\right]\right] x \quad (18)$$

But $e^x - e^x = 2Sin\ x$,

for the purpose of degradations in some formation especially those formations were the hydraulic conductivity is very high, the formation deposit decrease in adsorption rate so application of Suncidal mathematical techniques was applied in the system, the concept are applied in the quadratic expression. The express equation was base on time accumulation and distance travelled on the formation.

Therefore, the expression (19) can be of the form

$$C_{(t)} = 2Sin\left[\mathrm{K}^2 + \left(\mathrm{K}^2 + 4\theta m\, C^{\omega}{}_p - C^{\omega}{}_p\right)^{1/2}\right] x \qquad \ldots\ldots\ldots \ (19)$$

But $x\frac{V}{t}$

Therefore the model can be expressed as;

$$C_{(t)} = 2\mathrm{Sin}\left[\mathrm{K} + \left(\mathrm{K}^2 + 4\theta m\, C^{\omega}{}_p - C^{\omega}{}_p\right)1/_2\right]\frac{V}{t} \quad \text{.........} \quad (20)$$

The formation on this condition express the velocity of flow, it is reflected from the adsorption rate, constant regeneration rate of adsorption implies the carbon are transport from one formation to another, change in deposition reflect velocity of flow through change time of deposition, the velocity played it roles when the substance accumulate to the rate were it the substances migrate to the next formation, so there is change in formation deposition and time through velocity of transport, this condition are reflected on the degree of porosity at different formation, the increase in porosity of the formation are base on the deltaic nature in the study location, more so environmental influence from this dimension developed it pressure from high rain intensities, constant rain in the study location increase the degree of saturation and porosity in the formation ,consequently generate migration of the substance, the rate of adsorption are base on the change in stratification from this sources.

Again, if $\frac{V}{t} - x$

$$C_{(x)} = 2\mathrm{Sin}\left[\mathrm{K} + \left(\mathrm{K}^2 + 4\theta m\, C^{\omega}{}_p - C^{\omega}{}_p\right)1/_2\right]x \quad \text{.........} \quad (21)$$

Combining (20) and (22) yields

$$C_{(x,t)} = 2\mathrm{Sin}\left[\mathrm{K} + \left(\mathrm{K}^2 + 4\theta m\, C^{\omega}{}_p - C^{\omega}{}_p\right)1/_2\right]\frac{V}{t} +$$

$$2\mathrm{Sin}\left[\mathrm{K} + \left(\mathrm{K}^2 + 4\theta m\, C^{\omega}{}_p - C^{\omega}{}_p\right)1/_2\right]x \quad \text{.........} \quad (22)$$

The expression in [22] is the final model equation to monitor the rate of deposition adsorption rate of carbon in the coastal formation, the expression were generated from the established governing equation, these condition were made possible through various information from hydrological studies, but could not find better solution to the adsorption rate of carbon in the study area, other studies carried out could not develop perfect solution to determine the adsorption rate of carbon, the study area are deltaic in nature and this condition develop several environmental challenges, but further study was carried out to ensure that the rate of adsorption are determined in the study area, this is the development of mathematical model, the model were generated from various information that has produced variables and it was applied to formulate mathematical equation, the expression was derived to produced the final model that will monitor the adsorption rate of carbon in semi confined bed.

4. Conclusion

Adsorption is the rate substance accumulates in a particular region, these substances are mostly deposited on the surface layer of the formation, but since soil has lots of variation under the influence of porosity of the formation, it becomes a subject of concern. The rate of adsorption varies depending on the degree of porosity establish in the coastal formations, the study streamline several conditions, these are the geological setting of the formation including the stratification deposition of the formation, the coastal location were found to be deltaic in nature thus consequently developing several environmental challenges, climatic condition in the study area are of the challenges in the study area, high rain intensities are very high in the study location increasing the degree of saturation as expressed from the study. The challenging condition makes it imperative to develop a mathematical model through the governing equation, the expressed mathematical equation were resolved by application of mathematical methods that produce a mathematical model, this generate better solution by determining the rate of adsorption in semi confined bed in coastal area of okirika, several information were presented about the study area, this were all considered in the research, the study is imperative because the model will predict the rate of adsorption in the coastal area of okirika.

Reverences

[1] Dube1, A, Zbytniewski1 R.. Kowalkowski1, T Cukrowska E.,. Buszewski1 B Adsorption and Migration of Heavy Metals in Soil Polish Journal of Environmental Studies Vol. 10, No. 1 (2001) 1-10

[2] Akpokodje, G. E., (2001). Hydrogeochemical investigation of groundwater in parts of Niger Delta. Jour. of Mining and Geol. Vol.19, pp 145-150.

[3] Amadi, A. N. (2009). Physio-chemical and Bacteriological Evaluation of Groundwater in parts of Aba, Abia State, Southeastern Nigeria. International Journal of Applied Biological Research, Vol. 1, No. 1, pp 63-71.

[4] Amadi, A. N. (2009).Effects of urbanization on groundwater quality: a case study of port-Harcourt, southern Nigeria Natural and Applied Sciences Journal Vol. 11 No. 2

[5] Olobaniyi, S. B. and Owoyemi, F. B., (2006). Characterization by factor analysis of the chemical facies of groundwater in the deltaic plain-sands aquifer of Warri, Western Niger Delta, Nigeria. African Jour. Of Science and Tech., 7 (1), 73-81.

[6] Ashton-Jones, E., (1998). Human Ecology of the Niger Delta, Benin City, An ERA handbook.

[7] Aris, A. Z. and Abdullah, M. H. and Musta, B., (2007). Hydrochemical analysis on groundwater in Shallow aquifers of Manukan and Mabul island, Malaysia

[8] Hughes, C. E., Binning, P. H. and Willgoose, G. R., (1998). Characterization of the Hydrology of an estuarine wetland. Journal of Hydrology, Vol. 211, pp 34-49

[9] Nwankwoala, H. O. and Mmom, P. C., (2007). Towards sustainable management of Groundwater in Port-Harcourt Metropolis. Jour. Of Nigerian Environmental Society, Vol. 3, No. 3, pp 204-214.

[10] Nwankwoala, H. O., (2005). Estimating aquifer parameters in parts of Port-Harcourt and environs using pumping test data. Unpublished M.sc thesis, Rivers State University of Science and Technology, Nigeria.

[11] Teme, S. C., (2002). Geotechnical Consideration on Foundation Design in the Niger Delta. Lead paper presented at the plenary session. Proc. 38th Annual Inter. Conference of the Nigerian Mining and Geosciences Society (NMGS) held in Port-Harcourt.

[12] Prasand, B. G. and Narayana, T. S. (2004). Subsurface water quality of different sampling station with some selected parameters at Machilipatnan Town, Nat. Env. Poll. Tech., 3 (1), pp 47-50

[13] . Szefer, P. Bull. Environ. Contam. Toxicol. **58,** 108, **1997.**

[14] . Glasby, G.P. The Sci.of Tot. Environ. **212,** 49, **1998.**

[15] . Szefer, P. Applied Geochemistry **13,** 305, **1998.**

[16] . Szefer, P. Chemical Geology **120,** 111, **1995.**

[17] Szefer, P. Environment International **24,** 359, **1995.**

[18] Pacyna, J.M. Global Perspectives on Lead, Mercury and Cadmium Cycling in the Environment. Edited by T.C.

[19] Hutchingson Wiley Eastern Ltd. pp 315-328, **1994.**

[20] Dube A., Kowalkowski T., Zbytniewski R, Kosobucki Cukrowska E, Buszewski B, Pro ceedings of the XVth International Symposium on Physico-chemical Methods of the Mixtures Separation – **Ars Separatoria' 2000,** June 14 - 17, 2000, Borowno n. By dgoszcz, pp.21, **2000.**

[21] HulanickI, A. W: Chromatografia i inne techniki separacyjne u progu XXI wieku, B. Buszewski (red. nauk.), SARPomorze, Bydgoszcz **2000,** pp. 19.

[22] SIEPAK, J. Analiza specjacyjna metali w probkach wod i osadow dennych. Wyd. UAM Poznari, **1998.**

[23] Kot A., NAMIESNIK J., Trends in Anal. Chem. **19,** 69,**2000**