World Journal of Science and Technology Research
Vol. 1, No. 2, April 2013, PP: 44 - 52,
Available online www.wjst.org

Research article

PREDICTIVE MODEL TO MONITOR THE MIGRATION OF KLEBSIELLA INFLUENCED BY VOID RATIO AND POROSITY IN HOMOGENEOUS FORMATION IN CHOBA, RIVERS STATE OF NIGERIA

Eluozo, S. N.

Subaka Nigeria Limited, Port Harcourt Rivers, State of Nigeria
Director and Principal Consultant Civil and Environmental Engineering, Research and Development
E-mail: Soloeluozo2013@hotmail.com
E-mail: solomoneluozo2000@yahoo.com

Abstract

Predictive Model to monitor the migration of klebsiella influenced by void ratio and porosity has been developed. Klebsiella migrations are through soil structural formation in the study location. These types of microbial movement were confirmed leaching to ground water aquifers within a short period of time. Constant regeneration of this contaminant has developed high rate of klebsiella concentration to a very large extent in the study location**,** the model were derived through developed governing equation. An expressed equation was generated considering the variables that pressure the system on fast migration of klebsiella to ground water aquifers, this concept were to express the direction of fluid flow based on the soil structural formation, the deposit of aquifers are under the influences of high degrees of porosity and void ratio, variation of fluid pressure were expressed with respect to time of flow, this has increased ground water contaminant through leaching of klebsiella deposition in soil and water environment: These include distance travelled to ground water aquifers and other existence influence in the formations, the study is significant because the rate of fast migration of other substances are through the influence of regeneration of the contaminants, they are also influenced by formation characteristics such as porosity and void ratio, the variables played major roles in fast migration of the contaminants within a short period of time, the degree of this two parameters determined the rate of variation of klebsiella concentration in soil, since variation in fluid flow determine several ground water conditions in the study area.

Keywords: predictive model, migration of klebsiella void ratio and porosity and homogeneous formation

1. Introduction

Manmade pollution of water is divided into two kinds: point source is caused by discharge of pollutants from specific location for example discharge from factories sewage treatment plants and oil tankers into rivers, and non-point source occurs from rainfall or melting of snow and the run-off washes away pollutants into lakes, rivers and coastal waters Industries vary in size, nature of products, characteristics of waste discharged and the receiving environment. The major industrial categories in Nigeria are metals and mining, food, beverages and tobacco; breweries, distilleries, textile, leather products, wood processing and manufacture, furniture, pulp and paper industries and chemical and allied industries. Industrial effluents contain toxic and hazardous materials from the wastes that settle in river water as bottom sediments and constitute health hazards to the urban population that depend on the water as source of supply for domestic uses (Akaniwor et al, 2007). Groundwater quality is defined based on a set of health and safety regulations for domestic use. Ground water used for public domestic supply must adhere to a set of regulatory objectives for health and safety than ground water used strictly for irrigation needs. Groundwater contamination occurs when manmade products such as gasoline, oil, fertilizers, pesticides and other chemicals get into groundwater and cause it to be unsafe and unfit for human use. Septic systems, hazardous waste sites and landfills are major targets of pollution because rainfall and groundwater leach these highly contaminated substances into rivers, stream and waterways (surface water) which are inadvertently used by people in that area. (Asonye et al, 2007, Asuquo, 1999).

Contamination of drinking water supplies from industrial waste is as a result of various types of industrial processes and disposal practices. Industries that use large amounts of water for processing have the potential to pollute waterways through the discharge of their waste into streams and rivers, or by run-off and seepage of stored wastes into nearby water sources. Other disposal practices which cause water contamination include deep well injection and improper disposal of waste in surface impoundments. Industrial waste consists of both organic and inorganic substances. Organic wastes include pesticide residues, solvents and cleaning fluids, dissolved residue from fruits and vegetables, and lignin from pulp and paper. This impacts high organic pollutants on receiving waters consequently creating high competition for oxygen within the ecosystem. (Osibanjo and Adie,2007 Ofoma and Egbu, 2005).

Discharge of metals and some nonmetals into water bodies have serious environmental effects. Lead a prime environmental pollutant, is a multiorgan poison which in addition to well known toxic effects depresses immune status (Anetor and Adedeji, 1998 Anon, 1992), causes damage to the central nervous system, kidney and reproductive system. Ademoroti, 1998).Ingestion leads to a disease known as plumbism. It is also known to produce developmental neurotoxicity in particular infants and children are differentially sensitive to environmental lead exposure(Johnson, 1997). Heavy metals particularly arsenic, mercury and lead are environmental pollutants threatening the health of human population and natural ecosystem (Mercier et al, 1998).Land application of waste from confined animal production facilities is an effective method of disposing of animal waste while supplying nutrients to crops and pastureland. However, it has been well-documented that runoff from agricultural livestock and poultry litter applied areas is a source of fecal contamination in water (Crowther *et al.*, 2002; Edwards *et al.*, 1994, 2000; Gerba and Smith, 2005; Tian et *al.*, 2002). The EPA’s National Water Quality Inventory report (USEPA, 2000) identified bacteria as the leading cause of impairments in rivers and streams in the United States and agricultural practices were identified as the leading source of all bacterial impairments

Transport of animal manures into surface water bodies can be detrimental to the health of humans, animals, and the ecosystem (USEPA, 2003). Animal waste contains many different types of organisms pathogenic to humans and animals which could be transported into streams when over-applied to agricultural lands. More than 150 pathogens found in livestock manure are associated with risks tohumans, including *Campylobacter spp.*, *Salmonella spp.*, *Listeria monocytogenes*, *Escherichia coli* O157:H7, *Cryptosporidium parvum* and *Giardia lamblia*, which account for over 90% of food and waterborne diseases in humans (USEPA, 2003). An understanding of the overland transport mechanisms from land applied waste is needed to improve design of BMPs and modeling of NPS pollution for development and implementation of Total Maximum Daily Loads (TMDL). The process of classifying sources of NSP pollution could be greatly simplified by identifying the predominant species of *Enterococci* that are associated with specific sources of fecal pollution. The Biolog System identifies microorganisms based on carbon source utilization (Biolog, 2003). Hagedorn *et al.* (2003) employed carbon source utilization as a form of phenotypic fingerprinting to classify Enterococci isolates from known fecal sources in four different geographical regions (Soupir, 2006).

2. Theoretical background

Void ratio in soil is deposited based on disintegration of the sediment from sedimentary deposition, these conditions are in soil particles' based on the geological settings in the study area, the study area are in deltaic environment, thus deposition is predominantly formation of unconfined bed, it possesses the same geological setting in the deposition of homogeneous soil in the study location. The study area deposits shallow aquifers, this conditions are the influence from deltaic environment; porosity and void ratio were found to have major influence on the migration of the microbes at different formations to ground water aquifers. Such deposition in unconfined bed from deltaic stratification generates high degree of porosity and void ratio; high rain intensities develop high degree of porosity and void ratio and these results to fast migration of the microbes to aquiferious zone. Thus the stratification of the formation deposit homogeneous soil, the microbes in the same vein migrates under constant velocity in transport process, these implies that fluid without solute may also maintain constant flow in the formation of the soil. these expression developed the system that generated the governing equation to predict the migration of klebsiella in unconfined aquifers, the governing equations were derived in phase considering the behaviour of the microbes at different stratum in the study location. The developed model will express the behaviuor of the microbes in terms of exponential and degradation phases, the study is imperative because the behaviour of the microbes in deltaic environment depends on the degree of porosity and void ratio in the formations, Substrate deposition from the formations are expressed through the increase of the concentration in a shallow depth, high degree of this concentration of the contaminants in aquiferous zone should be a serious threat to human settlement due to high demand of ground water in the study area.

3. Governing equation

$$Q\frac{\partial^2 C}{\partial x^2} = U\frac{\partial C}{\partial x} - \alpha k \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Applying Laplace transformation into equation (1) we have

$$\frac{\partial^2 C}{\partial t^2} = S^2 C_{(x)} - SC_{(x)} - C_{(o)} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$\frac{\partial C}{\partial x} = S^1 C_{(x)} - SC_{(x)} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

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

The rate of klebsiella in this condition implies that there is constant deposition of the contaminants from man made activities, the state of this microbes in the transport process developed high level of concentration, this were expressed from equation (2) to (4) and where it was transformed into Laplace to express their functions to the level where the variables will develop a relation to each other at different phase. This is under the influence of soil stratification that has deposited high degree of porosity at various soil formations, leaching of the contaminant to ground water aquifers are subject to this transformation through these expressions, thus, generated the substitution stated in equation(5)

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

$$Q\left[S^2 C_{(x)} - SC_{(x)} - C_{(o)}\right] - U\left[SC_{(x)} - C_{(x)}\right]\alpha k\, C_{(o)} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

$$QS^2 C_{(x)} - QSC^1_{(x)} - C_{(o)} - USC_{(x)} + UC_{(o)} - \alpha k\, C_{(o)} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

Considering the following boundary condition at

$$t = 0,\ C^1_{(o)} = P_o = C_{(o)} = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (7)$$

We have

$$C_{(x)}\left(QS^2 - QS - US\right) = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (8)$$

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

The expression from equations (5) to (9) were to correlate the variables in the system with the transformation from equation (2) to (4) as expressed above, subject to the variables is by relating together and streamline the state of the microbes under exponential condition in several directions under the influence of formation characteristics in the system.

Considering the boundary condition at

$$t > 0,\ C^1_{(o)} = C_{(o)} = C_{(o)} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (10)$$

$$S^2 C_{(x)} - US_{(x)} - \alpha k C_{(x)} = QSC_o + QC_o + UC_o \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (11)$$

$$\left[QS^2 - Us - \alpha k\right] C_{(x)} = \left[QS + Q + U\right] C_o \qquad \ldots\ldots \quad \ldots$$

(12)

$$C_{(x)} = \frac{QS + Q + U}{\left[QS^2 - Us - \alpha k\right]} C_o \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (13)$$

Applying quadratic expression, we have

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

To monitor the rate of klebsiella in the system, an expression from Boundary conditions were included in the equation; this expressed the limits of the contaminant under the influence of formations variations in the study area. The variables in the system expressed significant roles, these were incorporated to observe the boundary limits of microbial transport, it experienced this condition through stratification that developed fast migration of klebsiella to ground water aquifers. Such expression implies that the transport process will definitely experience high degree of microbial concentration under the influence of the system variables, the rate of variation through the influence of void ratio and porosity are observed from the formation status in the study area. Equations (13) and (14) through the boundary values were expressed. Thus the integration generated several functions that influence the variation of microbial contaminant in the system.

Where $a = Q$, $b = -U$, $c = -\alpha k$

$$S = \frac{U \pm \sqrt{U^2 + 4Qakc}}{2Q} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (15)$$

$$S_1 = \frac{U - \sqrt{U^2 - 4Qakc}}{2Q} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (16)$$

$$S_2 = \frac{U + \sqrt{U^2 + 4Qak}}{2Q} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (17)$$

$$S_1 = \frac{U + \left[\sqrt{U^2 - 4Qak}\right]}{2Q} S_2 + \frac{U - \sqrt{U^2 + 4Qakc}}{2Q} \ell^{\frac{\left[U + \sqrt{U^2 + 4Qakc}\right]^{\frac{L}{v}}}{2Q}} +$$

$$\frac{\left[-U - U\sqrt{U^2 + 4Qakc}\right]}{2Q} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (18)$$

Applying Laplace inverse of the equation we obtain

$$C_t = \left[Q/_t + Q + U \right] C_o \ell^{\frac{\left[U + \sqrt{U^2 + 4Qakc} \right]^t}{2Q}} + \ell^{\frac{\left[U - \sqrt{U^2 + 4Qakc} \right]^t}{2Q}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (19)$$

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

$$\left[C\,[L,U] = Q/_{L/_U} + Q + U \right] C_o \ell^{\frac{\left[U + \sqrt{U^2 + 4Qakc} \right]^{\frac{L}{v}}}{2Q}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (20)$$

Considering the following boundary conditions at

$$t = 0$$

$$C^1{}_o = 0$$

$$C_o = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (21)$$

$$C_{(x)} = \left[Q/_t + Q + U \right] C_o \left[\ell^{\frac{\left[U + \sqrt{U^2 + 4Qakc} \right]}{2Q}} \right]^{\frac{L}{v}} + \frac{\left[U + \sqrt{U^2 + 4Qakc} \right]^{\frac{L}{v}}}{2Q} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (22)$$

The expressions of Boundary conditions were included on the appliance of quadratic expression; this is to examine the divergence of microbial contaminants with respect to change in distance, thus the formation characteristics influence ground water aquifers. These expressions are in line with other boundary limits that were applied above. Subject to this relation, the expressions that determine the variations of microbial deposition in this phase are based on variation in formation characteristics; this develops variation of soil stratification under the influence of geological setting in the study location. .

At $C^1{}_o = t \neq 0$

Again $C^1{}_{(o)} = C_{(o)}$ so that $C_o = [Q + U] C_o [1 + 1]$ *i.e.* $0 = [0 + U]^2$ ……………… (23)

$$\Rightarrow \quad U + U = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (24)$$

So that we have

$$C_{(x)} = \left[2 \frac{Q}{t}\right] C_o \, \ell^{\frac{\left[U + \sqrt{U^2 + 4Qakc}\right]^{\frac{L}{v}}}{2Q} + \frac{\left[U + \sqrt{U^2 + 4Qakc}\right]^{\frac{L}{v}}}{2Q}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (25)$$

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

$$C_{(x)} = \left[2 \frac{Q}{t}\right] C_o \, Cos \, \frac{\left[U + \sqrt{U^2 + 4Qakc}\right]^{\frac{L}{v}}}{2Q} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (26)$$

The expression (26) distinct the final representative formular that will monitor the rate of klebsiella in soil and water environment, this is under the influenced of porosity and void ratio in the study area. Klebsiella regenerate from constant dumping of waste indiscriminately or littering of waste in the study area. The derived mathematical equations were generated through the governing equation; the expressed equation will monitor the concentration of klebsiella to groundwater aquifers. Variation influence from several formation characteristics within a short period has been a serious concern to environmental experts. This implies that several ground water should be thoroughly examine, due high degree of contamination from microbial depositions in soil and water environment, this situation has generated several illness from these sources of pollution, because the rate of microbial Contaminants should be thoroughly observed to examine the migration of this pollutant, these are through velocity of transport of contaminant to ground water aquifers. The study of klebsiella transport in soil and water environment is imperative, because knowing the rate of pollution in the environment will made the experts ensure that risk assessment are carried out, this is to prevention pollution through design and construction of ground water system, this will be done through application safety factors in design. To monitor this type of contaminant, mathematical model that will prevent this type of pollution were developed. The negligence from this direction has also resulted to a lot of water-related diseases, thorough investigation were ignored in the study location. Variation of velocity of transport in microbial migration were found leach the contaminant through the flow pathways, this condition play major roles in the migration of solute, therefore the rate of velocity of transport are determined through the variation of structural deposition of soil formation, it has been found to develop a lots of influence on the transport system., therefore modeling for klebsiella are influence by void ratio and porosity, subject to this relation, the migration of klebsiella in soil formation are through fluid flow determined by velocity. The developed model will assist engineers to monitor the rate of klebsiella deposition because it has resulted to several illness in the study area, the major source of water for human utilization is groundwater. Thousands of people in the study area got their water from public water supply and private boreholes. The prevention of the source of pollution will go a long to increase the status of human health in the study area.

4. Conclusion

Variation of klebsiella depositions are from numerous factors, the migration of klebsiella are through soil geological setting, this stratification of the soil formation deposited are influenced by the degree of porosity and void ratio of the formation, the study area are predominant with deltaic formation, this conditions implies that formation has a lots of environmental influenced through climatic condition including the activities of man. Klebsiella migration in soil and water environment were found to have been influence by formation structural deposition, this determine the transport to ground water aquifers in the study locations. The study areas experienced regeneration of klebsiella and this increased the concentration of the microbes to a large extend in the study area; the rates of pollution transporting to ground water aquifer is a serious issue to environment health. this influences are through the flow path, the result of Fast migration of klebsiella are determined on the structural deposition of the strata, more so, formation characteristics through the micropores at high degree of depositions were also confirmed to influenced the migration of klebsiella with respect to time, more so it also determine the rate of fluid flow variation in strata to ground water aquifers, this situation are confirmed in hydrological studies in the study location, information from hydrological studies express several formation characteristics that influences the deposition of klebsiella in soil and water environment, such formation characteristics deposit several fluid pressures as presented in shallow aquifers, the deltaic nature of the study location deposit homogenous soil , this condition implies that the fluid dynamics in soil are found to be predominant as it is expressed in deltaic environment. To monitor the rate of klebsiella transport in the study area, mathematical models were found to be the absolute concepts, this is to monitor the rate of klebsiella migration in the study area. The models were derived through the governing equation developed to solve the problem, the governing equation were derived considering several conditions that influence the variation of fluid flow in deltaic environment, the derived mathematical model will monitor the migration of klebsiella in the study area.

References

[1] Ademoroti CMA (1996). Standard method for water and effluent analysis, March prints and Consultancy, Foludex press Ltd.Ibadan, p182

[2] Biolog: 2003, 'About the Company, Technology and Business Focus', Available at: http://www. biolog.com/techbusinFocus.html Accessed 28 April 2004.

[3] Edwards, D. R., Daniel, T. C., Moore, Jr., P. A. and Sharpley, A. N.: 1994, 'Solids transport and erodibility of poultry litter surface-applied to fescue', *Trans ASAE*. **37**(3), 771–776.

[4] Edwards, D. R., Larson, B. T. and Lim, T. T.: 2000, 'Runoff nutrient and fecal coliform content from cattle manure application to fescue plots', *J. Am. Water Resour. Assoc*. **36**(4), 711–721.

[5] Gerba, C. P. and Smith, J. E.: 2005, 'Sources of pathogenic microorganisms and their fate during land application of wastes', *J. Environ. Qual*. **34**, 42–48.

[6] Hagedorn, C., Crozier, J. B., Mentz, K. A., Booth, A. M., Graves, A. K., Nelson, N. J. and Reneau Jr., R. B.: 2003, 'Carbon source utilization profiles as a method to identify sources of faecal pollution in water', *J. Appl. Microbiol.* **94**, 792–799.

[7] Crowther, J., Kay, D. and Wyer, M. D.: 2002, 'Faecal-indicator concentrations in waters draining

lowland pastoral catchments in the UK: Relationships with land use and farming practices', *Water Res*. **36**(7), 1725–1734.

[8] USEPA (United States Environmental Protection Agency): 2000, 'National Water Quality Inventory', Office of Water, United States Environmental Protection Agency, Available at: http://www.epa.gov/305b/2000report/. Accessed 26 April 2002.

[9] USEPA (United States Environmental Protection Agency): 2003, 'National pollutant discharge elimination system permit regulation and effluent limitation guidelines and standards for concentrated animal feeding operations (CAFOs); final rule', *Federal Register*. 68(29), 7176–7274.

[10] Tian, Y. Q., Gong, P., Radke, J. D. and Scarborough, J.: 2002, 'Spatial and temporal modeling ofmicrobial contaminants on grazing farmlands', *J. Environ. Qual.* **31**(3), 860–869.

[11] Akaniwor J O, Anosike E O and Egwim O (2007) Effect of Indomie industrial effluent discharge on microbial properties of new Calabar River Sci Res Essays 2 (1):001-005.

[12] Asonye C C, Okolie N P, Okenwa E E and Iwuanyanwu U G (2007) Some physicochemical charasteristics and heavy metal profiles of Nigerian rivers, streams and waterways. Afr. J. Biotechnol.6(5):617-624

[13] Asuquo FE (1999).Physicochemical characteristics and anthropogenic pollution charasteritics of Calabar rivers .Nigeria Global J.Pure and Appl. Sci.30: 31-40

[14] Anon AO(1992) Standard methods of water and wastewater examination . 18 Ed. American Public Health Association, NW, Washington, DC.:2-127.

[15] Ofoma AE, Onwuka O S , Egbu O C (2005) Groundwater Quality in Lekwesi, Umuchieze Area, South-eastern Nigeria. The Pacific J S Technol.6:170-176.s

[16] Soupir M. L, MostaghimI S., , Yagow E. R.,. Hagedorn C and. Vaughan D. H transport of fecal bacteria from poultry litter and cattle manures applied to pastureland Water, Air, and Soil Pollution (2006) 169: 125–136