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Modelling Dispersion and Porosity Influence on Flexibacter Transport in Silty and Fine Sand Formation in Coastal Area Port Harcourt

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Abstract: This research work was carried out to monitor the rate of dispersion and porosity influences on Flexibacter in the study location. The study was to monitor the behaviour of the contaminant under the pressure from fluctuation of porosity reflecting on dispersion rate in fine and silty sand formation. Variation of Flexibacter were expressed in various condition through theoretical values from the simulation, the developed model generated concentration from various phase of the transport system reflecting variation pressure from porosity mostly in silty formation, such condition were observed from the level of concentration in various phase from the simulation values, application of mathematical modelling method were to ensure that the behaviour of the microbes are thoroughly captured in the study location, experimental values were compared with the theoretical values for model validation, the study is imperative because experts will definitely examined the effect from fluctuated porosity reflecting on dispersion on the concentration of Flexibacter in the study location.

Keywords: Modelling Porosity, Dispersion Flexibacter Transport, Fine Sand and Silty Formation

1. Introduction

The amount and assortment of the microbes in natural waters varies very much in different places and under dissimilar conditions. Bacteria are washed into the water from the air, the soil and from almost every conceivable object. Significant analysis through statistics of bacteria has been applied expressing the rates of migrate through media even when the proportion reserved is very high. It has been observed that faeces of animals contain enormous numbers of bacteria and many enter natural water systems. But porosity and permeability measurements on aquifer sediments indicate that adequate spaces for bacteria exist in many sediment types, even in some rather dense porous rock [1 - 4]. The interstices of the shallow aquifer sediments can easily accommodate bacteria and probably Protozoa and fungi as well. Larger organisms will be excluded from most subsurface formations, except for gravelly and cavernous aquifers [20, - 22]. More than 150 pathogens found in livestock manure are associated with risks to humans, 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 [4,- 6,]. An understanding of the overland transport mechanisms from land applied waste is needed to improve design of BMPs and modelling 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 *Enterococcus* that are associated with specific sources of faecal pollution. The Biology System identifies microorganisms based on carbon source utilization [7, - 10]. [11-, 13], employed carbon source utilization as a form of phenotypic fingerprinting to classify enterococcal isolates from known fecal sources in four different geographical regions. Environmental and public health problems associated with the spreading of sewage on land have been observed since the dawn of the 20th century. Instances of land application of sewage are increasing because this disposal process removes some of the pollutants from the applied sewage, constitutes a possible aquifer recharge source, and increases crop yields by supplying essential nutrients and by improving soil properties [15-16]. However, disadvantages of land application may include degradation of quality of surface and groundwater through chemical and microbial contamination, and accumulation of heavy metals in soil. Spreading agricultural wastes may constitute a source of pathogens to the groundwater, surface water and soil. The application of these wastes to agricultural lands can cause environmental problems even when the application procedures are within the current guidelines. Problems have been demonstrated in Ontario [17-19] where applications of liquid manure to agricultural fields have resulted in rapid movement of a tracer bacterium, nalidixic acid-resistant *Escherichia coli,* through the soil and under drain systems leading to contamination of surface receiving waters. Microbial contamination of water and soil due to land application of liquid manure and other liquid wastes is difficult to treat, because once applied; manure becomes a potential non-point source of pollution, less susceptible to correction than a point source [9, -12]. Pathogenic bacteria and viruses known to cause disease have been detected in groundwater. Contaminated groundwater causes almost half of the outbreaks of water-borne diseases each year in the United States [9]. The most important pathogenic bacteria and viruses that might be transported to groundwater include *Salmonella* sp., *Shigella* sp., *Escherichia coli and Vibrio* sp., and hepatitis virus, Norwalk virus, echovirus, poliovirus and coxsackie virus [3, 20-22]

2. Governing Equation

$$K\varphi\frac{\partial c_{(x)}}{\partial t} = D_{v(x)}\frac{\partial C}{\partial x} + V_{(x)}\frac{\partial c}{\partial x} - K_d\frac{\partial c}{\partial x} \quad (1)$$

Let $C = XT$ from equation (2), we have

$$K\varphi T^1 Z = D_v TX^1 + V_{(x)} TX^1 - K_d TX^1 \quad (2)$$

$$K\varphi\frac{T^1}{T} = D_v\frac{X^1}{X} + V_{(x)}\frac{X^1}{X} - K_d\frac{X^1}{X} = \tau^2 \quad (3)$$

$$K\varphi\frac{T^1}{T} = \tau^2 \quad (4)$$

$$D_v\frac{X^1}{X} = \tau^2 \quad (5)$$

$$V_{(x)}\frac{X^1}{X} = \tau^2 \quad (6)$$

$$K_d\frac{X^1}{X} = \tau^2 \quad (7)$$

This implies that equations (4), (5), (6) and (7) can be written as:

$$\left[D_v + V_{(x)} - K_d\right]\frac{X^1}{X} = \tau^2 \quad (8)$$

From (4) $K\varphi\frac{T^1}{T} = \tau^2$

i.e. $$K\varphi\frac{\partial T}{dT} = \tau^2 \quad (9)$$

$$\int\frac{dT}{T} = \frac{\tau^2}{K\varphi}\int dt \quad (10)$$

$$Ln\,T = \frac{\tau^2}{K\varphi}t + c_1 \quad (11)$$

$$\frac{\tau^2}{K\varphi} + c_1 \quad (12)$$

$$T = A\ell^{\frac{\tau^2}{K\varphi}} \quad (13)$$

From (8)

$$\left[D_v + V_{(x)} + K_d\right]\frac{X^1}{X} = \tau^2\,dx \quad (14)$$

$$\int\frac{dx}{dx} = \frac{\tau^2}{D_v + V_{(x)} - K_d}\int dx \quad (15)$$

$$Ln\,x = \frac{\tau^2}{D_v + V_{(x)} - K_d} + c_1 \quad (16)$$

$$Z = \exp\left[\frac{\tau^2}{D_v + V_{(x)} - K_d} + c_1\right] \quad (17)$$

$$X = B\exp\frac{\tau^2}{D_v + V_{(x)} - K_d}x \quad (18)$$

Combining (17) and (18), we have

$$C, TX = TX$$

$$A\ell^{K\varphi} B\left[\exp\frac{\tau^2}{D_v + V_{(x)} - K_d}\right] \quad (19)$$

$$C\ X, T = AB\exp\left[\frac{t}{K\varphi} + \frac{X}{D_v + V_{(x)} - K_d}\right]\tau^2 \quad (20)$$

3. Materials and Method

Standard laboratory experiment where performed to monitor Flexibacter concentration using the standard method for the experiment at different formation, the soil deposition of the strata were collected in sequences base on the structural deposition at different locations, this samples collected at different location generated variations at different depths producing different Flexibacter concentration through pressure flow at different strata, the experimental result were compared with the theoretical values for the validation of the model.

4. Results and Discussion

Results and discussion are presented in tables including graphical representation void ratios in lateritic and peat soil formations.

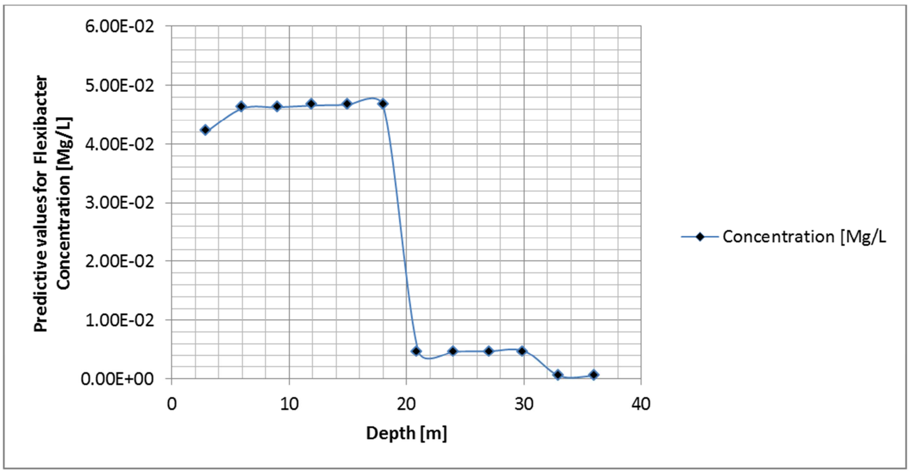

Figure 1. *Concentration of Flexibacter at Different Depth.*

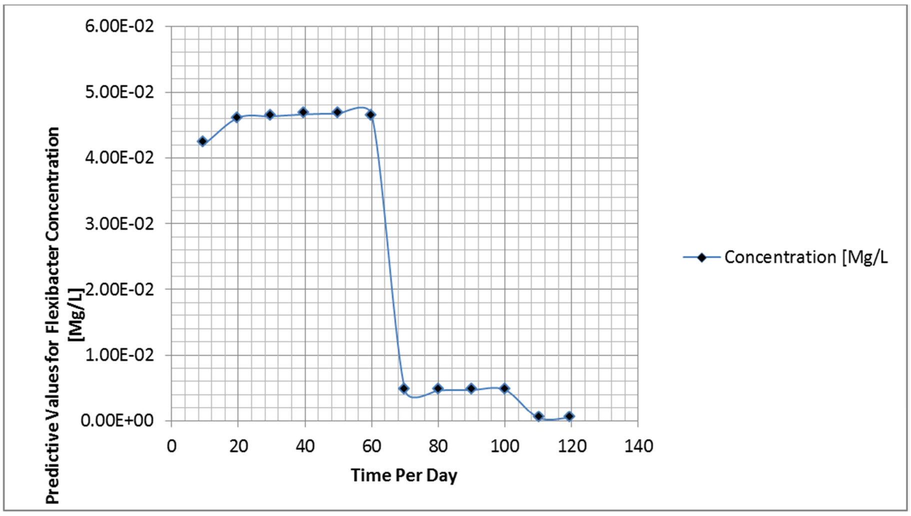

Figure 2. *Concentration of Flexibacter at Different Time.*

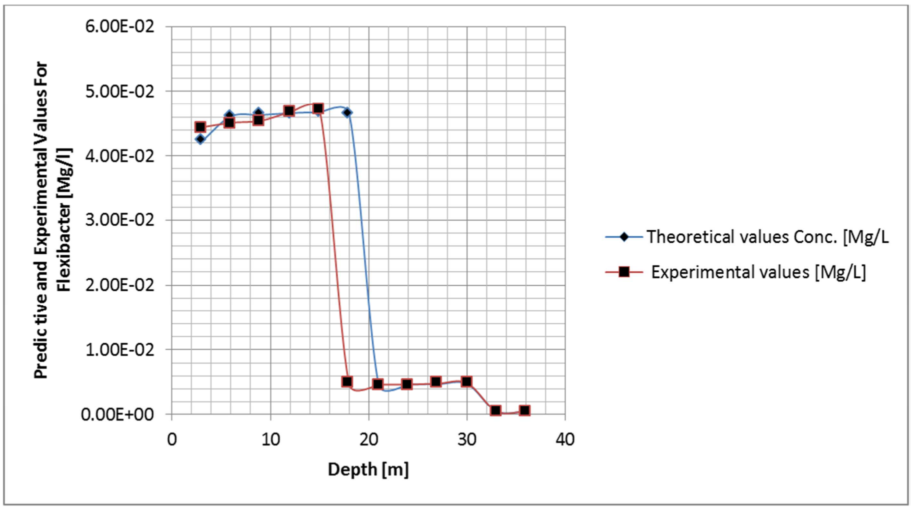

Figure 3. *Comparison of Predictive and Experimental of Flexibacter at Different Depth.*

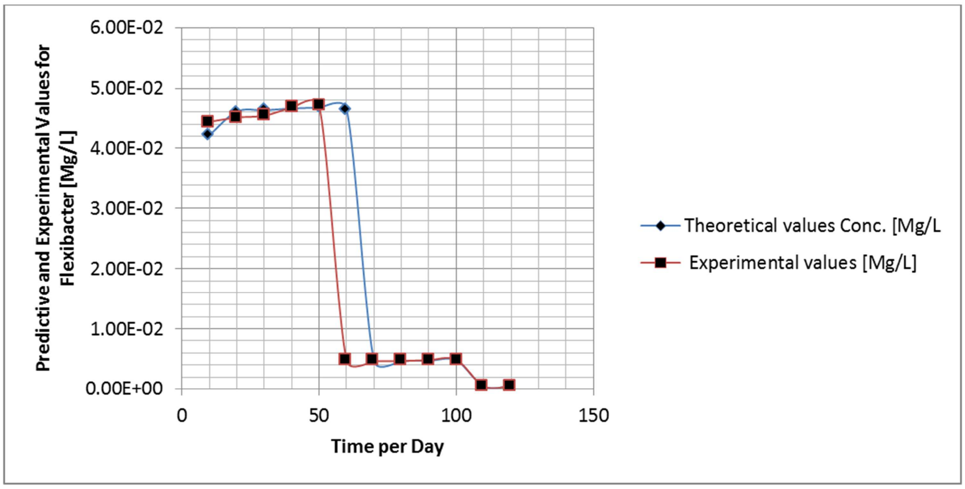

Figure 4. *Comparison of Predictive and Experimental of Flexibacter at Different Time.*

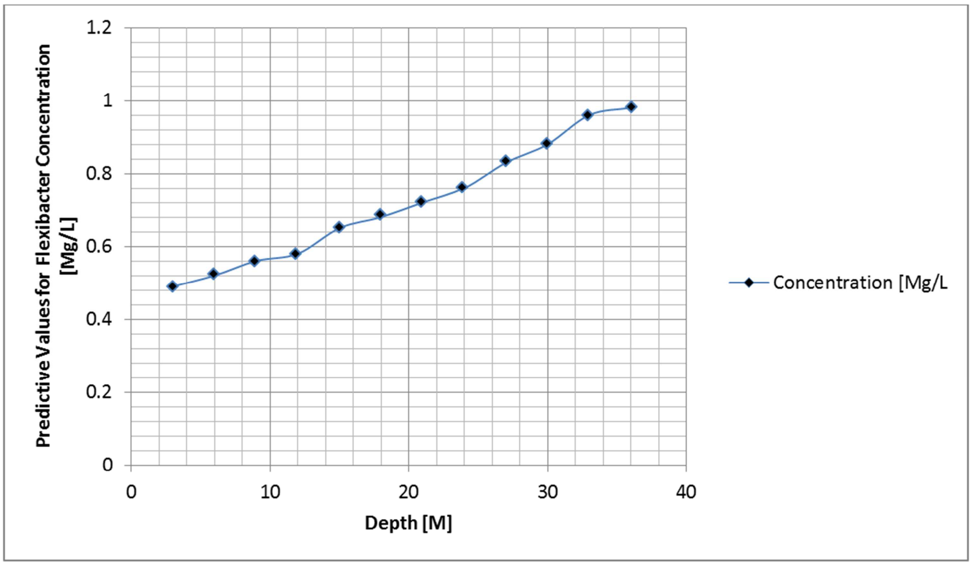

Figure 5. *Concentration of Flexibacter at Different Depth.*

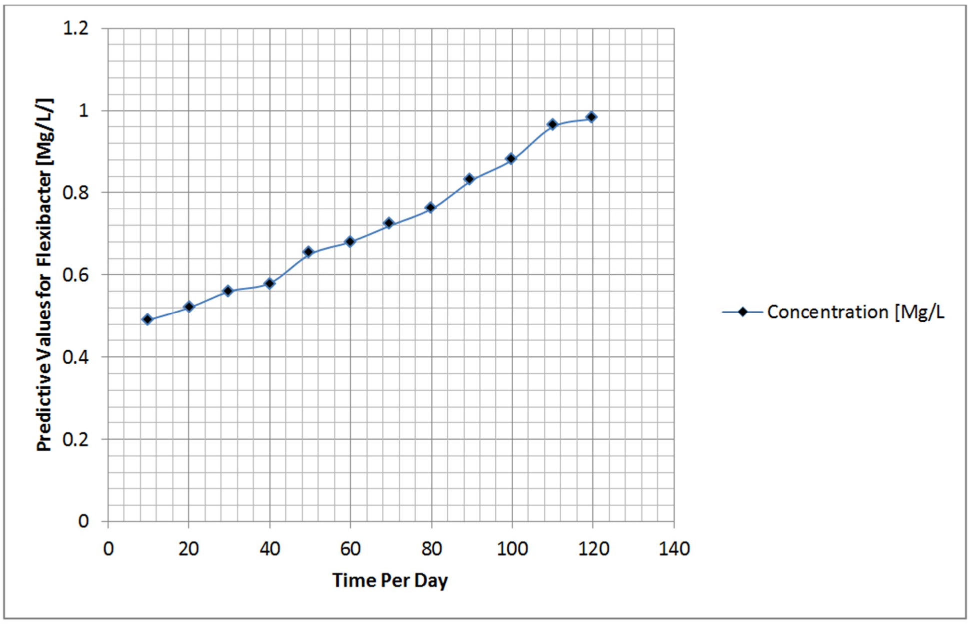

Figure 6. *Concentration of Flexibacter at Different Time.*

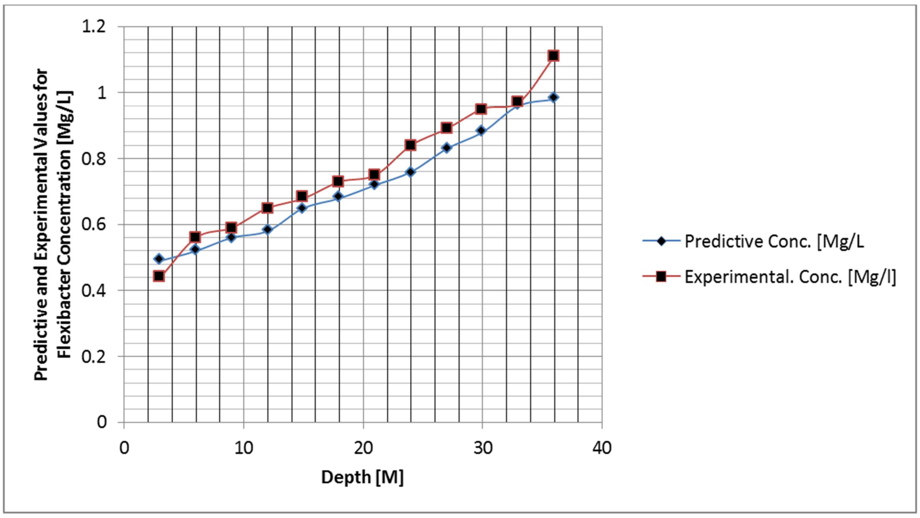

Figure 7. *Comparison of Predictive and Experimental of Flexibacter at Different Depth.*

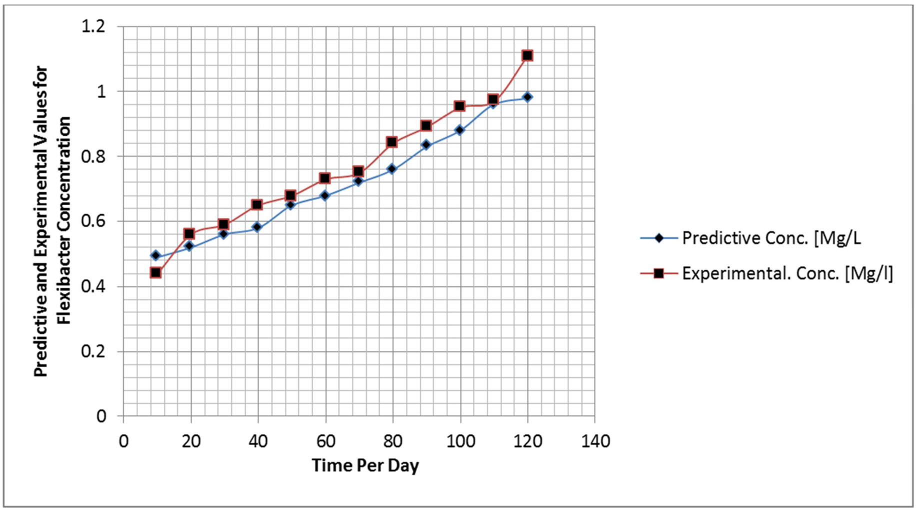

Figure 8. *Comparison of Predictive and Experimental of Flexibacter at Different Time.*

Table 1. *Concentration of Flexibacter at Different Depth.*

Depth [M]	Concentration [Mg/L
3	4.22E-02
6	4.61E-02
9	4.63E-02
12	4.66E-02
15	4.67E-02
18	4.65E-02
21	4.68E-03
24	4.69E-03
27	4.73E-03
30	4.75E-03
33	4.78E-04
36	4.79E-04

Table 2. *Concentration of Flexibacter at Different Depth.*

Time Per Day	Concentration [Mg/L
10	4.22E-02
20	4.61E-02
30	4.63E-02
40	4.66E-02
50	4.67E-02
60	4.65E-02
70	4.68E-03
80	4.69E-03
90	4.73E-03
100	4.75E-03
110	4.78E-04
120	4.79E-04

Table 3. *Comparison of Predictive and Experimental of Flexibacter at Different Depth.*

Depth [M]	Theoretical values Conc. [Mg/L	Experimental values [Mg/L]
3	4.22E-02	4.44E-02
6	4.61E-02	4.51E-02
9	4.63E-02	4.54E-02
12	4.66E-02	4.67E-02
15	4.67E-02	4.71E-02
18	4.65E-02	4.75E-03
21	4.68E-03	4.65E-03
24	4.69E-03	4.66E-03
27	4.73E-03	4.82E-03
30	4.75E-03	4.88E-03
33	4.78E-04	4.68E-04
36	4.79E-04	4.71E-04

Table 4. *Comparison of Predictive and Experimental of Flexibacter at Different Depth.*

Time Per Day	Theoretical values Conc. [Mg/L	Experimental values [Mg/L]
10	4.22E-02	4.44E-02
20	4.61E-02	4.51E-02
30	4.63E-02	4.54E-02
40	4.66E-02	4.67E-02
50	4.67E-02	4.71E-02
60	4.65E-02	4.75E-03
70	4.68E-03	4.65E-03
80	4.69E-03	4.66E-03
90	4.73E-03	4.82E-03
100	4.75E-03	4.88E-03
110	4.78E-04	4.68E-04
120	4.79E-04	4.71E-04

Table 5. *Concentration of Flexibacter at Different Depth.*

Depth [M]	Concentration [Mg/L
3	0.49
6	0.52
9	0.56
12	0.58
15	0.65
18	0.68
21	0.72
24	0.76
27	0.83
30	0.88
33	0.96
36	0.98

Table 6. *Concentration of Flexibacter at Different Depth.*

Time Per Day	Concentration [Mg/L
10	0.49
20	0.52
30	0.56
40	0.58
50	0.65
60	0.68
70	0.72
80	0.76
90	0.83
100	0.88
110	0.96
120	0.98

Table 7. *Comparison of Predictive and Experimental of Flexibacter at Different Depth.*

Depth [M]	Predictive Conc. [Mg/L	Experimental. Conc. [Mg/l]
3	0.49	0.44
6	0.52	0.56
9	0.56	0.59
12	0.58	0.65
15	0.65	0.68
18	0.68	0.73
21	0.72	0.75
24	0.76	0.84
27	0.83	0.89
30	0.88	0.95
33	0.96	0.97
36	0.98	1.11

Table 8. *Comparison of Predictive and Experimental of Flexibacter at Different Depth.*

Time Per Day	Predictive Conc. [Mg/L	Experimental. Conc. [Mg/l]
10	0.49	0.44
20	0.52	0.56
30	0.56	0.59
40	0.58	0.65
50	0.65	0.68
60	0.68	0.73
70	0.72	0.75
80	0.76	0.84
90	0.83	0.89
100	0.88	0.95
110	0.96	0.97
120	0.98	1.11

The figure expresses the behaviour of Flexibacter in fine and silty sand formation in the study area, figure one to four expresses it migration process in serious vacillation in the formation, dispersions and porosity influences were found to affect the deposition of the system, fluctuation from high to lower concentration were examined to deposit in different concentrations, the figure express concentration variation in some location, the deposition of the contaminant are determine by the rate of dispersions and porosity in the deposited formation, since there are some content of clay in silty formation, there are tendency of porosity and velocity of flow within the intercedes of the formation hindering the migration of Flexibacter in the study area. While in some other location there is the tendency of deltaic influences from high rain intensities increasing degree of saturation reducing the accumulation of Flexibacter in fine and silty sand formation, such porosity and dispersion influences were found to vary between figure five to eight as it develop increase in velocity and dispersion in fine and silty sand formation thus increase the concentration of Flexibacter in those location, despite linear deposition observed in those figures, the concentration in figure five to eight are higher than figure one to four.

5. Conclusion

The deposition of Flexibacter has been evaluated through different notions to ensure that the behaviour of these types of microbial species are examined. The study were evaluated through mathematical expression applied to monitor the behaviour and transport process of Flexibacter in fine and silty formation, low variation of porosity were found to deposit in some deposited strata, these were observed through the rate of concentration deposited in the study area, fluctuation and linear increase were observed, but the deposited concentration varies base on the pressure from variation of porosity and dispersion in the study area. The study were to investigate the rate of porosity influences on the deposition and transport process of Flexibacter in the formation, these were examined from the application of the mathematical modelling techniques, the developed model generated theoretical values that has express the rate of porosity and dispersion influences and its concentration in the study location, these were compared with experimental values, and both parameters express best fit validating developed model for the study.

Nomenclature

V = Void Ratio [-]
K = Permeability [LT^{-1}]
ϕ = Porosity [-]
D = Dispersion in number [-]
V(x) = Velocity [LT^{-1}]
K_d = Decay [-]
C = Concentration [ML^{-3}]
T = Time [T]
X = Depth [L]

References

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

[2] Hagedorn, C., Crozier, J. B., Mentz, K. A., Booth, A. M., Graves, A. K., Nelson, N. J. and eneau 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.

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

[4] 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.

[5] Soupir M., mostaghimi, S, E.. yagow, F. hagedorn C and D. H. Vaughan Transport of fecal bacteria from poultry litter and cattle manures applied to pastureland Water, Air, and Soil Pollution (2006) 169: 125–136.

[6] Crane, S. R., Moore, J. A., Grismer, M. E., and Miner, J. R.: 1983, *Transactions of the American Society of Agricultural Engineers* 26, 858.

[7] Craun, G. E: 1984, 'Health Aspects of Groundwater Pollution', in G. Bitton and C. P. Gerba (eds.), *Groundwater Pollution Microbiology,* John Wiley & Sons, Inc., New York.

[8] Dean, D. M. and Foran, M. E.: 1990a, The Effect of Farm Liquid Waste Application on Receiving Water Quality, Interim report submitted by Ausable Bayfield Conservation Authority to the Research Management Office of the Ontario Ministry of the Environment. April 1990.

[9] Fleming, R. J., Dean, D. M., and Foran, M. E. 1990, *Effect of Manure Spreading on Tile Drainage Water Quality,* Proceedings of the 6th International Symposium on Agricultural and Food Processing Wastes. Chicago, Illinois, p. 38.

[10] Gerba, C. P. and Keswick, B. H.: 1981, 'Survival and Transport of Enteric Viruses and Bacteria in Groundwater', in W. van Duijvenbooden, P. Glasbergen, and H. van Lelyveld (eds.), *Studies in Environmental Science,* Elsevier Scientific Publ. Co., The Netherlands, pp. 511-515.

[11] Khaleel, R., Reddy, K. R., and Over cash, M. R.: 1980, *WaterRes.* 14, 421.

[12] Lance, J. C., Gerba, C. P., and Wang, D. S.: 1982, J. *Environ. QuaL* 11, 347.

[13] Palmateer, G. A., McLean, D. E., Walsh, M. J., Kutas, W. L., Janzen, E. M., and Hocking, D. E.: 1989, *Toxicity Assess.* 4, 377.

[14] Tim, U. S., Mostaghimi, S., and Dillaha, T. A.: 1988, *Modeling the Movement and Persistence of Bacteria and Viruses in Porous Media,* AZO paper No. 88-2627, St. Joseph, MI.

[15] Engelbrecht, J. F. P., 1993. An assessment of health aspects of the impact of domestic and industrial waste disposal activities on groundwater resources. ISBN 1-86845-028-7.

[16] Gerba, C. P., Wallis, G. and Melnick, J. L., 1975. Fate of wastewater bacteria and viruses in soil. Journal of the irrigation and drainage division. American Society of Civil Engineering, Vol. 101, pp 157-174.

[17] Ghiorse, W. C. and Wilson, J. T., 1988. Microbial ecology of the Terrestrial Subsurface. Advances in Applied Microbiology. Vol. 33. Academic Press, Inc., 1988.

[18] Mcnabb, J. F. and Dunlap, W. J., 1975. Subsurface biological activity in relation to groundwater pollution. Ground Water Vol. 13 no. 1. January - February 1975.

[19] Tredoux, G. 1978. nIntensieweopname van waterbronne in die omgewing van Stampriet, Namibia. Project Report No. 15 (unpublished), NIWR-CSIR Windhoek.

[20] Updegraff, David M., 1991. Background and practical applications of microbial ecology in Modelling the environmental fate of microorganisms, Ed, C J Hurst. American Society for microbiology, ISBN 1-55581-031-4, 1991.

[21] Engelbrecht J F P & Tredoux G bacteria in "unpolluted" groundwater Presented at the WISA 2000 Biennial Conference, Sun City, South Africa, 28 May - 1 June 2000 \ *Cape Water Programme, CSIR, P O Box 320, Stellenbosch 7599 Tel: 021-888 2659, Fax: 021-888 2682, email: pengelbr@csir.co.za*

[22] Eluozo, S, N. 2013: Modelling Burkholderia pseudomallei transport in heterogeneous silty formation in Ahoada region of rivers state Niger delta of Nigeria International Journal of Sustainable Energy and Environment Vol. 1, No. 8, September 2013, PP: 150-157.