World Journal of Physical and Analytical Sciences
Vol. 1, No. 1, October 2014, pp. 1 -13
Available online at http://wjpas.com/

Research article

PREDICTING THE BEHAVIOUR OF ENTEROCOCCI IN PLUG FLOW PHASE TRANSPORT IN SALINE COASTAL AREA OF ABONNEMA, 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

Enterococci deposition has been the subject of concern in soil and water environment, regeneration of this microbes has been seen as the cause of deterioration of the water quality in Abonnema, since there ground water aquiferous zone deposit heterogeneous setting, it deposit in shallow and deep Phreatic zone, it is also observed to be predominantly influenced by saline and other mineral in the formation, the influences of alluvium deposit in these condition could not influences the aquiferous zone by uniformity of the Phreatic deposited state in the strata. Formation characteristics stated above were found insignificant in the migration of enterococci from surface to Phreatic zone, most people find the exploitation of groundwater at shallow depth less capital intensive, so they always settle for shallow depth in construction of bore holes, theses condition do not produces quality ground water for utilization, it always increase water pollution, rendering hundreds of people illness in the study area, application of monitoring and evaluating of microbial transport were found easier through mathematical modeling method, the study were thoroughly evaluated to monitor the rate of migration process to Phreatic zone in the study area. The system developed governing equations that were derived to generate the expressed model that will predict the behaviour of the microbes in the formation. The models were simulated and it produced theoretical values compared with other measured results, both parameters developed a favuorable fit validating the model.

Keywords: predicting, enterococci, plug flow phase, transport, and saline

---

1. Introduction

The effectiveness microbes to be convert ass absorbed soil carbon into microbial biomass have been called the microbial growth efficiency (Y), carbon-use efficiency, or substrate-use effectiveness. This physiological features of the microbial biomass powerfully pressure overall soil unrefined carbon (SOC) budgets and carbon sequestration in ecosystems (3). Since: nutrient ratios in microbial biomass differ over comparatively narrow ranges Y also contributes to regulation of nitrogen (and other nutrient) mineralization and immobilization in soils (3). Measurements of microbial growth efficiency in soil span a surprisingly wide range, from 0.14 to 0.77 (4, 6, 5). Despite the high variability of this integrative trait and its importance in influencing organic matter turnover and nutrient availability, we have limited understanding of how environmental variables influence growth efficiency (15, 3; and 5). The size and structure of the soil microbial population is a role of net primary making, plant carbon (C) portion, rhizosphere activity, and litter substrate superiority (11,10,7,and 9), and is controlled through complex communications with plants (12,13and 14). Changes in atmospheric CO2 concentration and nitrogen (N) deposition rates alter both the quality and quantity of above- and belowground plant litter inputs to soil (2, 8,14,), which in turn can affect belowground microbial society arrangement and function (4,15,and17). Considering the mechanisms controlling belowground C processes is useful in predicting future changes in soil C stores in response to climate and land-use change (17). Altering root and coarse woody debris (CWD) inputs to soil is one method to examine the feedbacks between plants, microbes, and soil organic matter (SOM) dynamics (18,19). In a Douglas-fir forest, 7 y of CWD additions and litter and root exclusion have produced significant changes in annual soil CO2 efflux (16, 11).

2. Governing equation

$$K\frac{\partial^2 c}{\partial t^2} = D\frac{\partial c}{\partial Z} - U\lambda\frac{\partial c}{\partial Z} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (1)$$

Nomenclature

C	=	Enterococci concentration	[ML-3]
λ	=	Saline concentration	[ML-3]
K	=	Permeability	[LT-1]
U	=	Velocity	[LT-1]
T	=	Time	[T]
Z	=	Depth	[L]

Let $C = T, Z$

$$KT^{11}Z = DTZ^1 - U\lambda TZ^1 \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (2)$$

$$K\frac{T^{11}}{T} = D\frac{Z^1}{Z} - U\lambda\frac{Z^1}{Z} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (3)$$

$$K\frac{T^{11}}{T} = \theta^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (4)$$

$$D\frac{Z^1}{Z} = \theta^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (5)$$

World Journal of Physical and Analytical Sciences
Vol. 1, No. 1, October 2014, pp. 1 -13
Available online at http://wjpas.com/

$$-U\lambda\frac{Z^1}{Z} = \theta^2 \quad \text{......................................} \quad (6)$$

$$[D - U\lambda]\frac{Z^1}{Z} = \theta^2 \quad \text{......................................} \quad (7)$$

$$K\frac{dc}{dt} = \theta^2 \quad \text{......................................} \quad (8)$$

$$K\frac{dc^2}{dt^2} = \theta^2 \quad \text{......................................} \quad (9)$$

$$D\frac{dc}{dZ} = \theta^2 \quad \text{......................................} \quad (10)$$

$$-U\lambda\frac{dc}{dZ} = \theta^2 \quad \text{......................................} \quad (11)$$

$$d^2Z = \left[\frac{\theta^2}{K}\right] = dZ \quad \text{......................................} \quad (12)$$

$$\int d^2 = \int\frac{\theta^2}{K}dZ \quad \text{......................................} \quad (13)$$

$$dZ = \frac{\theta^2}{K}Z + C_1 \quad \text{......................................} \quad (14)$$

$$\int dZ - \int\frac{\theta^2}{K}Z\ dZ + C_1\int dZ \quad \text{......................................} \quad (15)$$

$$Z = \frac{\theta^2}{K}\frac{Z^2}{2} + C_1 + C_2 \quad \text{......................................} \quad (16)$$

$$Z = \frac{\theta^2}{K}\frac{Z^2}{2} + C_{1^2} + C_2 \quad \text{......................................} \quad (17)$$

$$\boxed{Z = \frac{\theta^2}{K}Z^2 + C_{1^2} + C_2} \quad \text{......................................} \quad (18)$$

$$\Rightarrow \frac{\theta^2}{2K}Z^2 + C_{1^2} + C_2 = 0 \quad \text{......................................} \quad (19)$$

World Journal of Physical and Analytical Sciences
Vol. 1, No. 1, October 2014, pp. 1 -13
Available online at http://wjpas.com/

Auxiliary equation becomes

$$\frac{\theta^2}{2K} M_2 + C_2 M + C_2 = 0 \quad \text{.......................................} \quad (20)$$

Applying quadratic expression, we have

$$M_{1^2} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \quad \text{.......................................} \quad (21)$$

$$M = \frac{-C_1 \sqrt{C^2 - 4 \frac{(\theta^2)}{2K} C_2}}{2 \frac{\theta^2}{K}} \quad \text{.......................................} \quad (22)$$

$$M_1 = \frac{-+C_1 \sqrt{C^2 - 2C_2 \frac{\theta^2}{K}}}{2 \frac{\theta^2}{K}} \quad \text{.......................................} \quad (23)$$

$$M_2 = \frac{-C - \sqrt{C_1^{\,2} - 2C_2 \frac{\theta^2}{K}}}{2 \frac{\theta^2}{K}} \quad \text{.......................................} \quad (24)$$

Assuming this discriminant is complex, therefore equation (23) and (24) can be written as:

$$C[T, Z] = F1\, Cos\, M_1 t + F2\, Sin\, M_2 Z \quad \text{.......................................} \quad (25)$$

But if But if $t = \frac{d}{v}$ and $Z = v \cdot t$

The expressed model can be written as

$$C[T, Z] = F1\, Cos\, M_1 \frac{d}{v} + F2\, Sin\, M_2 V \cdot t \quad \text{.......................................} \quad (26)$$

3. Material and Method

Column experiments were also performed using soil samples from several borehole locations, the soil samples were collected at intervals of three metres each (3m). An Enterococci solute was introduced at the top of the column and effluents from the lower end of the column were collected and analyzed for Enterococci and the effluent at the down of the column were collected at different days, analysis,. This experiment were performed to compare with the theoretical values from the developed model for validation

4. Results and Discussion

Results and discussion are presented in tables including graphical representation of E.coli system condition

Table 4.1: Theoretical vales of Enterococci at Different Depth

Depth [m]	Theoretical Values Conc.
3	1.42E-04
6	2.85E-04
9	4.28E-04
12	5.71E-04
15	7.14E-04
18	8.56E-04
21	9.99E-04
24	1.14E-03
27	1.28E-03
30	1.42E-03

Table 4.2: Theoretical vales of Enterococci at Different Time

Time per day	Theoretical Values Conc.
10	1.42E-04
20	2.85E-04
30	4.28E-04
40	5.71E-04
50	7.14E-04
60	8.56E-04
70	9.99E-04
80	1.14E-03
90	1.28E-03
100	1.42E-03

Table: 4.3 Theoretical and Measured values of Enterococci Concentration at Different depth

Depth [m]	Theoretical Values Conc.	Measured Values
3	1.42E-04	1.52E-04
6	2.85E-04	3.02E-04
9	4.28E-04	4.52E-04
12	5.71E-04	6.02E-04
15	7.14E-04	7.52E-04
18	8.56E-04	9.02E-04
21	9.99E-04	1.05E-03
24	1.14E-03	1.20E-03
27	1.28E-03	1.35E-03
30	1.42E-03	1.50E-03

World Journal of Physical and Analytical Sciences
Vol. 1, No. 1, October 2014, pp. 1 -13
Available online at http://wjpas.com/

Table: 4.4 Theoretical and Measured values of Enterococci Concentration at Different Time

Time per day	Theoretical Values Conc.	Measured Values
10	1.42E-04	1.02E-04
20	2.85E-04	2.02E-04
30	4.28E-04	3.02E-04
40	5.71E-04	4.02E-04
50	7.14E-04	5.02E-04
60	8.56E-04	6.02E-04
70	9.99E-04	7.02E-04
80	1.14E-03	8.02E-04
90	1.28E-03	9.02E-04
100	1.42E-03	1.00E-03

Table 4.5: Theoretical vales of Enterococci at Different Depth

Depth [m]	Theoretical Values Conc.
3	8.39E-03
6	0.016
9	0.025
12	0.033
15	0.041
18	0.05
21	0.058
24	0.067
27	0.076
30	0.083

Table 4.6: Theoretical vales of Enterococci at Different Depth

Time per day	Theoretical Values Conc.
10	8.39E-03
20	0.016
30	0.025
40	0.033
50	0.041
60	0.05
70	0.058
80	0.067
90	0.076
100	0.083

World Journal of Physical and Analytical Sciences
Vol. 1, No. 1, October 2014, pp. 1 -13
Available online at http://wjpas.com/

Table: 4.7 Theoretical and Measured values of Enterococci Concentration at Different Time

Depth [m]	Theoretical Values Conc.	Measured Values Conc.
3	8.39E-03	6.00E-03
6	0.016	0.012
9	0.025	0.018
12	0.033	0.024
15	0.041	0.03
18	0.05	0.036
21	0.058	0.042
24	0.067	0.048
27	0.076	0.054
30	0.083	0.06

Table: 4.8 Theoretical and Measured values of Enterococci Concentration at Different Time

Time per day	Theoretical Values Conc.	Measured Values Conc.
10	8.39E-03	7.80E-03
20	0.016	1.80E-02
30	0.025	2.30E-02
40	0.033	3.10E-02
50	0.041	3.90E-02
60	0.05	5.00E-02
70	0.058	5.70E-02
80	0.067	6.60E-02
90	0.076	7.40E-02
100	0.083	7.90E-02

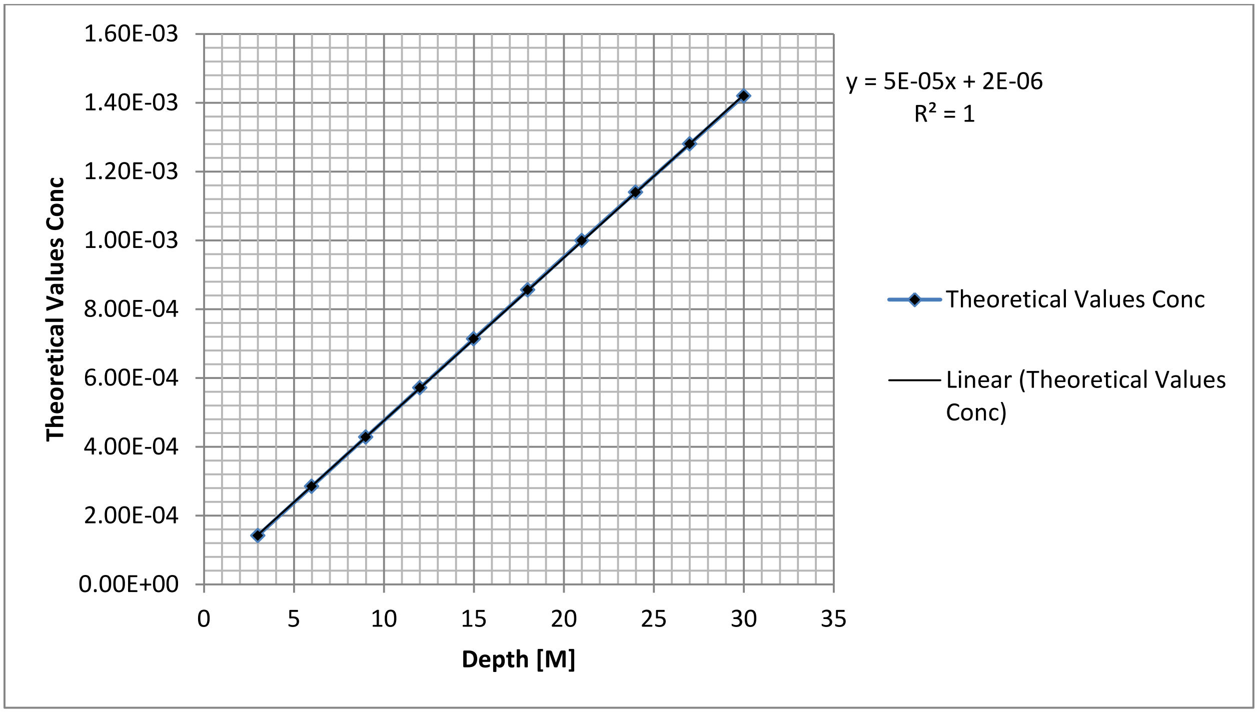

Figure 4.1: Theoretical vales of Enterococci at Different Depth

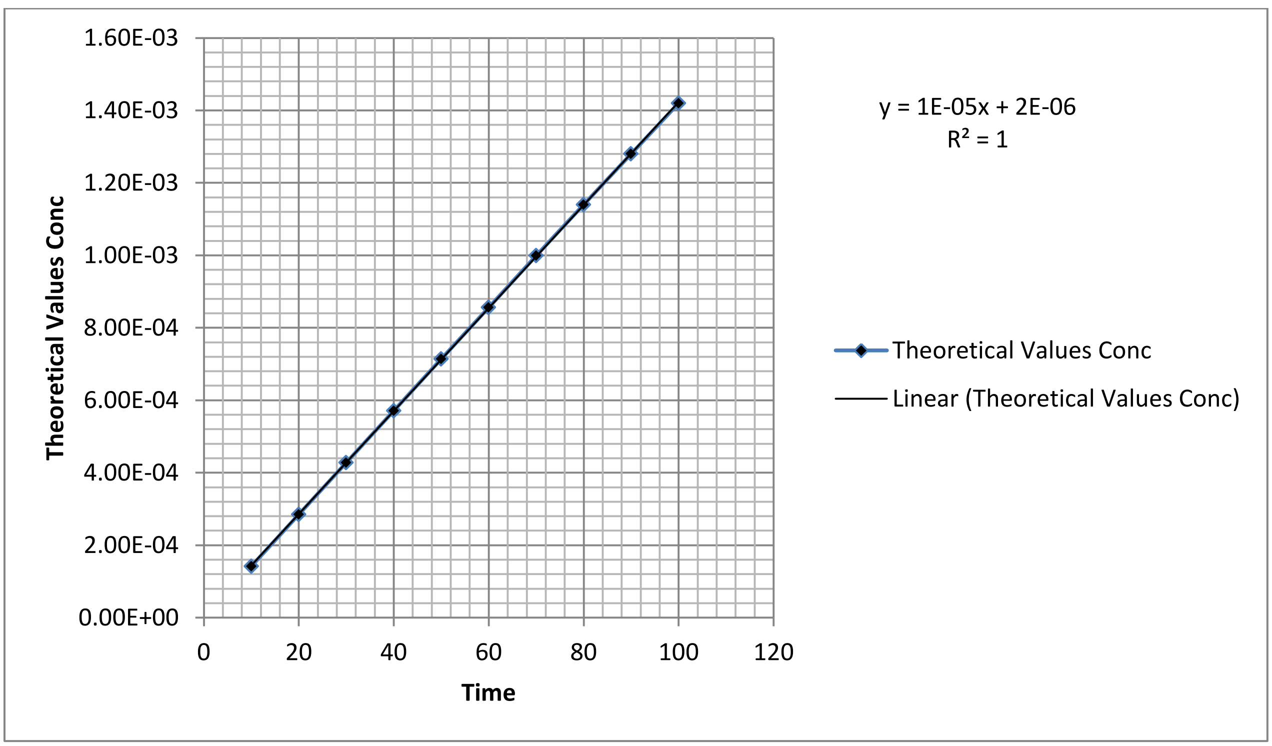

Figure 4.2: Theoretical vales of Enterococci at Different Time

World Journal of Physical and Analytical Sciences
Vol. 1, No. 1, October 2014, pp. 1 -13
Available online at http://wjpas.com/

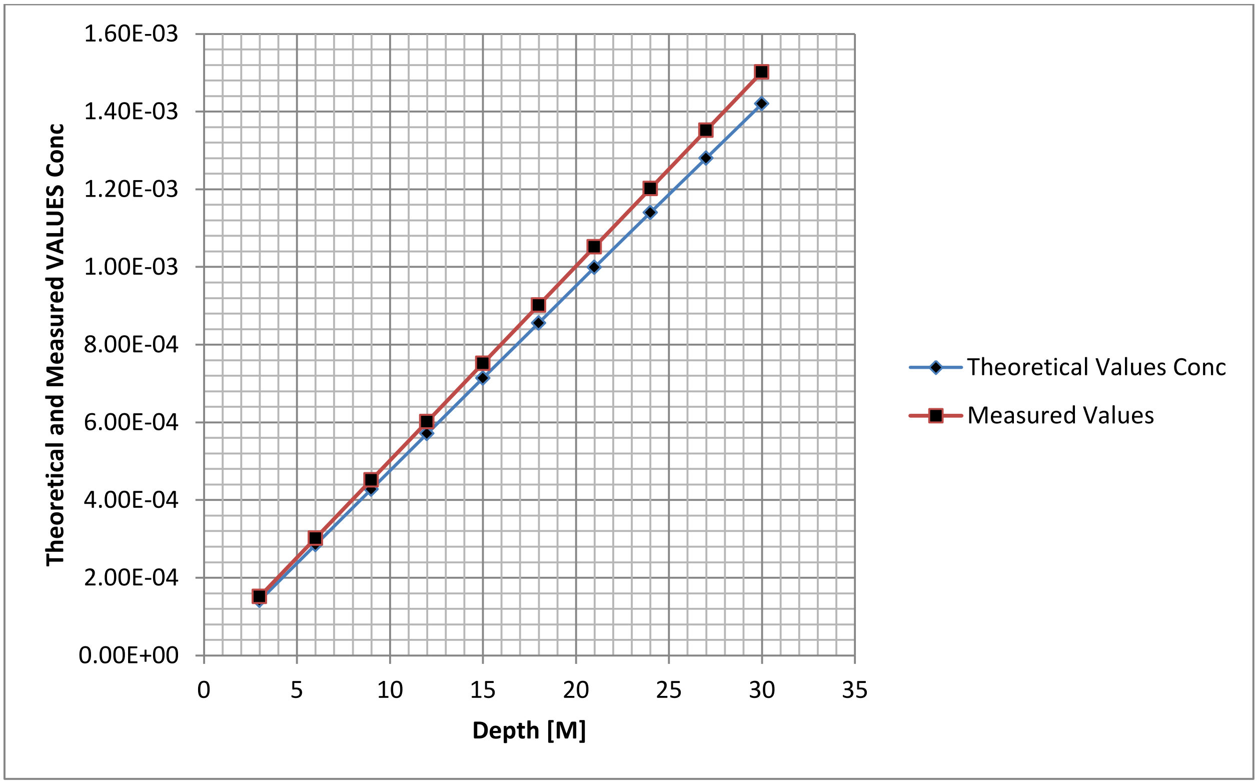

Figure: 4.3 Theoretical and Measured values of Enterococci Concentration at Different Time

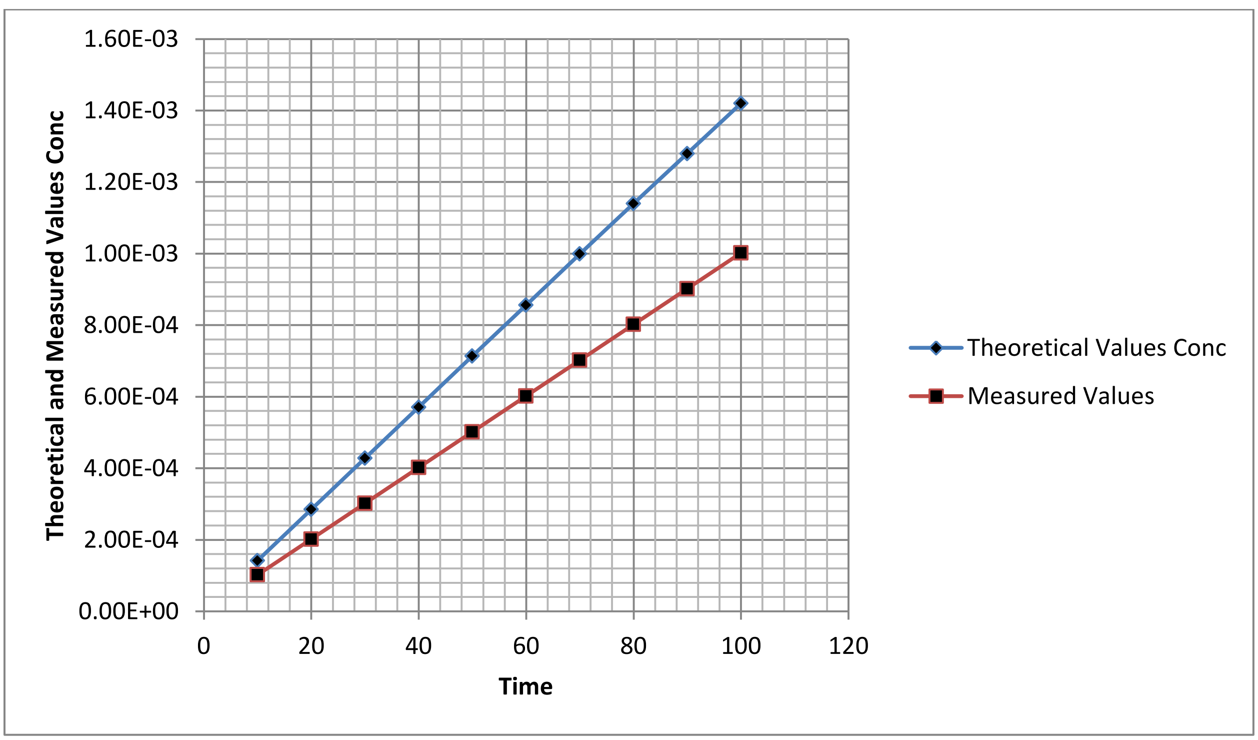

Figure: 4.4 Theoretical and Measured values of Enterococci Concentration at Different Time

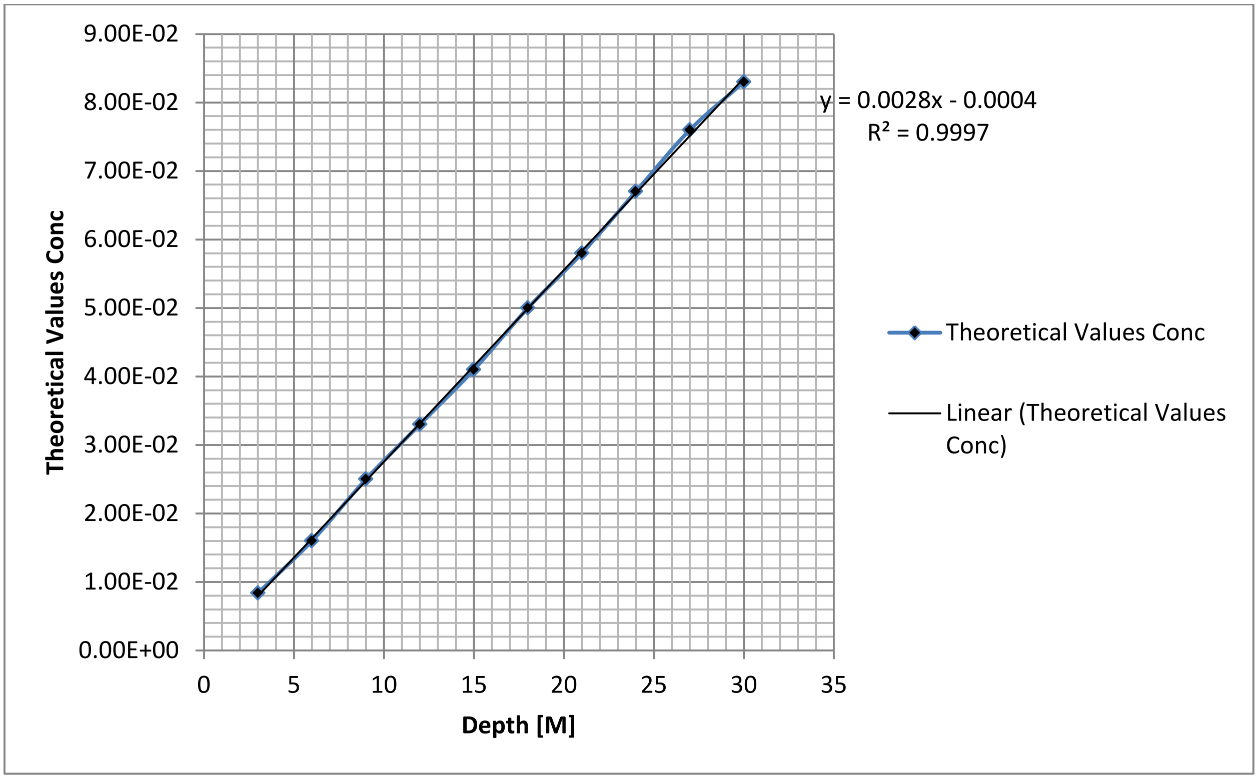

Figure 4.5: Theoretical vales of Enterococci at Different Depth

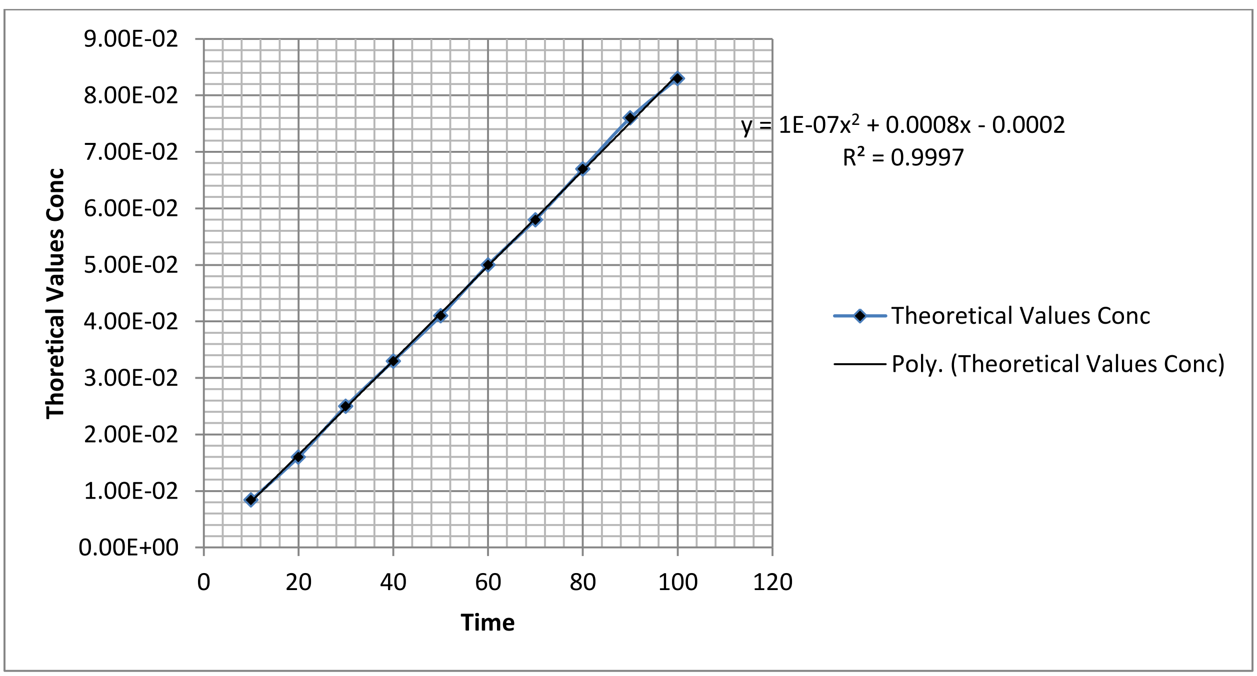

Figure 4.6: Theoretical vales of Enterococci at Different Time

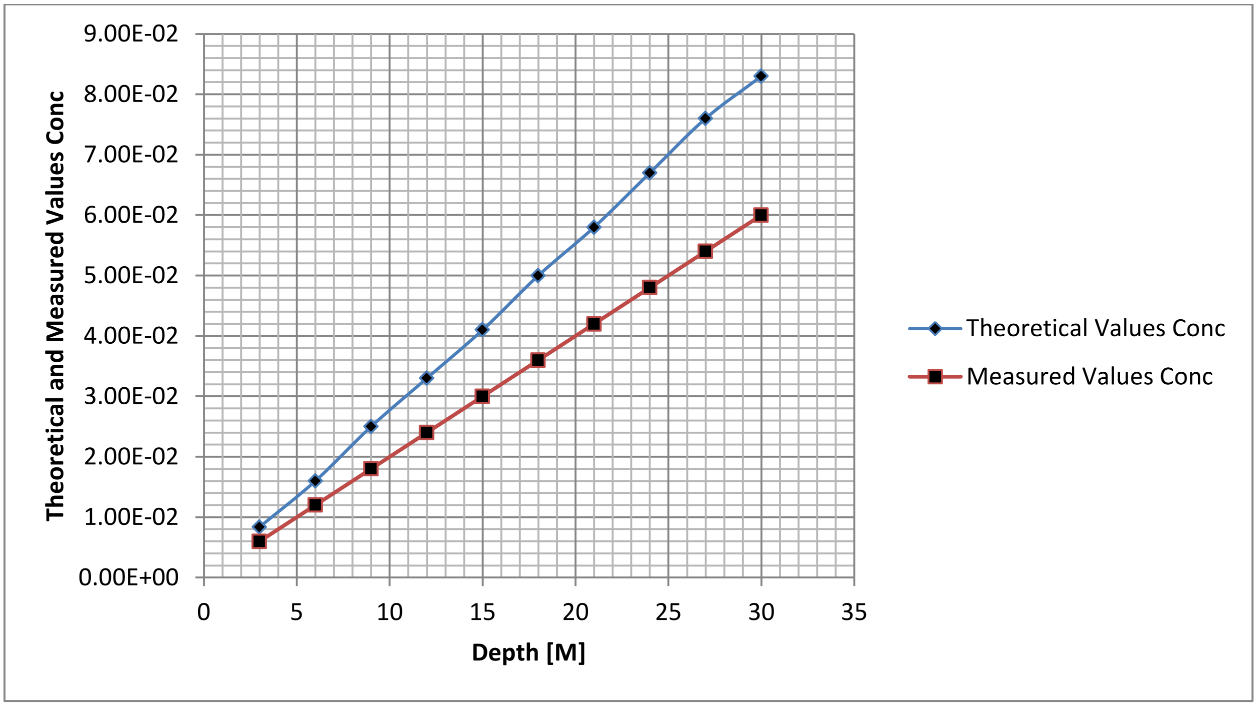

Figure: 4.7 Theoretical and Measured values of Enterococci Concentration at Different Time

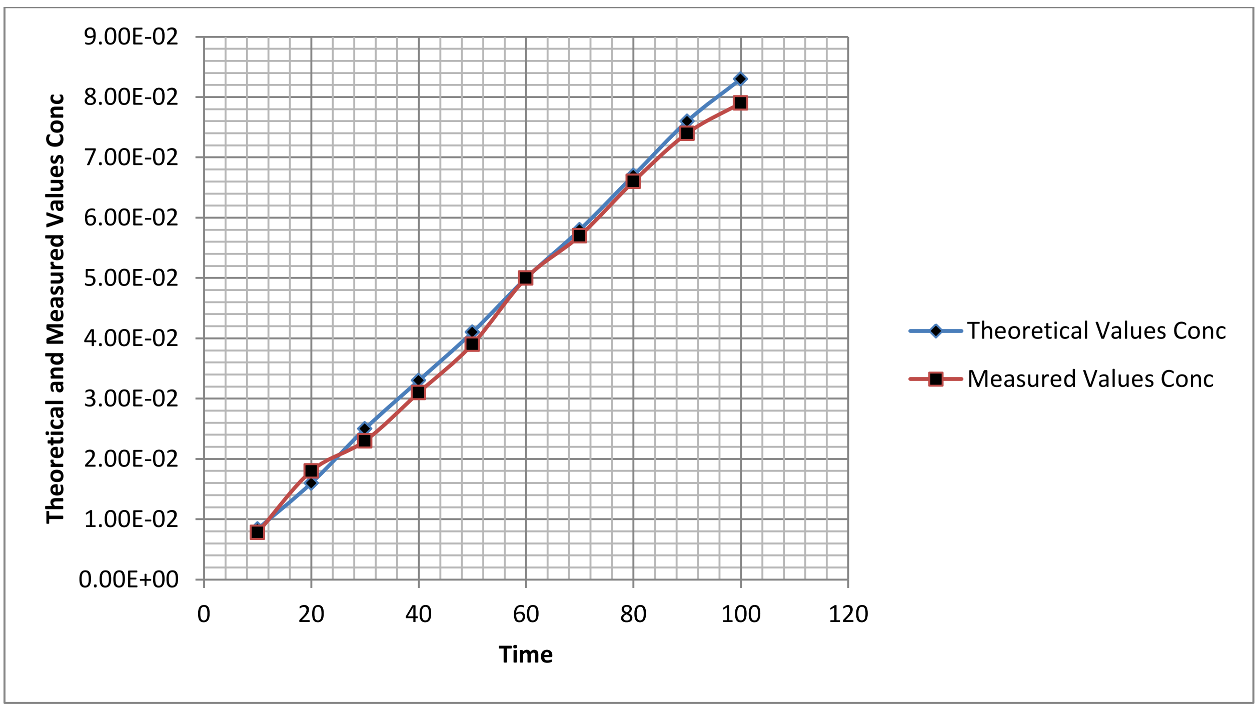

Figure: 4.8 Theoretical and Measured values of Enterococci Concentration at Different Time

The expression from the graphical representation shows the migration level and behaviour of the microbes in the study area, the concentration are in exponential phase, the condition of the microbial deposition and concentration is a subject of concern, the deposition of the enterococci in the study area were found from the developed model to be influence by predominant deposition of one of the formation characteristics, the formation parameter pressure the deposition of the enterococci migration and concentration under the influences of porosity discovered to be the predominantly higher in the study location. The behaviour of enterococci definitely depend on the deposition of the structural setting of the formation, the pressure of deltaic condition has also expressed it influences on the transport and depositional level of the microbes, the migration of enterococci has been express from the developed model through the simulation values, the results were compared with other experimental values, both developed a favuorable fits validating the developed model, the study in this condition were able to express insignificant effect of saline deposition on the migration of the microbes at coastal environments, the study has developed a base line that will be applied in monitoring and evaluation of enterococci deposition including its behaviour in costal environments.

4. Conclusion

Enterococci were found in saline environments, the deposition of this microbes were evaluated to monitor it migration process on such predominant saline environments, the application were through mathematical modeling, the system of this migration at saline environment were developed generating derived governing equation, the derived solution generated model simulated that determined the behaviour of the microbes in saline coastal environments, study were able to express the rate of migration and other influences that pressured the behaviour of the microbes in the study area. Such condition were able to influences the concentration process of enterococci in coastal environments, there is no doubt that the process were necessary to confirm it rates of concentration because of the health implication this pollutant sources has cause to the human settlers in the study area. Experts will ensure that this approach will be applied proactively to eradicate ground water pollution in the study environment.

References

[1] Patrick M. Herron John M. Stark, Carson Holt Toby Hooker Zoe G. Cardon 2009 Microbial growth efficiencies across a soil moisture gradient assessed using 13C-acetic acid vapor and 15N-mmonia Soil Biology & Biochemistry 41 1262–1269

[2] Justin B. Brant, Elizabeth W. Sulzman_, David D. Myrold Microbial community utilization of added carbon substrates in response to long-term carbon input manipulation Soil Biology & Biochemistry 38 (2006) 2219–2232

[3] Six, J., Frey, S.D., Thiet, R.K., Batten, K.M., 2006. Bacterial and fungal contributions to C-sequestration in agro ecosystems. Soil Science Society of America Journal 70, 555–569.

[4] Schimel, D.S., 1988. Calculation of microbial growth efficiency from 15N immobilization. Biogeochemistry 6, 239–243.

[5] Thiet, R.K., Frey, S.D., Six, J., 2006. Do growth yield efficiencies differ between soil microbial communities iffering in fungal bacterial ratios? Reality check and methodological issues. Soil Biology & Biochemistry 38, 837–844.

[6] Hart, S.C., Stark, J.M., Davidson, E.A., Firestone, M.K., 1994. Nitrogen mineralization, immobilization, and nitrification. In: Weaver, R.W., Angle, S., Bottomley, P., Bezdicek, D., Smith, S., Tabatabai, A.,Wollum, A. (Eds.), Methods of Soil Analysis. Part 2. Microbiological and Biochemical Properties. Soil Science Society of America, Madison, WI, pp. 985–1018

[7] Frey, S.D., Gupta, V.V.S.R., Elliott, E.T., Paustian, K., 2001. Protozoan grazing affects estimates of carbon utilization efficiency of the soil microbial community. Soil Biology & Biochemistry 33, 1759–1768

[8] Aber, J.D., Magill, A., Boone, R., Melillo, J.M., Steudler, P., Bowden, R. 1993. Plant and soil responses to chronic nitrogen additions at theHarvard Forest, Massachusetts. Ecological Applications 3, 156–166

[9] Myers, R.T., Zak, D.R., White, D.C., Peacock, A., 2001. Landscape-level patterns of microbial community composition and substrate use in upland forest ecosystems. Soil Science Society of America Journal 65, 359–367

[10] Fisk, M.C., Fahey, T.J., 2001. Microbial biomass and nitrogen cycling responses to fertilization and litter removal in young northern hardwood forests. Biogeochemistry 53, 201–223

[11] Smith, J.L., Paul, E.A., 1990. The significance of soil microbial biomass estimations. In: Bollag, J., Stotzky, G. (Eds.), Soil Biochemistry. Mercel Dekker, New York, pp. 357–393.

[12] Zak, D.R., Pregitzer, K.S., Curtis, P.S., Holmes, W.E., 2000. Atmospheric CO2 and the composition and function of soil microbial communities. Ecological Applications 10, 47–59.

[13] Butler, J.L., Bottomley, P.J., Griffith, S.M., Myrold, D.D., 2004. Distribution and turnover of recently fixed photosynthate in ryegrass rhizospheres. Soil Biology & Biochemistry 36, 371–382.

[14] Canadell, J.G., Pitelka, L.F., Ingram, J.S.I., 1996. The effects of elevated CO2 on plant-soil carbon belowground: a summary and synthesis Plant and Soil 187, 391–400.

[15] Frey, S.D., Knorr, M., Parrent, J.L., Simpson, R.T., 2004. Chronic nitrogen enrichment affects the structure and function of the soil microbial community in temperate hardwood and pine forests. Forest Ecology and Management 196, 159–171

[16] Waldrop, M., Firestone, M.K., 2004. Microbial community utilization of recalcitrant and simple carbon compounds: impact of oak-woodland plant communities. Oecologia 138, 275–284.

[17] Pendall, E., Bridgham, S., Hanson, P.J., Hungate, B.A., Kicklighter, D.W., Johnson, D.W., Law, B.E., Luo, Y.Q., Megonigal, J.P., Olsrun, M., Ryan, M.G., Wan, S.Q., 2004. Below-ground process responses to elevated CO2 and temperature: a discussion of observations, measurement methods, and models. New Phytologist 162, 311–322.

[18] Sulzman, E.W., Brant, J.B., Bowden, R.D., Lajtha, K., 2005. Contribution of aboveground litter, belowground litter, and rhizosphere respiration to total soil CO2 efflux in an old growth coniferous forest. Biogeochemistry 73, 231–256.

[19] Nadelhoffer, K.J., Boone, R.D., Bowden, R.D., Canary, J.D., Kaye, J., Micks, P., Ricca, A., Aitkenhead, J.A., Lajtha, K., McDowell, W.H., 2004. The DIRT experiment: litter and root influences on forest soil organic matter stocks and function. In: Foster, D., Aber, J. (Eds.), Forests in Time: The Environmental Consequences of 1000 Years of Change in New England. Yale University Press, New Haven, pp 300–315

[20] Eluozo S.N 2013 Mathematical model to monitor the deposition of carbon on influence of E.coli transport in soil water environment in Port Harcourt, rivers state of Nigeria International Journal of Waste Management and Technology Vol. 1, No. 2, May 2013, PP: 31 – 48, ISSN: 2327-8757 (Online) Available online www.ijwmt.com