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Research article

MODELING AND SIMULATION OF STREPTOCOCCI INFLUENCED BY PERMEABILITY AND POROSITY IN PENETRATING UNCONFINED BED IN OBIO-AKPOR, RIVERS STATE OF NIGERIA

Eluozo, S. N

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

Abstract

Modeling and simulation were to express the behaviour of streptococci in the study location, the rate of concentration were to monitor the transport of the microbes at different influences in the system. The developed model were simulated to express the migration condition reflected on the figure presented, the deposition of the microbes were influences from high percentage level of porosity and void ratio, the expressed model from the derived solution expressed its rate of deposition and migration at different concentration influenced by regenerating of biological waste in the study location, investigation carried out could not developed solution, therefore modeling the deposition and migration of the microbes were found suitable in other to find lasting solution to the contaminants threat in the study area, the developed model simulated produces theoretical values compared with experimental results, both parameter generated best fit expressing model validation in the study area.

Keywords: modeling and simulation streptococci permeability and porosity, unconfined bed

1. Introduction

To determine if a given water supply is safe, the source needs to be protected and monitored regularly. There are two broad approaches to water quality monitoring for pathogen detection. The first approach is direct detection of the pathogen itself, for example, the protozoan *Cryptosporidium parvum*. While it will be more accurate and precise if specific disease-causing pathogens are detected directly for the determination of water quality, there are several problems with this approach. First, it would be practically impossible to test for each of the wide variety of pathogens that may be present in polluted water. Second, even though most of these pathogens can now be directly detected, the methods are often difficult, relatively expensive, and time-consuming (WHO, 1996). Instead, water monitoring for microbiological quality is primarily based on a second approach, which is to test for .indicator organisms. For a classification table created by the author of typical indicator organisms). The indicator microorganisms should fulfill the following criteria (Stetler, 1994 Eluozo, 2000).

The precipitation that reaches the ground surface may flow in to stream, lake and ocean, where it will either be evaporated or form seepages intruding in to the ground likewise soil moisture and further percolate downward to underline aquifer where it may be held for several years longer. Groundwater in Nigeria is restricted by the fact that more than half of the country is underlain by crystalline basement rock of pre-cambian era. The main rock types in this geological terrain include igneous and metamorphic rock such as migmatites and granite gneisses. Generally in their unaltered form, they are characterized by low porosity and permeability. Porosity in basement rocks is by induction through weathering while secondary permeability induces by tectonic activities which manifest in form of that often act as conduct path facilitating water movement. In other words, aquiferous zones in the basement terrain include fractured/weathered rocks. The yielding capacity of well, drilled within such rock are always very enormous. (Shitta 2007, Eluozo, 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). 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 Nwankwoala, 2005). 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). Port-Harcourt falls within the Niger Delta Basin of Southern Nigeria which is defined geologically by three sub-surface sedimentary facies: Akata, Agbada and Benin formations (Whiteman, 1982). The Benin Formation (Oligocene to Recent) is the aquiferous formation in the study area with an average thickness of about 2100 m at the centre of the basin and consists of coarse to medium grained sandstone, gravels and clay with an average thickness of about 2100 m at the centre of the basin and consists of coarse to medium grained sandstone, gravels and clay (Etu-Efeotor and Akpokodje, 1990). The Agbada Formation consists of alternating deltaic (fluvial, coastal, fluviomarine) and shale, while Akata Formation is the basal sedimentary unit of the entire Niger Delta, consisting of low density, high pressure shallow marine to deep water shale (Schield, 1978).

2. Governing equation

Nomenclature

V = Volumetric concentration of Transport [ML^{-1}]
K = Permeability [LT^{-1}]
ϕ = porosity [-]
T = Time [T]
X = Distance [L]
ρ = bulk density [-]

$$K\frac{\partial^2 v}{\partial t} = \phi\frac{\partial\ V}{\partial x}\ K\frac{\partial v_2}{\partial x} = -Q\frac{\partial v}{\partial x} \quad \ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$\left.\begin{array}{l} t = 0 \\ x = 0 \\ C_{(o)} = 0 \\ \left.\dfrac{\partial v}{\partial t}\right| \quad = 0 \\ \qquad\quad t = 0, B \end{array}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Applying direct integration on (1)

$$K\frac{\partial v_1}{\partial t} = \phi v + K_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Again, integrate equation (2) directly yield

$$Kv = \phi vt + Kt + K_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

Subject to equation (3), we have

$$Vv_o = K_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

And subjecting equation (2) to (3) we have

$$\text{At } \left.\frac{\partial v_1}{\partial x}\right| \quad = 0 \quad v(o) = vo$$
$$\qquad\qquad\quad t = 0$$

Yield

$$0 = \phi v + K_2$$

$$\Rightarrow V_1 = \phi v_o = K_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

So that we put (3) and (4) into (3), we have

$$Kv_1 = \phi v_{1t} - \phi vox\ Kvo \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (7)$$

$$Kv_1 - \phi v_{1x} = Kv_o - \phi vox \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (8)$$

$$v_1 = v_o \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (9)$$

Hence equation (18) entails that at any given distance x, we have constant concentration of the contaminant in the system. This condition implies in transport system there some region of the soil that the migration will develop constant deposition of concentration, this condition depends on the deposition of the strata, and such expression implies that deposition of the formation may have deposition homogeneous void ratio that may pressure the concentration to reduces it concentrations and maintain constant rate, at most it may also implies that they reaction with other deposited minerals has reduce or inhibit the concentrations of the microbes .

$$K\frac{\partial v_2}{\partial x} = -Q\frac{\partial v}{\partial x} \quad \ldots\ldots\ldots\ldots \quad (1)$$

We approach the system, by using the Bernoulli's method of separation of variables

$$v_2 = XT \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$K\frac{\partial v_2}{\partial x} = X^1T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

i.e.

$$K\frac{\partial_2}{\partial x} = X^1T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

Put (12) and (13) into (11), so that we have

$$KXT^1 = -QX^1T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

i.e. $$K\frac{X^1}{X} = Q\frac{X^1}{X} = -\lambda^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

Hence $$K\frac{T^1}{T} + \lambda^2 = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (7)$$

i.e. $$X^1 + \frac{\lambda}{K}x = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (8)$$

$$KX^1 + \lambda^2 X = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (9)$$

From (9), $$X = ACos\frac{\lambda}{K}X + BSin\frac{\lambda}{\sqrt{K}}X \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (10)$$

And (11) gives

$$T = C\ell^{\frac{-\lambda^2}{V}t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (11)$$

And (4) gives

$$C_2 = \left(A Cos \frac{\lambda}{K} x + B Sin \frac{\lambda}{\sqrt{K}} x \right) C \ell^{\frac{-\lambda^2}{V} x} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (12)$$

Subject to equation (12) to conditions , so that we have

$$V_o = AC \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (13)$$

Equation (13) becomes

$$v_2 = v_o \ell^{\frac{-\lambda^2}{K} x} \; Cos \frac{\lambda}{\sqrt{K}} x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (14)$$

Again, at

$$\left. \frac{\partial v_2}{\partial x} \right| \begin{array}{l} = 0, \; x = 0 \\ x = 0, \; B \end{array}$$

Equation becomes

$$\frac{\partial v_2}{\partial x} = \frac{\lambda}{\sqrt{K}} v_o \ell^{\frac{-\lambda}{V} x} \; Sin \frac{\lambda}{\sqrt{K}} x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (15)$$

i.e. $0 = -\frac{vo\lambda}{K} \; Sin \frac{\lambda}{KV} 0$

$vo \frac{\lambda}{K} \neq 0$ Considering NKP

Which is the substrate utilization for microbial growth (population) so that

$$0 = vo \frac{\lambda}{\sqrt{K}} \; Sin \frac{\lambda}{\sqrt{K}} B \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (16)$$

$$\Rightarrow \frac{\lambda}{K} = \frac{n\pi}{2} n, 1, 2, 3 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (17)$$

$$\Rightarrow \lambda = \frac{\lambda}{K} = \frac{n\pi\sqrt{R}}{2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (18)$$

So that equation (14) becomes

$$\Rightarrow v_2 = vo \ell^{\frac{-n^2\pi^2 R}{2} t} \; Cos \frac{n\pi\sqrt{K}}{2\sqrt{K}} x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (19)$$

$$\Rightarrow v_2 = vo\ell \frac{-n^2\pi^2 K}{2} x\, Cos\frac{n\pi}{2} x \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (20)$$

3. Materials and method

Soil samples from several different borehole locations, were collected at intervals of three metres each (3m). Soil sample were collected in five different location, applying insitu method of sample collection, the soil sample were collect for analysis, standard laboratory analysis were collected to determine the soil formation, the result were analysed to determine the rate of streptococci concentration between unconfined formation through column experiment in the study area.

4. Results and Discussion

Theoretical and experimental values from every condition on the developed model are expressed in figures and tables below.

Table: 1 concentration of the streptococci at Different Depths

Depths [M]	Concentration [Mg/l]
3	2.00E-01
6	4.10E-01
9	6.20E-01
12	8.30E-01
15	1.04E+00
18	1.25E+00
21	1.46E+00
24	1.67E+00
27	1.88E+00
30	2.09E+00

Table: 2 concentrations of the streptococci at Different Time

Time [Per Day]	Concentration [Mg/l]
10	2.00E-01
20	4.10E-01
30	6.20E-01
40	8.30E-01
50	1.04E+00
60	1.25E+00
70	1.46E+00
80	1.67E+00
90	1.88E+00

100	**2.09E+00**

Table: 3 Comparison of theoretical and experimental values of streptococci at Different Depths

Depths [M]	**Theoretical values [**Mg/l]	**Experimental values** [Mg/L]
3	**2.00E-01**	**2.11E-01**
6	**4.10E-01**	**4.22E-01**
9	**6.20E-01**	**6.28E-01**
12	**8.30E-01**	**8.44E-01**
15	**1.04E+00**	**1.11E+00**
18	**1.25E+00**	**1.31E+00**
21	**1.46E+00**	**1.52E+00**
24	**1.67E+00**	**1.71E+00**
27	**1.88E+00**	**1.84E+00**
30	**2.09E+00**	**2.11E+00**

Table: 4 Comparison of theoretical and experimental values of streptococci at Different Time

Time [Per Day]	**Theoretical values [**Mg/l]	**Experimental values** [Mg/L]
10	**2.00E-01**	**2.11E-01**
20	**4.10E-01**	**4.22E-01**
30	**6.20E-01**	**6.28E-01**
40	**8.30E-01**	**8.44E-01**
50	**1.04E+00**	**1.11E+00**
60	**1.25E+00**	**1.31E+00**
70	**1.46E+00**	**1.52E+00**
80	**1.67E+00**	**1.71E+00**
90	**1.88E+00**	**1.84E+00**
100	**2.09E+00**	**2.11E+00**

Table: 5 concentrations of the streptococci at Different Depths

Depths [M]	**Concentration [Mg/l]**
3	**4.20E-03**
6	**1.90E-02**
9	**4.30E-02**
12	**7.60E-02**
15	**1.20E-01**
18	**1.70E-01**
21	**2.30E-01**
24	**3.00E-01**
27	**3.90E-01**

30	**4.80E-01**

Table: 6 concentrations of the streptococci at Different Time

Time [Per Day]	Concentration [Mg/l]
10	**4.20E-02**
20	**1.90E-02**
30	**4.30E-02**
40	**7.60E-02**
50	**1.20E-01**
60	**1.70E-01**
70	**2.30E-01**
80	**3.00E-01**
90	**3.90E-01**
100	**4.80E-01**

Table: 7 Comparison of theoretical and experimental values of streptococci at Different Depths

Depths [M]	Theoretical values [Mg/l]	Experimental values [Mg/L]
3	**4.20E-03**	**4.44E-03**
6	**1.90E-02**	**2.04E-02**
9	**4.30E-02**	**4.44E-02**
12	**7.60E-02**	**7.68E-02**
15	**1.20E-01**	**1.27E-01**
18	**1.70E-01**	**1.80E-01**
21	**2.30E-01**	**2.37E-01**
24	**3.00E-01**	**3.11E-01**
27	**3.90E-01**	**4.11E-01**
30	**4.80E-01**	**5.04E-01**

Table: 8 Comparison of theoretical and experimental values of streptococci at Different Depths

Time [Per Day]	Theoretical values [Mg/l]	Experimental values [Mg/L]
10	**4.20E-03**	**4.44E-03**
20	**1.90E-02**	**2.04E-02**
30	**4.30E-02**	**4.44E-02**
40	**7.60E-02**	**7.68E-02**
50	**1.20E-01**	**1.27E-01**
60	**1.70E-01**	**1.80E-01**
70	**2.30E-01**	**2.37E-01**
80	**3.00E-01**	**3.11E-01**

90	**3.90E-01**	**4.11E-01**
100	**4.80E-01**	**5.04E-01**

Table: 9 concentrations of the streptococci at Different Depths

Depths [M]	Concentration [Mg/l]
3	**4.81E+01**
6	**1.92E+02**
9	**4.33E+02**
12	**7.69E+02**
15	**1.20E+03**
18	**1.73E+03**
21	**2.36E+03**
24	**3.08E+03**
27	**3.90E+03**
30	**4.81E+03**

Table: 10 concentrations of the streptococci at Different Time

Time [Per Day]	Concentration [Mg/l]
10	**4.81E+01**
20	**1.92E+02**
30	**4.33E+02**
40	**7.69E+02**
50	**1.20E+03**
60	**1.73E+03**
70	**2.36E+03**
80	**3.08E+03**
90	**3.90E+03**
100	**4.81E+03**

Table: 11 Comparison of theoretical and experimental values of streptococci at Different Depths

Depths [M]	Theoretical values [Mg/l]	Experimental values [Mg/L]
3	**4.81E+01**	**4.67E+01**
6	**1.92E+02**	**1.89E+02**
9	**4.33E+02**	**4.55E+02**
12	**7.69E+02**	**7.88E+02**
15	**1.20E+03**	**1.26E+03**
18	**1.73E+03**	**1.78E+03**
21	**2.36E+03**	**2.44E+03**

24	**3.08E+03**	**3.18E+03**
27	**3.90E+03**	**4.05E+03**
30	**4.81E+03**	**4.88E+03**

Table: 11 Comparison of theoretical and experimental values of streptococci at Different Time

Time [Per Day]	**Theoretical values [**Mg/l]	**Experimental values** [Mg/L]
10	**4.81E+01**	**4.67E+01**
20	**1.92E+02**	**1.89E+02**
30	**4.33E+02**	**4.55E+02**
40	**7.69E+02**	**7.88E+02**
50	**1.20E+03**	**1.26E+03**
60	**1.73E+03**	**1.78E+03**
70	**2.36E+03**	**2.44E+03**
80	**3.08E+03**	**3.18E+03**
90	**3.90E+03**	**4.05E+03**
100	**4.81E+03**	**4.88E+03**

Table: 12 concentrations of the streptococci at Different Depths

Depths [M]	**Concentration [Mg/l]**
3	**1.90E-01**
6	**7.70E-01**
9	**1.75E+00**
12	**1.45E+00**
15	**4.76E+00**
18	**6.85E+00**
21	**9.33E+00**
24	**1.28E+01**
27	**2.72E+01**
30	**1.95E+01**

Table: 13 concentrations of the streptococci at Different Depths

Time [Per Day]	**Concentration [Mg/l]**
10	**1.90E-01**
20	**7.70E-01**
30	**1.75E+00**
40	**1.45E+00**
50	**4.76E+00**
60	**6.85E+00**

70	**9.33E+00**
80	**1.28E+01**
90	**2.72E+01**
100	**1.95E+01**

Table: 14 Comparison of theoretical and experimental values of streptococci at Different Depths

Depths [M]	**Theoretical values [**Mg/l]	**Experimental values** [Mg/L]
3	**1.90E-01**	**1.88E-01**
6	**7.70E-01**	**1.98E-01**
9	**1.75E+00**	**1.89E+00**
12	**1.45E+00**	**1.55E+00**
15	**4.76E+00**	**4.88E+00**
18	**6.85E+00**	**6.77E+00**
21	**9.33E+00**	**9.55E+00**
24	**1.28E+01**	**1.37E+01**
27	**2.72E+01**	**2.67E+01**
30	**1.95E+01**	**1.93E+01**

Table: 11 Comparison of theoretical and experimental values of streptococci at Different Time

Time [Per Day]	**Theoretical values [**Mg/l]	**Experimental values** [Mg/L]
10	**1.90E-01**	**1.88E-01**
20	**7.70E-01**	**1.98E-01**
30	**1.75E+00**	**1.89E+00**
40	**1.45E+00**	**1.55E+00**
50	**4.76E+00**	**4.88E+00**
60	**6.85E+00**	**6.77E+00**
70	**9.33E+00**	**9.55E+00**
80	**1.28E+01**	**1.37E+01**
90	**2.72E+01**	**2.67E+01**
100	**1.95E+01**	**1.93E+01**

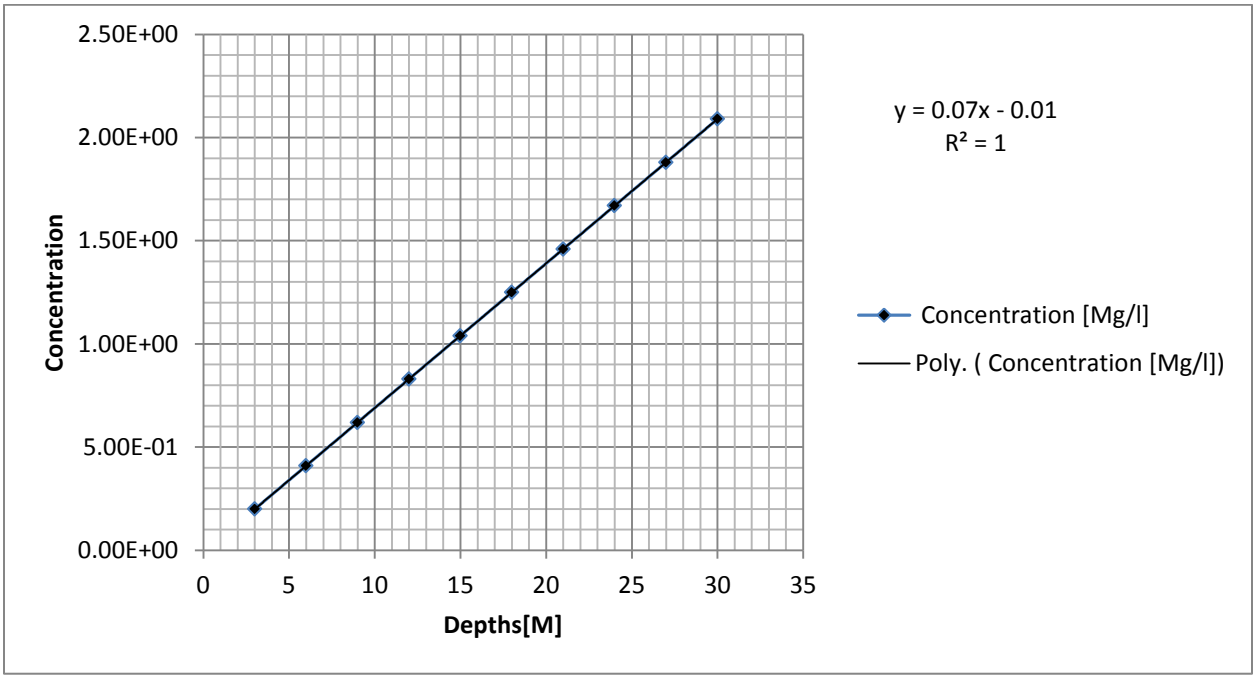

Figure: 1 concentration of the streptococci at Different Depths

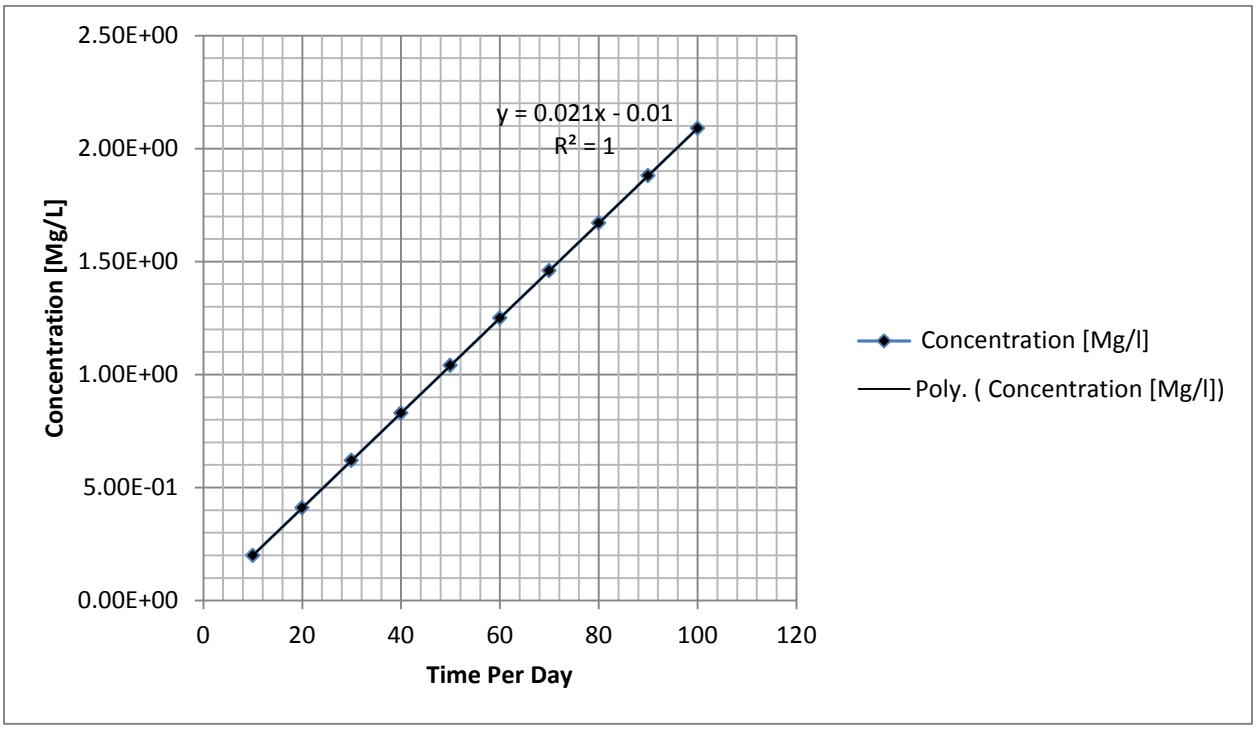

Figure: 2 concentrations of the streptococci at Different Time

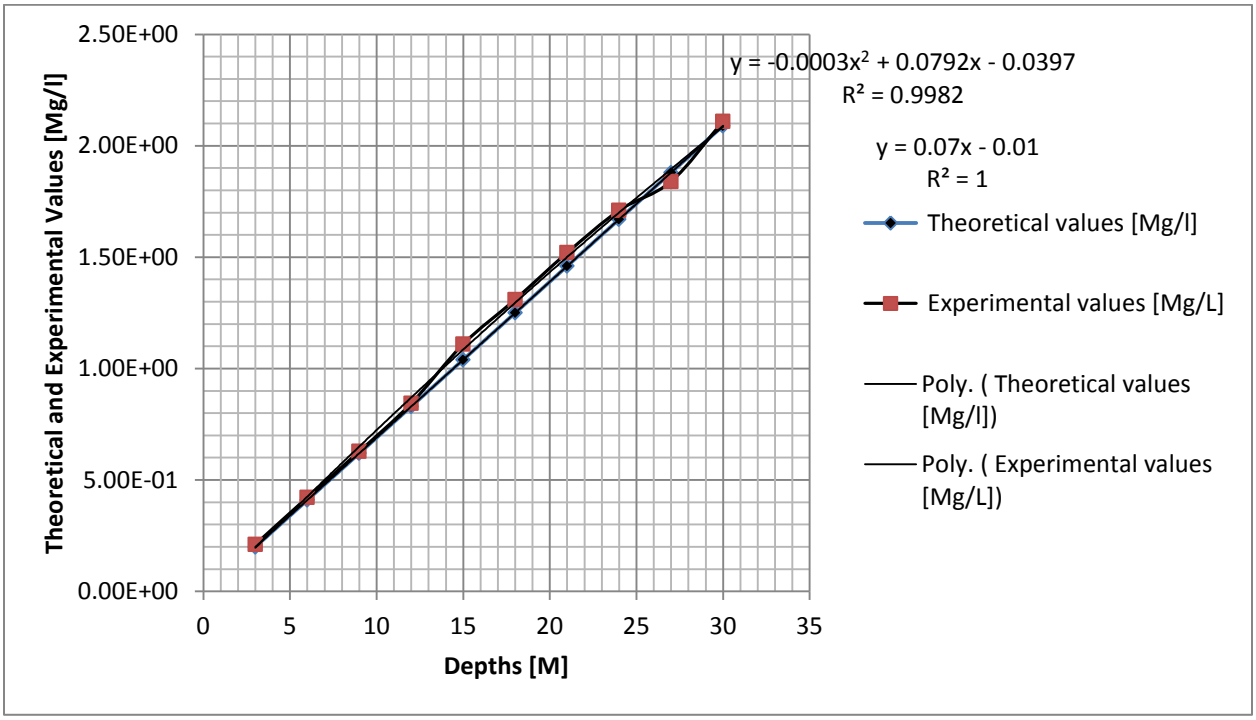

Table: 3 Comparison of theoretical and experimental values of streptococci at Different depths

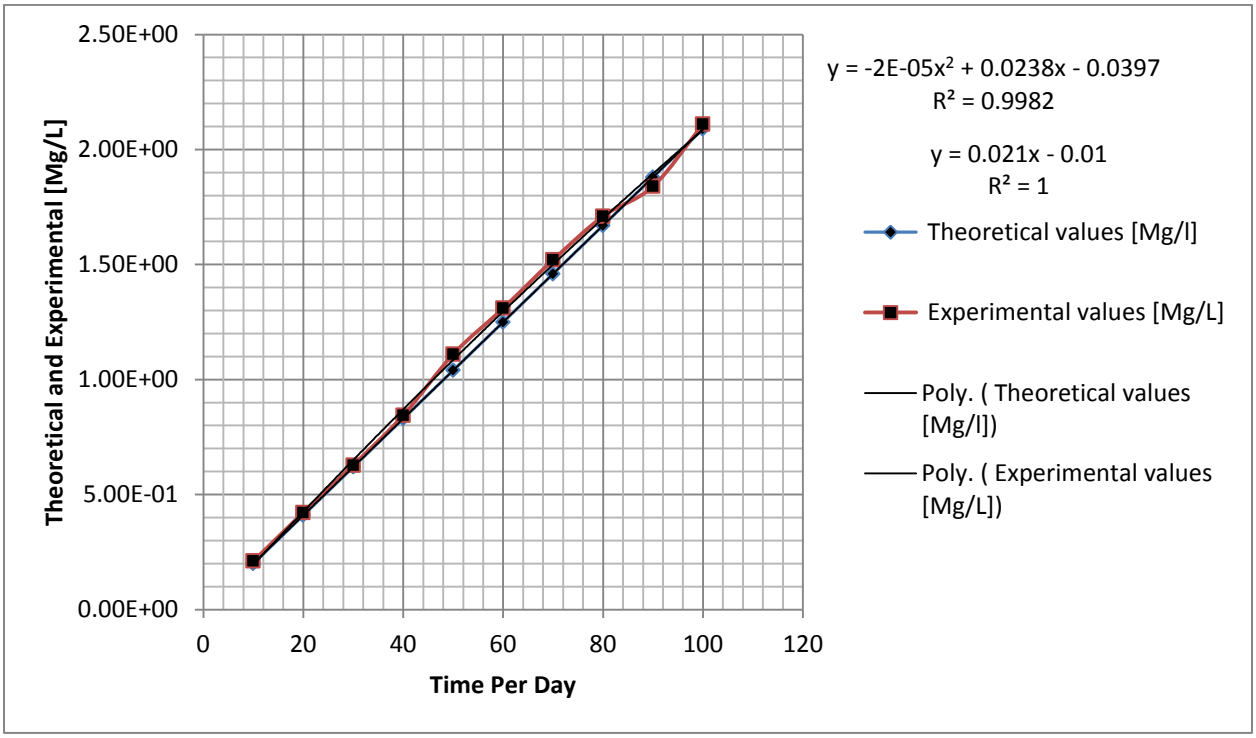

Table: 4 Comparison of theoretical and experimental values of streptococci at Different Time

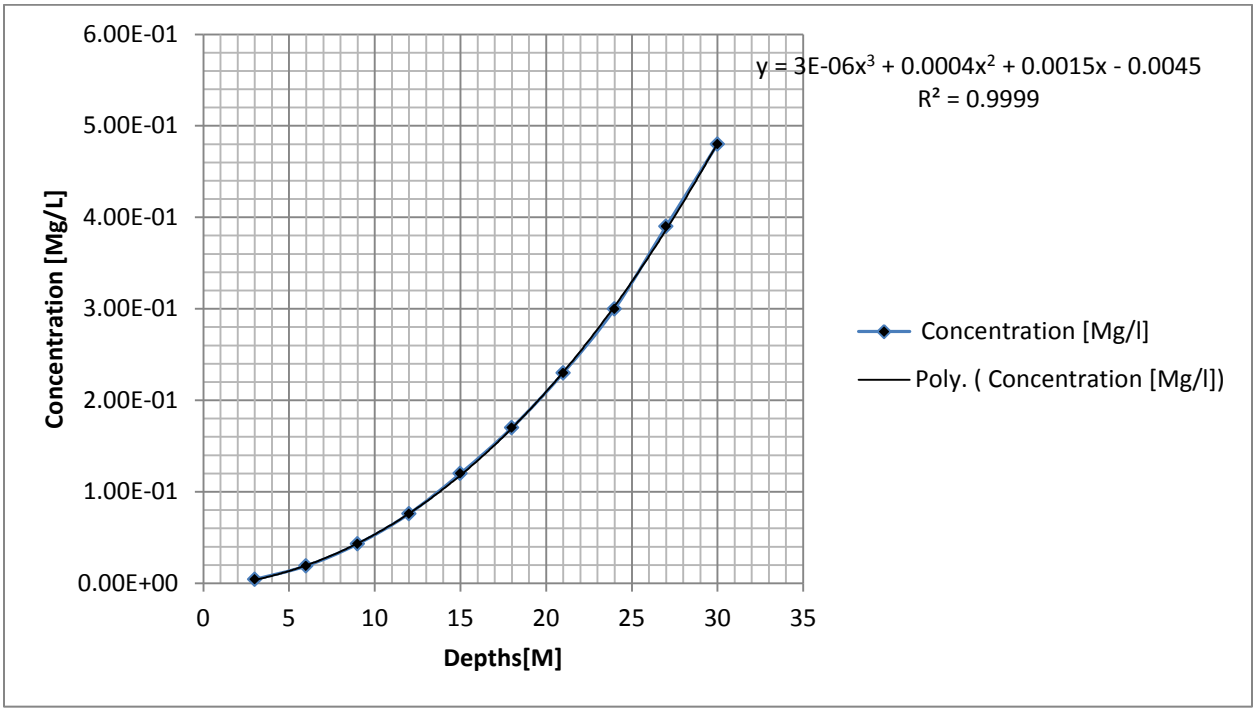

Figure: 5 concentrations of the streptococci at Different Depths

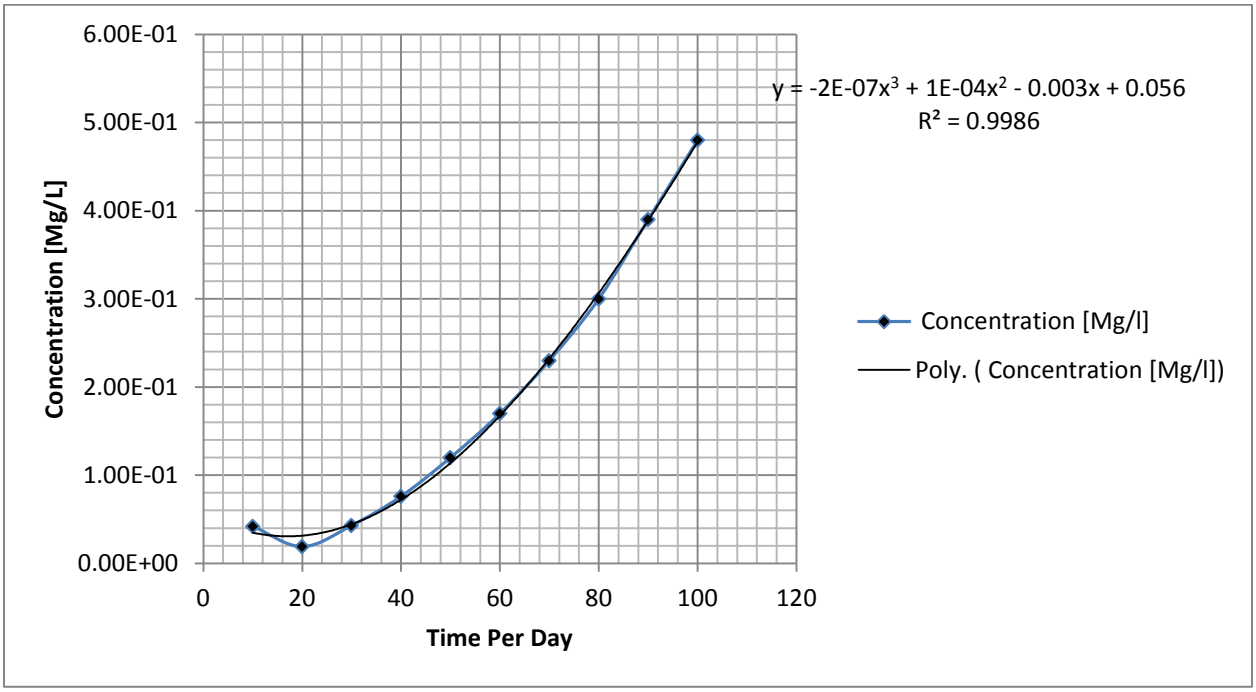

Figure: 6 concentrations of the streptococci at Different Time

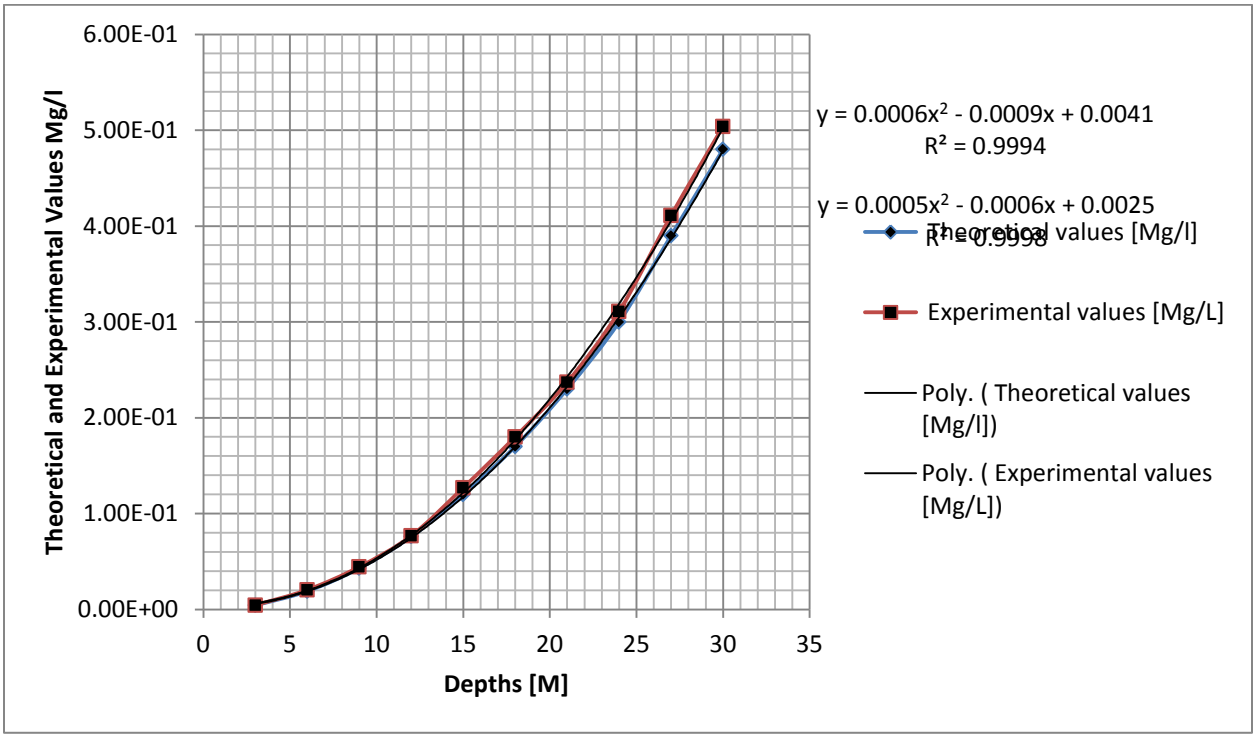

Table: 7 Comparison of theoretical and experimental values of streptococci at Different Depths

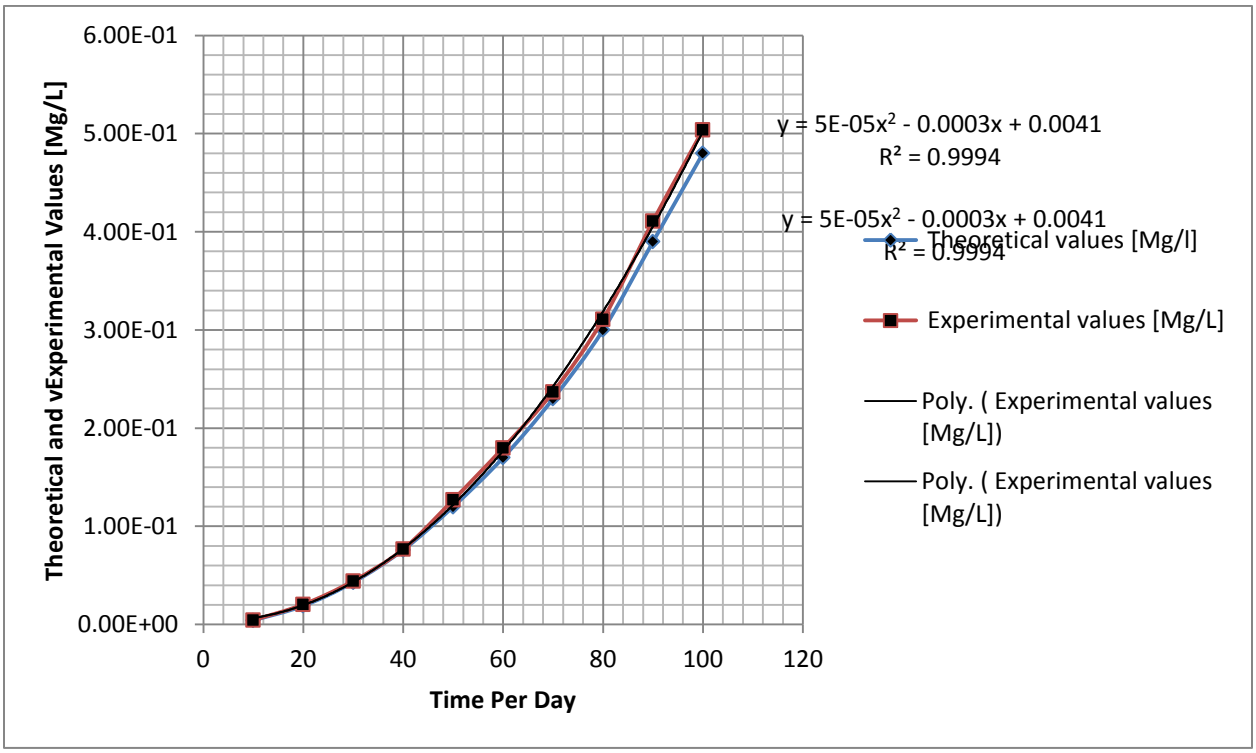

Table: 8 Comparison of theoretical and experimental values of streptococci at Different Time

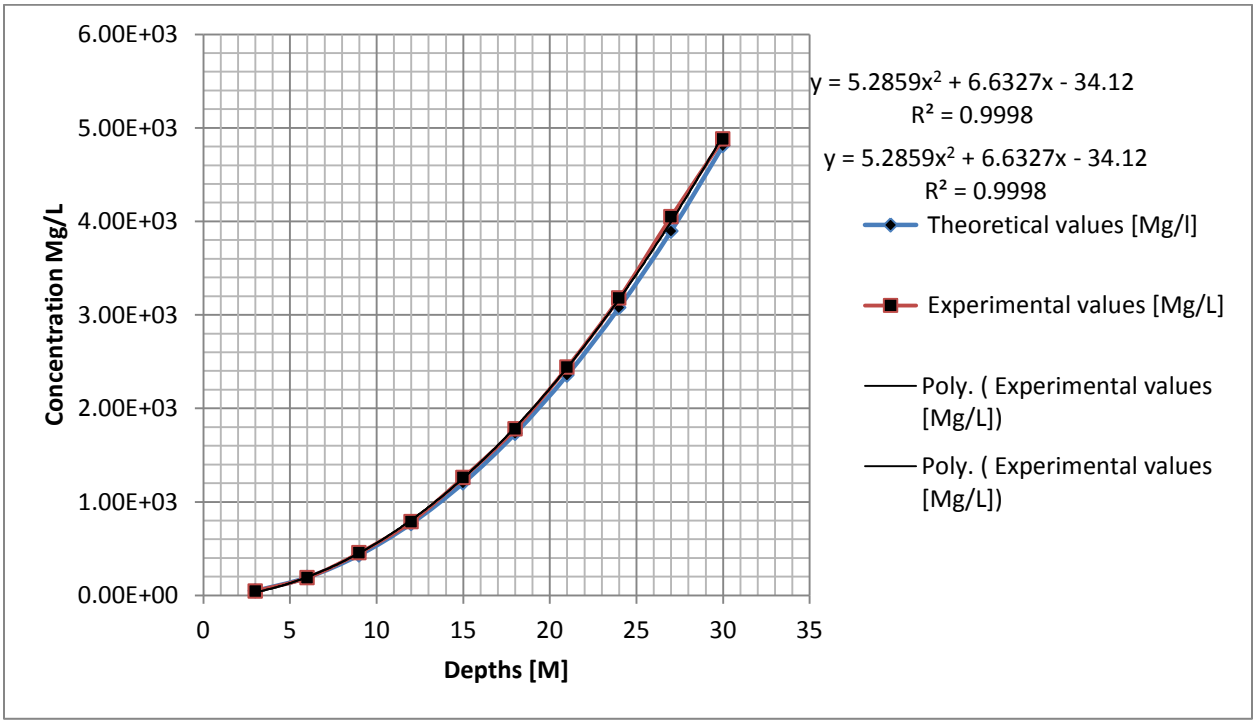

Table: 9 Comparison of theoretical and experimental values of streptococci at Different Depths

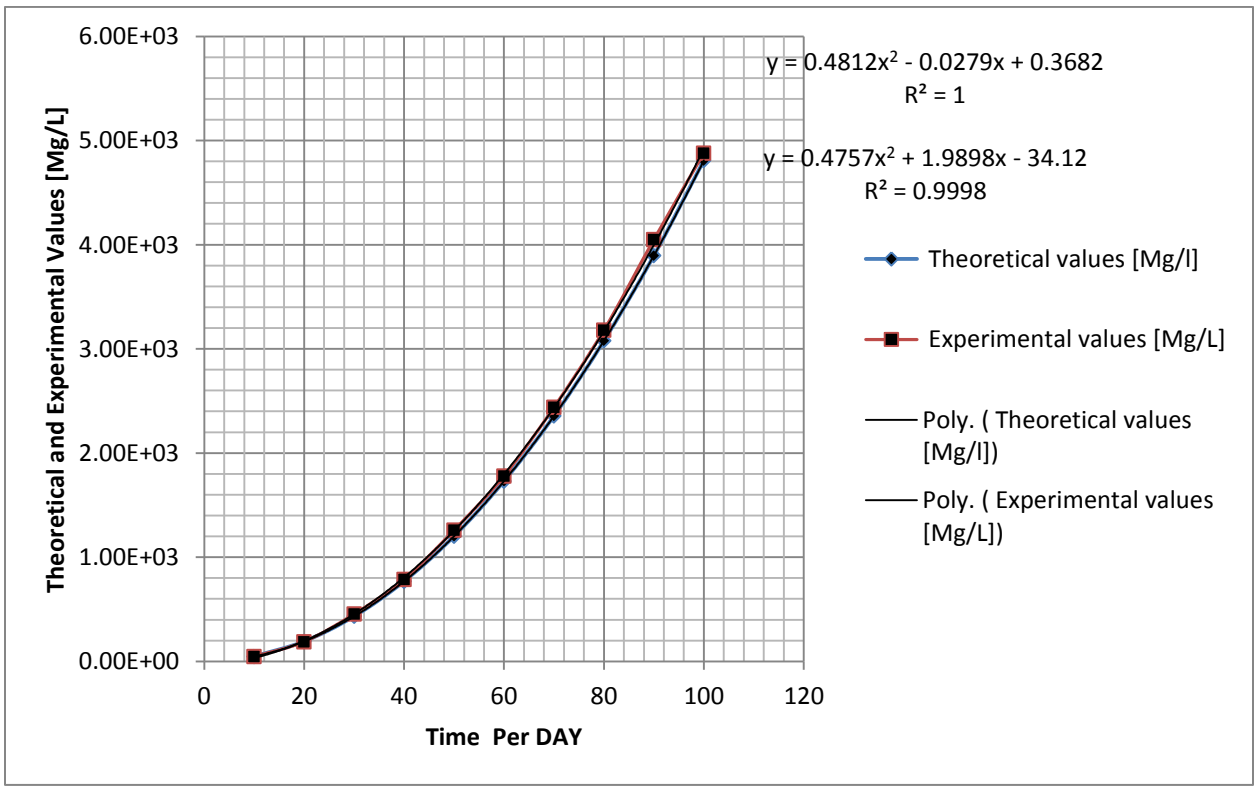

Table: 10 Comparison of theoretical and experimental values of streptococci at Different Time

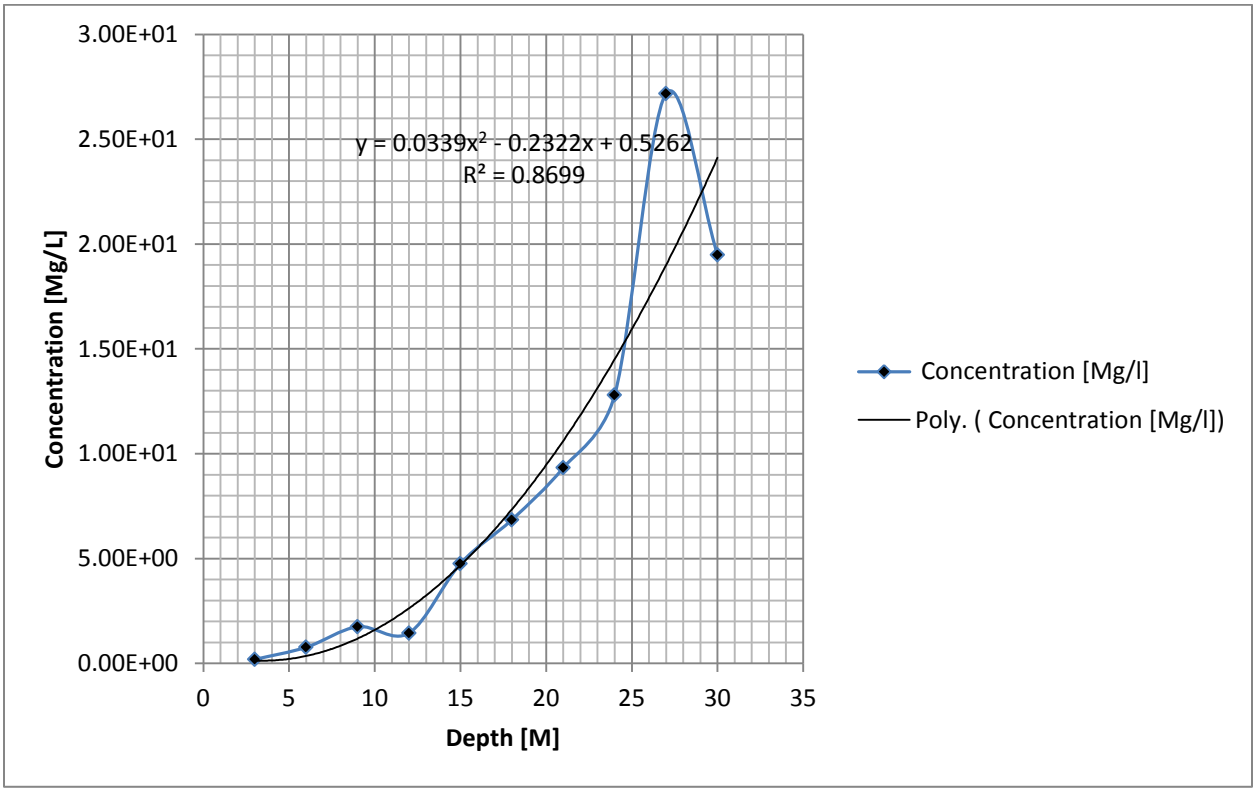

Figure: 11 concentrations of the streptococci at Different Time

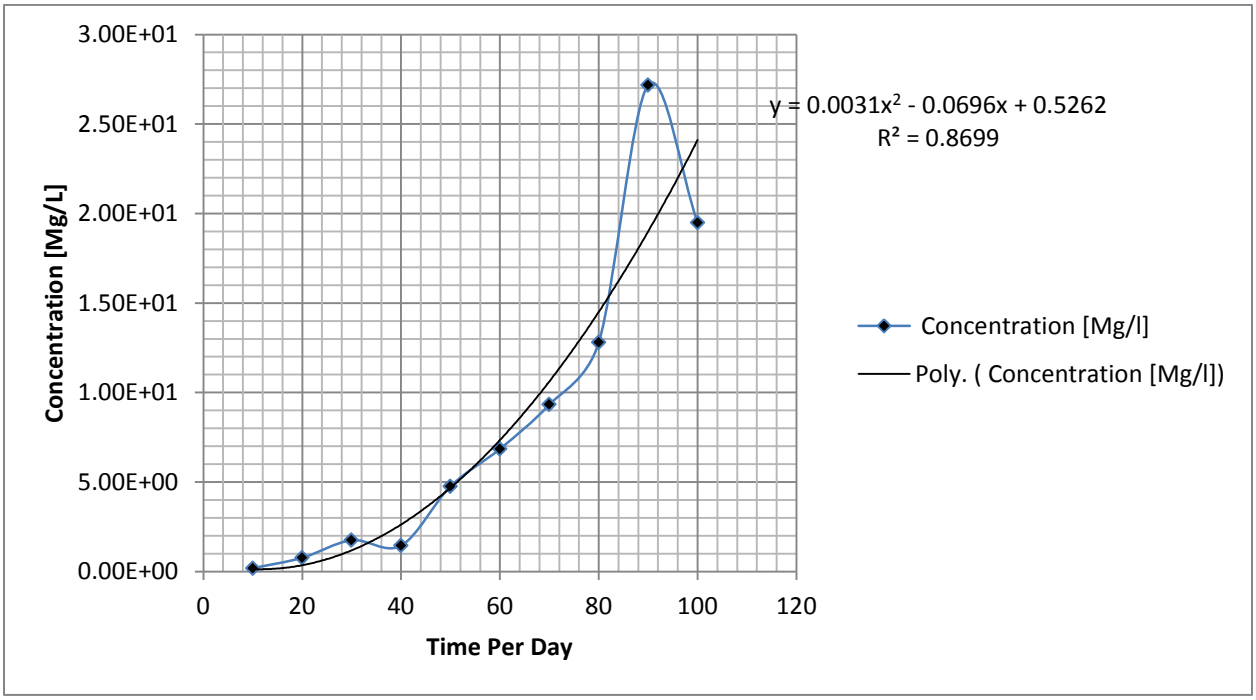

Figure: 12 concentrations of the streptococci at Different Time

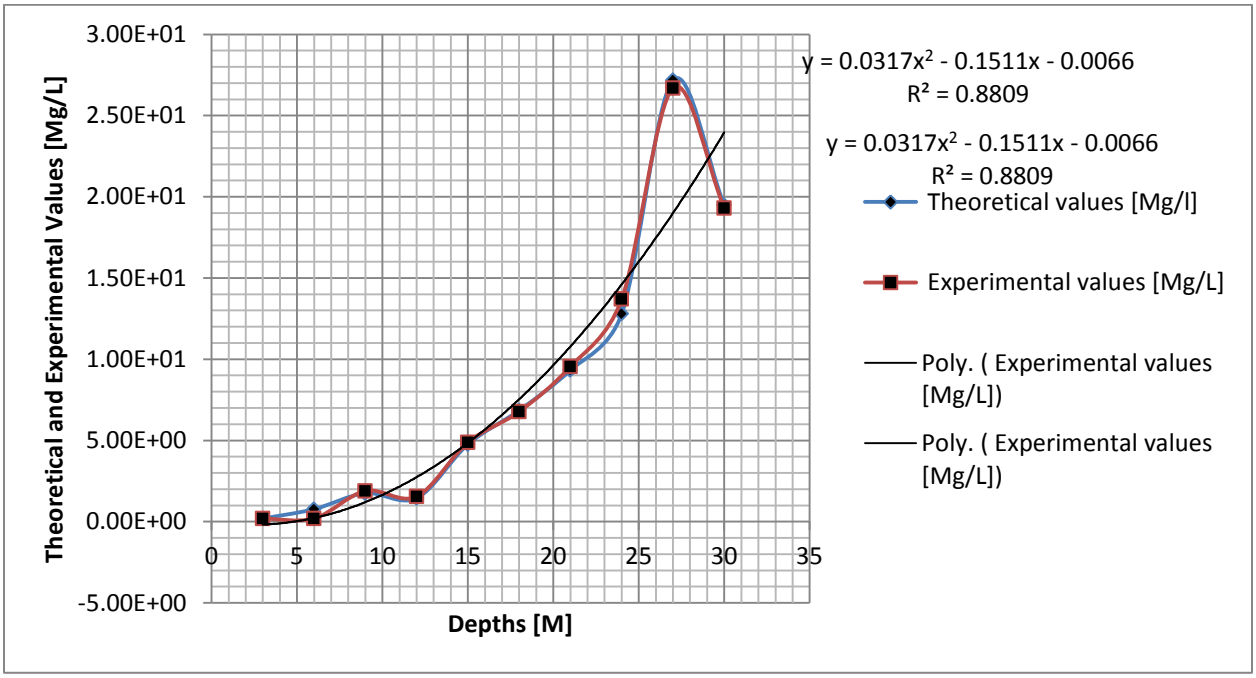

Table: 13 Comparison of theoretical and experimental values of streptococci at Different Time

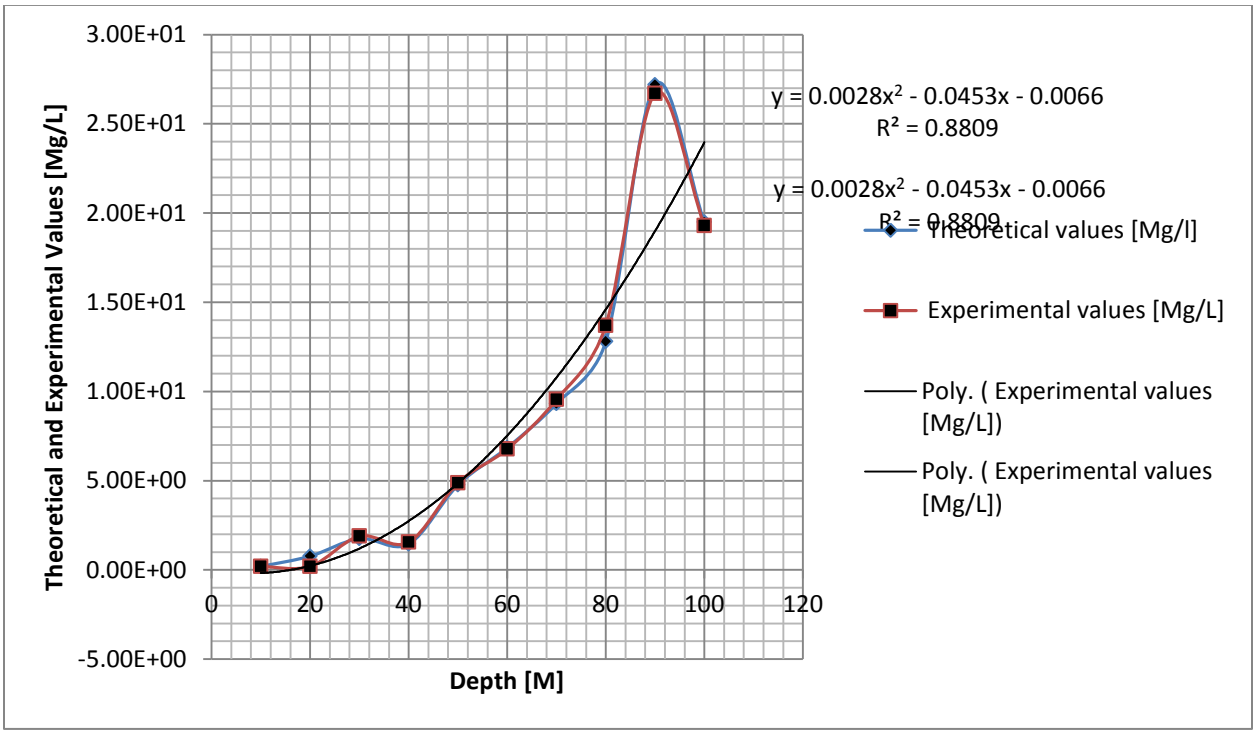

Table: 14 Comparison of theoretical and experimental values of streptococci at Different Time

Figure one to four shows that the concentration experienced rapid migration of the contaminant from the lowest at 0.20 to the optimum level at 2.09 mg/l , the deposition of streptococci were found to express rapid migration from different influences that is deposited in the formation, the migration of the microbes were found to deposit linear

exponential phase as it is expressed in the state figures, but the concentration were base on the rate of generation in some part of the study location, such condition developed high concentration, but may not be compared with other region of the study area, similar condition were found on figure five to eight in the study area, the concentration rates developed lower rate compare to figure one to four, the parameters also express rapid migration but were in constant migration rates, some part of the formation were found to express higher values of concentration showing the level of deposition including increase of regeneration of biological waste in the study locations. The lowest from the theoretical values were 0.042 while the highest 0.48 mg/l. The rate of concentration can be attributed to the deposited percentage of void ratio and variation in porosity, but figure nine to fifteen were found to deposit highest value in the study location, the lowest 48.09 and highest 3895.69mg/l including 0.19 and 19.49mg/l, the rate of deposition was influenced by lots of low deposition of formation characteristics developing higher accumulation of streptococci in the formation, rapid deposition of the microbes at this stage of the study can be attributed to deposition of high substrate giving energy to the microbes and increasing it population in the formation, the study were developed base on the investigations carried out in the study location, these produces results of predominant streptococci in the system, the investigation could not produces productive results to remove such contaminants in the formation migrating to aquiferous zone, modeling and simulation were found imperative to ensure that such threats are remove in the ground water aquifers. The developed model generated theoretical values from the simulation at different concentration; comparing both parameters they developed a best fit expressing model validation.

5. Conclusion

The depositions of streptococci in the study location were expressed in different dimensions through mathematical expressions. The concept were found necessary to ensure that the contaminant are monitored in at different conditions, including behaviour of the contaminant reflecting on the presented figure, the simulations rapid migration at different concentrations were expressed from the figure presented above, the expressed mathematical model generated theoretical values that represent different rate of contaminant at different depths, formation characteristics such as high degree of porosity were found to influences the deposition and migration of the contaminants in the system, generated theoretical values at different concentration and at various strata were expressed from the figures, the theoretical values were compared with experimental values for validation of the developed model equations, the expressed model compared with experimental values established the rate of contaminants at different formation influenced by high percentage of void ratio in the study location, experts will find the model favuorable to monitor and engineer out these type of contaminants in the study area.

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