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Research article

MODELING AND SIMULATING THE BEHAVIOUR OF EDWARDSIELLA DEPOSITION IN PENETRATION SEMI UNCONFINED BED IN RUMUOMASI DISTRICT OF PORT HARCOURT METROPOLIS, NIGER DELTA OF NIGERIA

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Abstract

Modeling and simulation of Edwardsiella deposition has express the rate of concentration under the influences of predominant high degree of porosity, the rate of such formation developed lots of dispersion in the study area, the migration of Edwardsiella has developed lots of ill health to the settlers in the study area, the expressed mathematical model were able to monitor the rate of concentration at different strata, the influences from other formation were also considered in the system, but it was the predominant parameters that were thoroughly express in the system, the derived model were simulated to produces theoretical values, it was compared with other experimental values, both parameters compared faviourably well expressing model validation, experts will definitely applied this model to monitor and evaluate the deposition and migration of Edwardsiella in the study location.

Keywords: modeling and simulation, Edwardsiella deposition, and penetrating unconfined bed

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1. Introduction

There are lots of characteristics that affect the survival of pathogens in water, mainly bacteria and viruses, comprise temperature, pH, dissolved oxygen, water hardness, presence of organic material, exposure to sunlight,

the existence of other micro-organisms and water conductivity (O'Brien & Newman, 1977; Lund, 1978; Melnick & Gerba, 1980; Davies-Colley et al. 1994). Protozoan cysts live above a wide variety of Ph values and are opposed to to osmotic pressures. *Cryptosporidium* oocysts can survive for over one year in isotonic the solutions are from laboratory; this may remain viable for long time in aquatic environments (Smith et al. 1991). The foremost issue affecting cyst and also helminth egg survival in water temperature is the higher temperatures resulting in faster death (Feachem et al. 1983; O'Donohue, 1995). Pathogens are carried through water over quite large distances. Analysis done in Zambezi River express that the bacteria were still detected 18.6 km downstream from the source of pollution at levels at 1.4 x 103 *E. coli*/100 ml (Feresu & Van Sickle, 1990). Lund (1978) similarly observations were pressed in tropical waters. Too much quantity of fecal bacteria in surface water, these were found to increase the risk of bacteria−induced illness to humans (Frenzel and Couvillion, 2002). Payment et al. (2000) found that the presence of pathogenic microorganisms (human enteric virus, *Cryptosporidium*, and *Giardia*) deposited in Saint Lawrence River in Canada; this was comprehensively correlated with bacterial indicators (total coliform, fecal coliform, and *Clostridium perfringens*). Concentration rate of fecal coliform from 200 colony−forming units (cfu) per 100 mL of water was established as a water−quality standard by the Federal Water Pollution Control Administration of the Department of the Interior in 1968 (USEPA, 1986). Current research, however, established that fecal coliforms confound to deposit less correlation to swimming−associated gastroenteritis than the other two common indicator bacteria (*Escherichia coli* and enterococci), prompting a shift in the suggested indicator organisms (USEPA, 1998, 2002). Total coliform, fecal coliform, fecal streptococci, enterococci, and *E. coli* bacteria shows the existence of pecies used to recognize the potential presence of pathogens. Preferably indicators for pathogens exist in much greater concentrations, demonstrate similar die−off and re−growth formations, and are connected with the equivalent sources (Moore et al., 1982). The first indicator used to examine pollution of drinking water by human waste was total coliform. Since exact pathogens are very complicated to collect and culture, the total coliform assembly was initially selected as an indicator because it was easy to detect, easy to culture, and typically is connected with fecal pollution from warm−blooded animals (Larsen et al., 1994). However, total coliforms include several organisms exists in non−fecal sources, making this indicator group too broad to be a steadfast indicator of fecal pathogens (Rosen, 2000).Fecal coliforms are a subgroup of total coliforms that originate specifically from the intestinal tracts of warm− blooded animals. Fecal coliforms are the predominant indicator used to assess human health hazards in streams (Rosen, 2000), but *E. coli* and enterococci are thought to have a higher degree of association with outbreaks of gastrointestinal illness (USEPA, 1986). *E. coli* is a constituent of the fecal coliform group and includes the toxin−producing O157:H7 strain. Enterococci is a subgroup of fecal streptococci that belongs to the genus *Streptococcus* and differs from fecal coliforms in that enterococci are less abundant in feces, are not known to replicate in the environment, and are more resistant to environmental stress (Maier et al., 2000). 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 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 (USEPA, 2003).

2. Governing equation

$$v\frac{\partial v_3}{\partial x} = -\rho\frac{\partial v}{\partial t} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$v_3 = XT^1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$\frac{\partial v_3}{\partial x} = X^1T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

i.e. $K\frac{\partial v_3}{\partial t} = XT^1$ $\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$ (4)

Putting the expression together so that we have

$$KX^1T = -XT^1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

i.e. $K\frac{x^1}{x} - = \rho\frac{T^1}{T}$ $\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$ (6)

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

$$X^1 + -\frac{\lambda}{K}t = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (8)$$

And $KT^1 + \lambda^2 t = 0$ $\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$ (9)

From (37), $x = ACos\frac{\lambda}{K}x + BSin\frac{\lambda}{\sqrt{K}}t$ $\ldots\ldots\ldots\ldots\ldots\ldots$ (10)

and (32) give

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

By substituting (38) and (39) into (37), we get

$$v_3 = \left(A Cos \frac{\lambda}{K} tx + B Sin \frac{\lambda}{\sqrt{K}} t \right) C \ell \frac{-\lambda^2}{\rho} t \quad \ldots\ldots\ldots\ldots\ldots \quad (12)$$

Subject equation (12) to conditions in (7), so that we have

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

The expressed Equation becomes

$$v_3 = vo \ell \frac{-\lambda^2}{\rho} t \; Cos \frac{\lambda}{K} t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (14)$$

Again, at $\left. \frac{\partial v_3}{\partial x} \right| \begin{matrix} = 0 \;\; t = \;\; 0 \\ t = 0, B \end{matrix}$ ..... (15)

Equation (14) becomes

$$\frac{\partial v_3}{\partial x} = \frac{\lambda}{K} Co \ell \frac{-\lambda}{\rho} t \; Sin \frac{\lambda}{K} t \quad \ldots\ldots\ldots\ldots\ldots \quad (16)$$

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

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

The considerations of substrate utilization is imperative, several depositions in the soil has been expressed, this condition implies that the deposition of micro elements are deposited in most region of the strata, base on these conditions it is imperative to monitor the microbes when such depositions are confirmed to deposition in some region of the soil, therefore the expressions were found suitable to consider the rates of concentration at various deposited region of the soil [Eluozo 2013]

Due to the rate of growth, which is known to be the substrate utilization of the microbes we have

$$0 = -vo \frac{\lambda}{\sqrt{K}} \; Sin \frac{\lambda}{\sqrt{K}} B \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (17)$$

$$\Rightarrow \frac{\lambda}{K} = \frac{n\pi}{2} n, 1, 2, 3 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (18)$$

$$\Rightarrow \lambda = \frac{n\pi\sqrt{V}}{2} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (19)$$

So that equation (44) becomes

$$v_3 = vo\ell \frac{-n^2\pi^2 k}{2\rho} x\, Cos\frac{n\pi}{2} t \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (20)$$

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 analyzed to determine the rate of Edwardsiella concentration between the semi unconfined bed 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 Edwardsiella 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: 2 concentration of the Edwardsiella at Different Time

Time [Per Day]	Concentration [Mg/l]
10	4.20E-03
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: 3 Comparison of theoretical and experimental values of Edwardsiella 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: 4 Comparison of theoretical and experimental values of Edwardsiella at Different Time

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: 5 concentration of the Edwardsiella 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: 6 concentration of the Edwardsiella 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: 7 Comparison of theoretical and experimental values of Edwardsiella 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: 8 Comparison of theoretical and experimental values of Edwardsiella 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**

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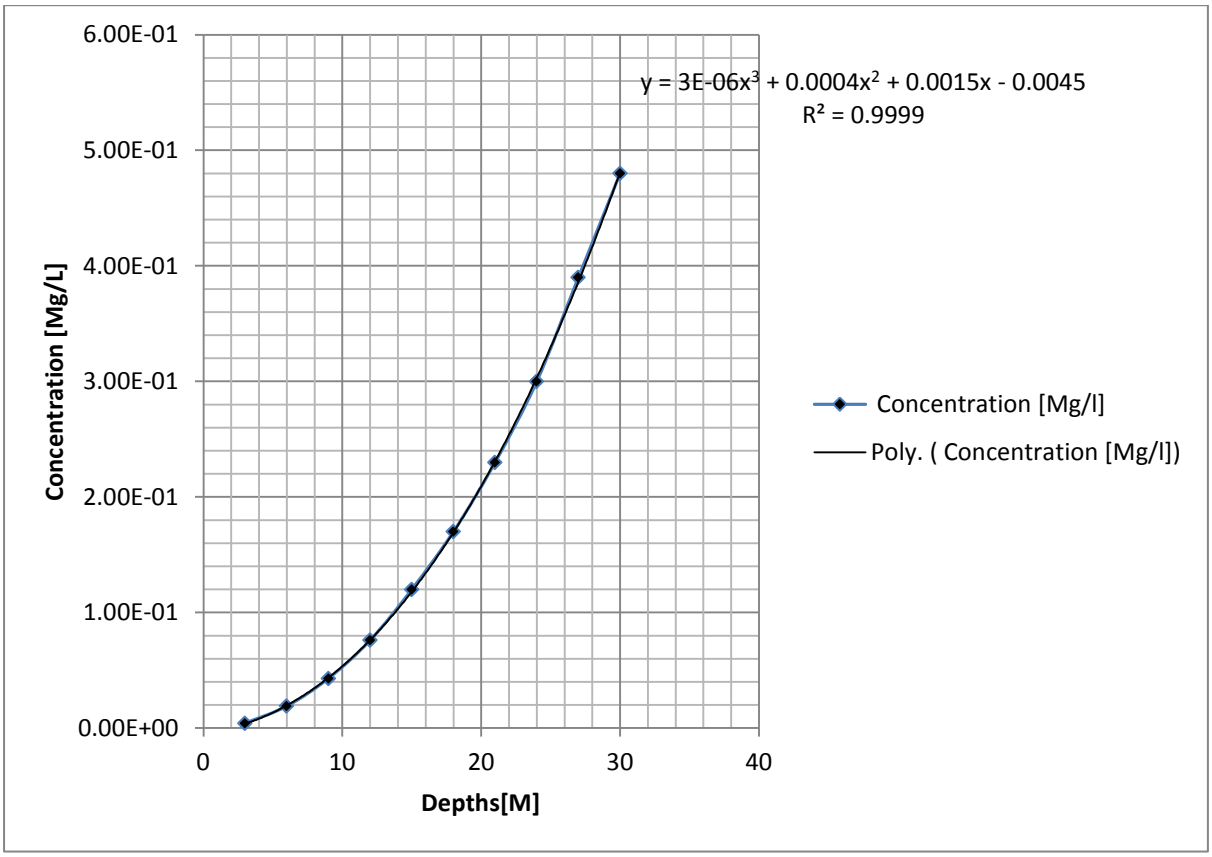

Figure: 1 concentration of the Edwardsiella at Different Time

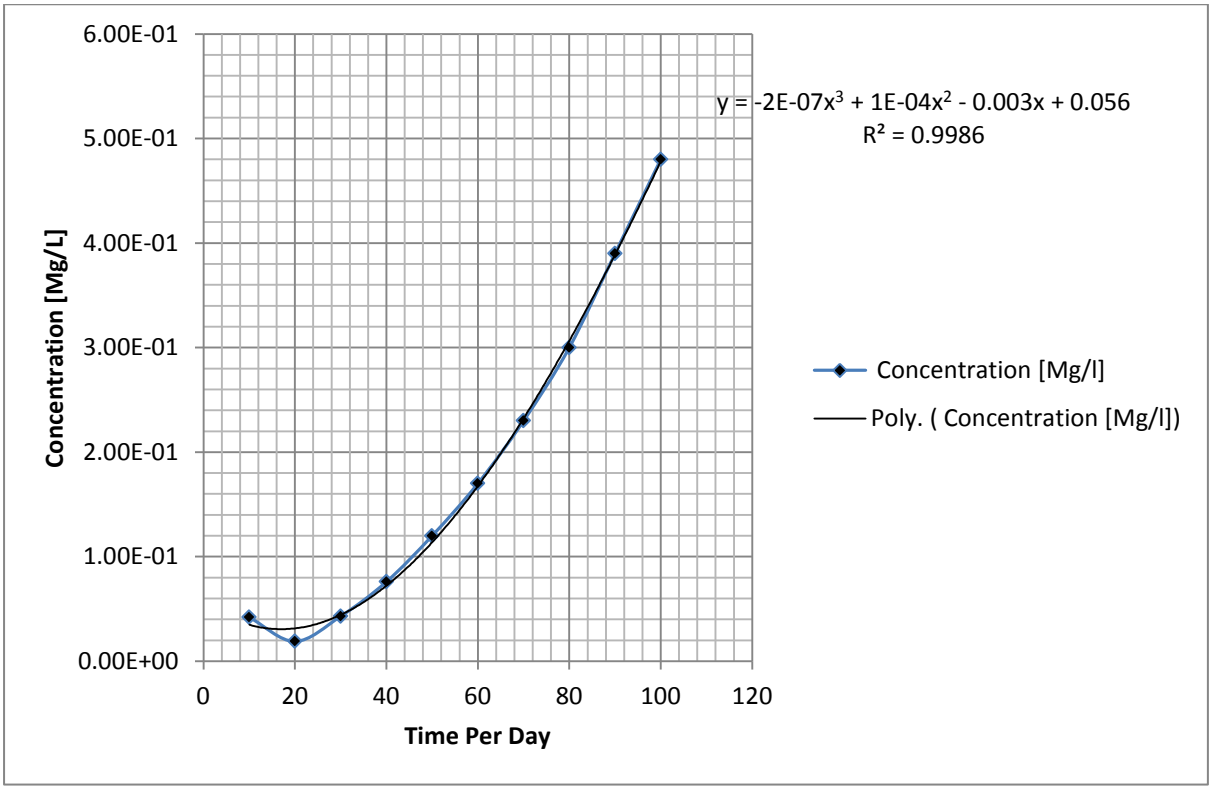

Figure: 2 concentration of the Edwardsiella at Different Time

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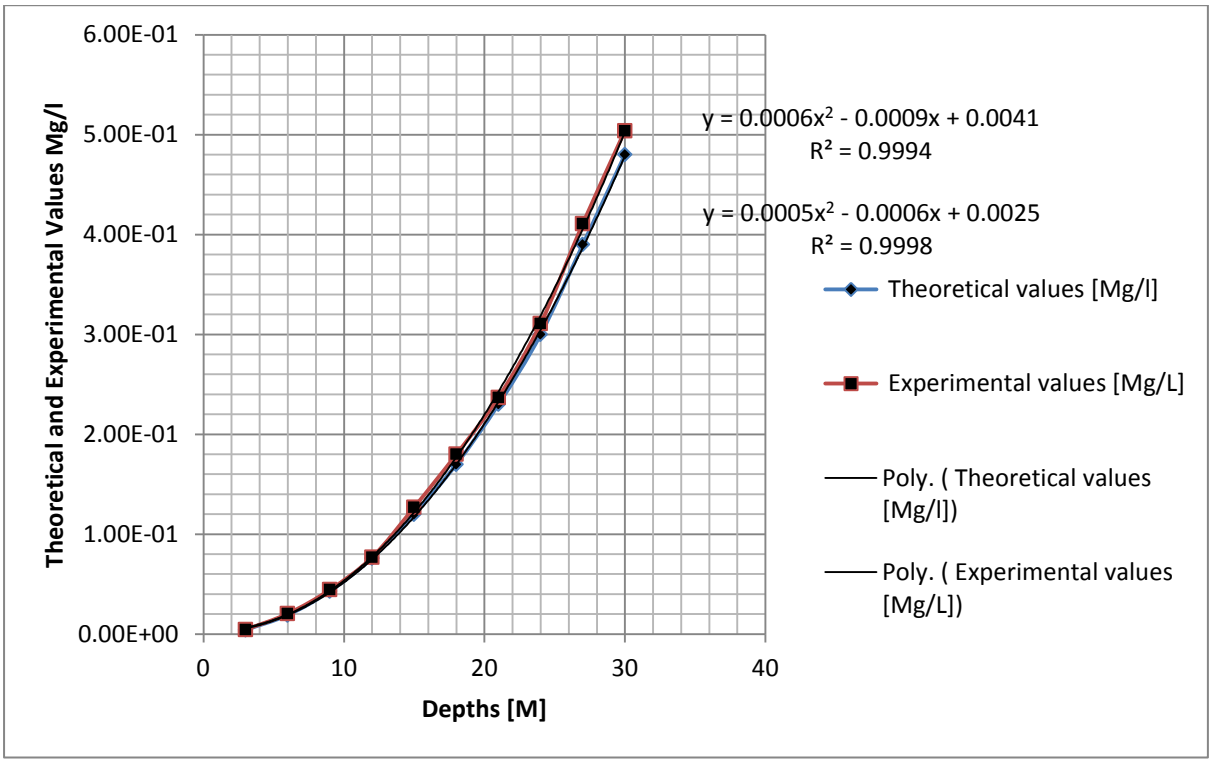

Figure 3 Comparison of theoretical and experimental values of Edwardsiella at Different Depths

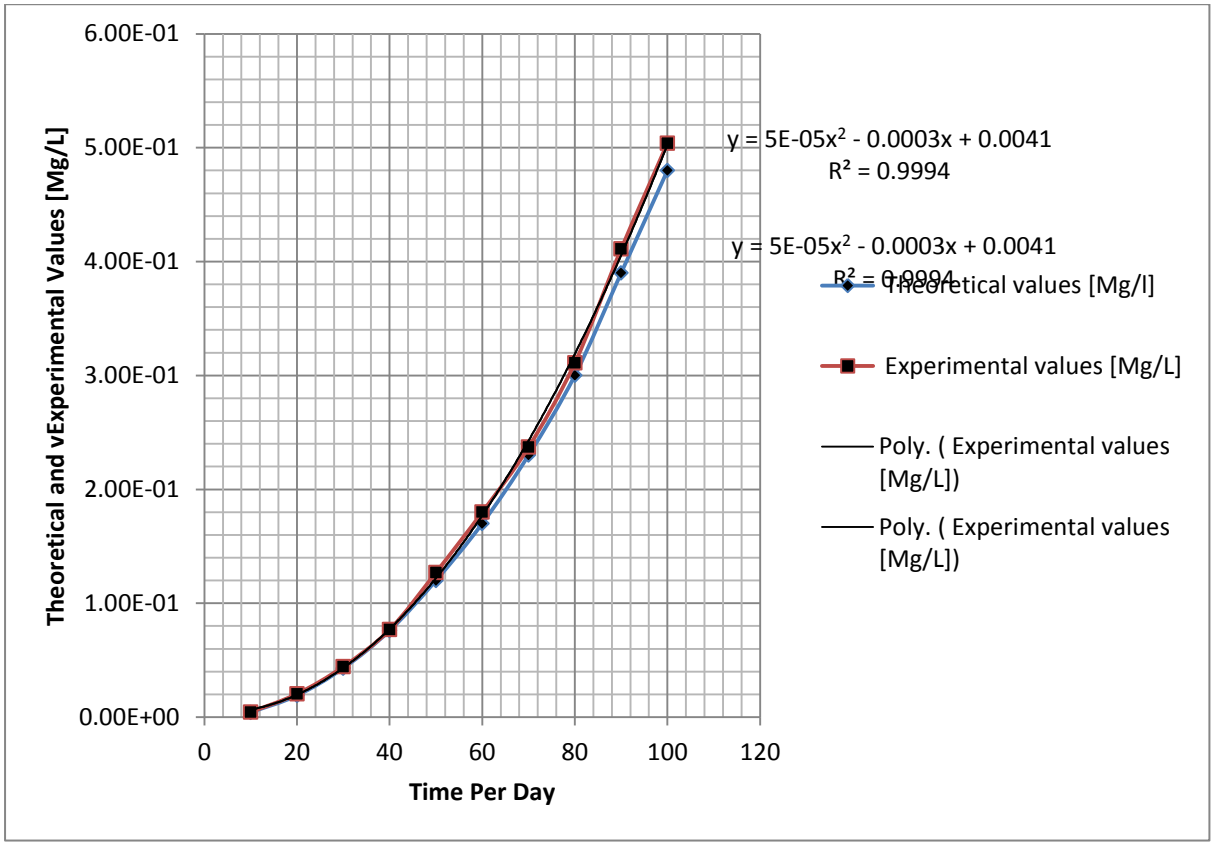

Figure: 4 Comparison of theoretical and experimental values of Edwardsiella at Different Time

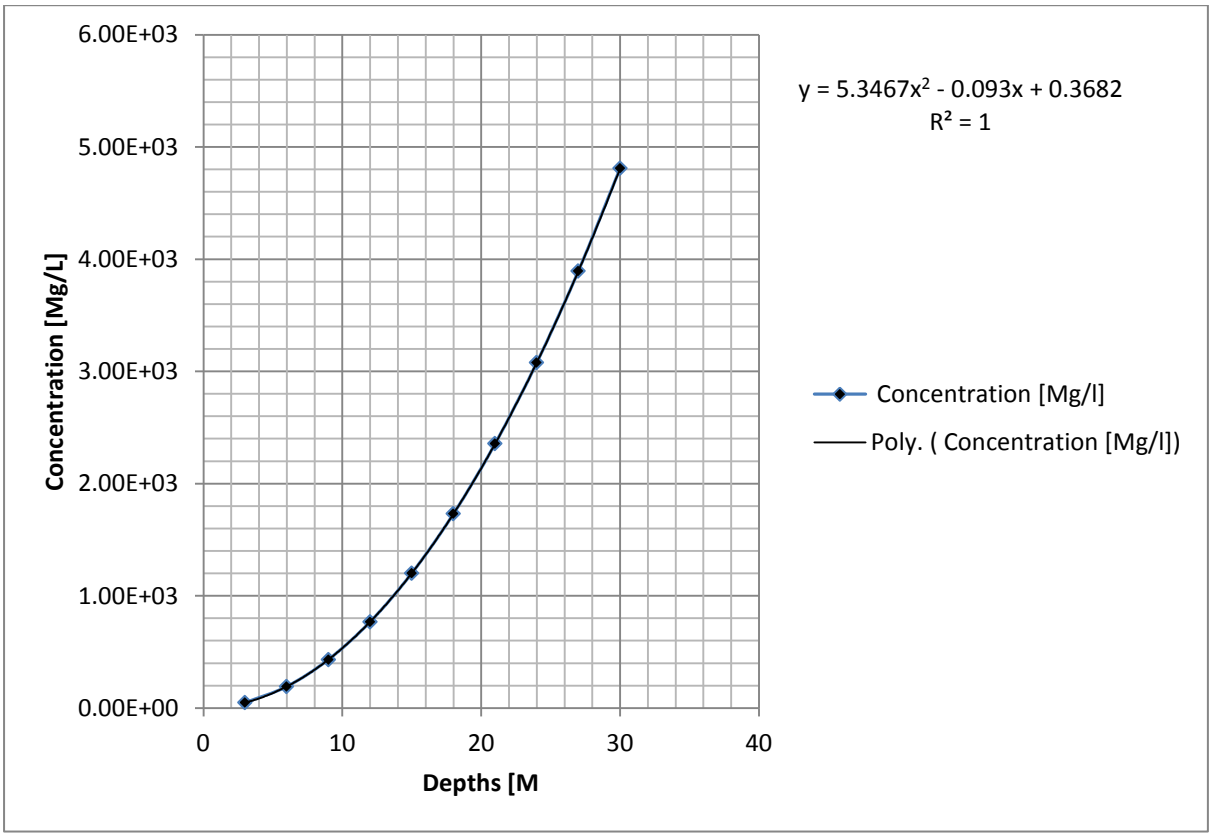

Figure: 5 concentration of the Edwardsiella at Different Depths

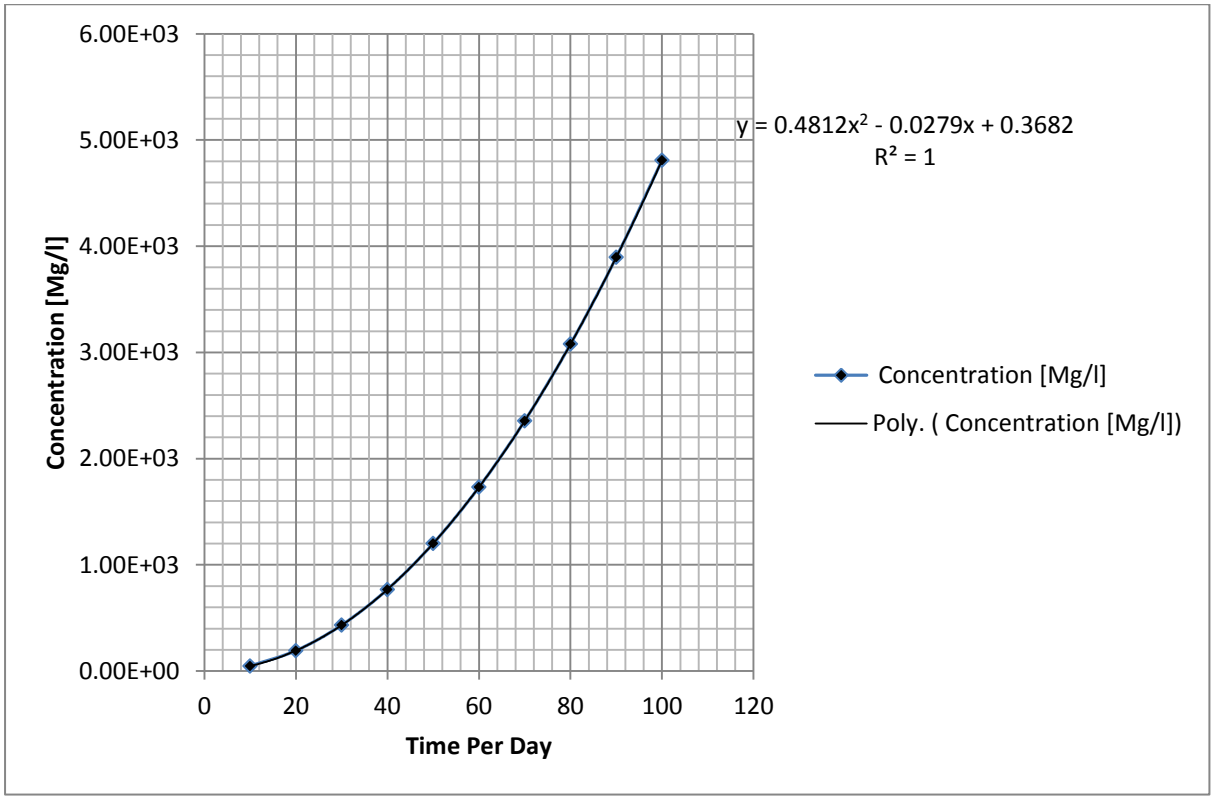

Figure: 6 concentration of the Edwardsiella at Different Time

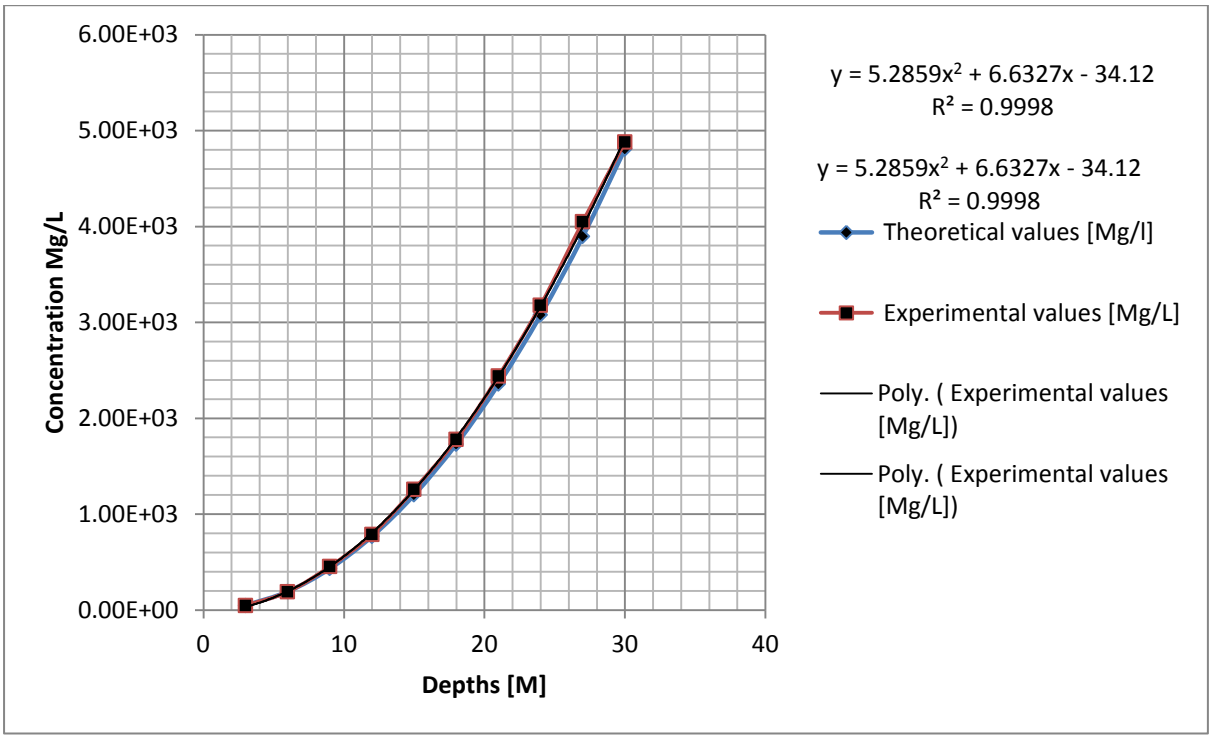

Figure: 7 Comparison of theoretical and experimental values of Edwardsiella at Different time

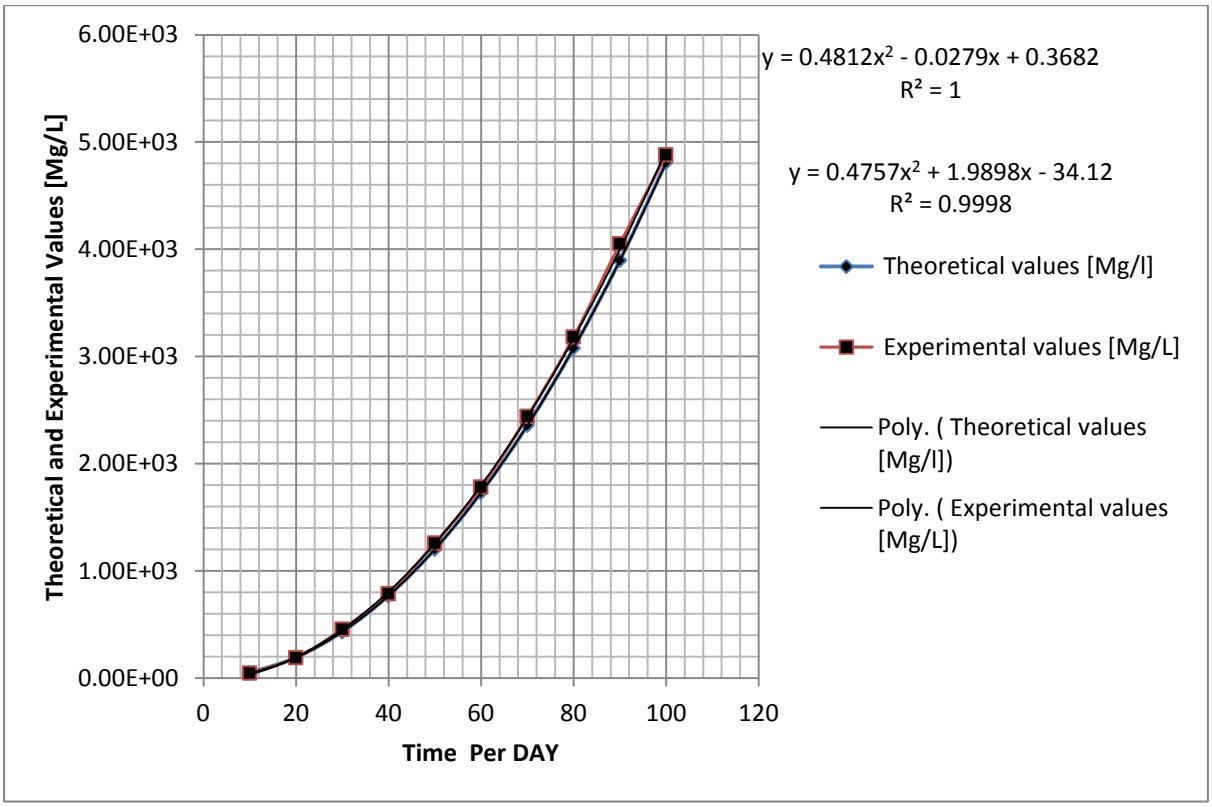

Figure: 8 Comparison of theoretical and experimental values of Edwardsiella at Different Time

Figure one to four shows that the depositions of Edwardsiella are on rapid increase under the influences of micronutrients deposition in some region of the formations, the lowest at three metres 4.44E-03 and the highest

at thirty metres of **5.04E-01**, the expression from this direction entails that high deposition of porosity from the strata may have develop increase in migration including the substrate depositions. The expression of the figures shows how the structural stratification is predominantly influenced by high degree of porosity in the system. Figures five to eight express higher concentration, this condition are base on the region where there is constant regeneration with low rate of porosity in the formation. The system at this condition implies that it may be closed to a waste dump site, these conditions implies that high rate of pollution may have cause lots of unhealthy environment; dispersion influence from high degree of porosity may have increase the concentration of the microbes. The investigation carried out found Edwardsiella predominant in the study location, although there are other contaminant found in the study area, but the predominant contaminants is Edwardsiella, they are found to rapidly regenerate faster than others in the formation, the investigation for Edwardsiella in the study area express the rate of its concentration and rates of migration in every strata of the formations. The investigation has expressed the rate of the influences on high porosity predominantly generating dispersion in the entire area. Mathematical modeling approach were found suitable for the study, this concept were imperative to apply since risk evaluation could not produces better results that prevent the deposition and migration of the contaminant in soil and water environments. The study formulated system that generated governing equation, the principal equation were derived to produces the developed model, the derived model solution were simulate to express the behaviour of the system that produced the model, the generated theoretical values were compared with experimental results and both parameter developed a faviourable fits expressing validation of the model.

5. Conclusion

The study of Edwardsiella deposition and migration has express different rate of contaminant behaviour influenced by high degree of porosity in the study area, since it remain the most predominant parameters that has generated dispersion of Edwardsiella in the study area, it means that such formation characteristics has a serious influences on the transport system of Edwardsiella, such condition were acknowledged in the formation of the system that generated the derived governing equation, the expressed model were simulated to produced theoretical values, this values expressed different rates of migration in the study area, such condition show various porosity influences on the deposition and migration of Edwardsiella in the study environment , comparison of both parameters developing faviourable fits, it implies that the developed model has been validated, the study is imperative because experts will applied this method in monitoring and evaluation of the Edwardsiella in soil and water environment.

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