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Research article

MODELING AND SIMULATION OF NICKEL DEPOSITION IN HOMOGENEOUS FINE SAND IN BORIKIRI DISTRICT OF PORT HARCOURT, NIGER DELTA OF NIGERIA

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Abstract

Nickel deposition in soil and water environment has cause lots of unhealthy environments in the study area; this study call for serious concern as the substances has generated soil pollution thus further in migration to aquiferous zone. Such condition were investigated and it was discovered that permeability were the predominant formation characteristics that pressure fast migration of the substance at shallow depths within a short period of time. To prevent this hazard in the environment, mathematical modeling techniques were found appropriate for the study, the model were developed through the formulated system, the developed model were simulated and it produced theoretical values, experimental results were compared with the theoretical values, both parameters compare faviourably well, this condition express the validation of the model in the study location .

Keywords: modeling and simulation, nickel Deposition and homogeneous find sand

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,Eluozo,2013). 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 1.4 103 *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 species 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, Eluozo,2013). 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* account for over

monocytogenes, *Escherichia coli* O157:H7, *Cryptosporidium parvum* and *Giardia lamblia*, which 90% of food and waterborne diseases in humans (USEPA, 2003, Eluozo,2013).

2. Governing equation

$$V\frac{\partial q_2}{\partial t} = -V\frac{\partial q^2}{\partial x} \quad \ldots\ldots\ldots\ldots \quad (1)$$

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

$$q_2 = XT \quad \ldots\ldots\ldots\ldots \quad (2)$$

i.e. $$V\frac{\partial q_2}{\partial t} = XT^1 \quad \ldots\ldots\ldots\ldots \quad (3)$$

$$V\frac{\partial q_2}{\partial x} = X^1T \quad \ldots\ldots\ldots\ldots \quad (4)$$

Put (2) and (3) into (2), so that we have

$$VXT^1 = -VX^1T \quad \ldots\ldots\ldots\ldots \quad (5)$$

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

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

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

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

From (8), $$X = ACos\frac{\lambda}{R}X + BSin\frac{\lambda}{\sqrt{R}}X \quad \ldots\ldots\ldots\ldots \quad (10)$$

And (3) gives

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

And (3) gives

$$C_2 = \left(ACos\frac{\lambda}{V}t + BSin\frac{\lambda}{\sqrt{V}}t\right)C\ell^{\frac{-\lambda^2}{V}x} \quad \ldots\ldots\ldots\ldots \quad (12)$$

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

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

Equation (13) becomes

$$q_2 = q_o \ell^{\frac{-\lambda^2}{V}x} \; Cos\frac{\lambda}{\sqrt{V}}t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (14)$$

Again, at

$$\left.\frac{\partial q_2}{\partial t}\right| \begin{matrix} = 0, \; x = 0 \\ t = 0, \; B \end{matrix}$$

Equation (14) becomes

$$\frac{\partial q_2}{\partial t} = \frac{\lambda}{\sqrt{V}} q_o \ell^{\frac{-\lambda}{V}x} \; Sin\frac{\lambda}{\sqrt{V}}t \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (15)$$

i.e. $0 = -\frac{qo\lambda}{\sqrt{V}} \; Sin\frac{\lambda}{V}0$

$Co\frac{\lambda}{V} \neq 0$ Considering NKP

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

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

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

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

So that equation (14) becomes

$$\Rightarrow q_2 = qo\ell^{\frac{-n^2\pi^2 v}{2}t} \; Cos\frac{n\pi\sqrt{V}}{2\sqrt{V}}x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (19)$$

$$\Rightarrow q_2 = qo\ell^{\frac{-n^2\pi^2 V}{2}t} \; Cos\frac{n\pi}{2}x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (20)$$

3. Results and Discussion

Results and discussion from the expressed figures through the theoretical generated values are presented in tables and figures, the expression explain the rate of concentration through graphical representation for every condition assessed in the developed model equations.

Table 1: Concentration of Nickel at Different Depths

Depths [M]	Concentration[Mg/L]
1	688
2	275.38
3	619.62
4	1101.56
5	1721.18
6	2478.5
7	3373.52
8	4406.23
9	5576.64
10	6884.7

Table 2: Concentration of Nickel at Different Time

Time [Per Day]	Concentration[Mg/L]
10	688
20	275.38
30	619.62
40	1101.56
50	1721.18
60	2478.5
70	3373.52
80	4406.23
90	5576.64
100	6884.7

Table 3: Comparison of Theoretical and Experimental Values of Nickel concentration at Different Depths

Depths [M]	Theoretical values [Mg/l]	Experimental values [Mg/L]
1	688	691
2	275.38	285.43
3	619.62	629.44
4	1101.56	1106.74
5	1721.18	1743.23

6	2478.5	2488.5
7	3373.52	3381.44
8	4406.23	4416.44
9	5576.64	5588.45
10	6884.7	6894.5

Table 4: Comparison of Theoretical and Experimental Values of Nickel concentration at Different Time

Time [Per Day]	Theoretical values [Mg/l]	Experimental values [Mg/L]
10	688	691
20	275.38	285.43
30	619.62	629.44
40	1101.56	1106.74
50	1721.18	1743.23
60	2478.5	2488.5
70	3373.52	3381.44
80	4406.23	4416.44
90	5576.64	5588.45
100	6884.7	6894.5

Table 5: Concentration of Nickel at Different Depths

Depths [M]	Concentration[Mg/L]
2	27.53
4	110.1
6	247.85
8	440.62
10	688.47
12	991.4
14	1349.4
16	1762.49
18	2230.65
20	2753.75

Table 6: Concentration of Nickel at Different Time

Time [Per Day]	Concentration[Mg/L]
2	27.53
4	110.1
6	247.85
8	440.62

10	**688.47**
12	**991.4**
14	**1349.4**
16	**1762.49**
18	**2230.65**
20	**2753.75**

Table 7: Comparison of Theoretical and Experimental Values of Nickel concentration at Different Depths

Depth [M]	Theoretical values [Mg/l]	Experimental values [Mg/L]
2	**27.53**	**29.44**
4	**110.1**	**114.21**
6	**247.85**	**255.44**
8	**440.62**	**467.45**
10	**688.47**	**666.22**
12	**991.4**	**956.45**
14	**1349.4**	**1356.3**
16	**1762.49**	**1865.45**
18	**2230.65**	**2311.23**
20	**2753.75**	**2789.45**

Table 8: Comparison of Theoretical and Experimental Values of Nickel concentration at Different Time

Time [M]	Theoretical values [Mg/l]	Experimental values [Mg/L]
2	**27.53**	**29.44**
4	**110.1**	**114.21**
6	**247.85**	**255.44**
8	**440.62**	**467.45**
10	**688.47**	**666.22**
12	**991.4**	**956.45**
14	**1349.4**	**1356.3**
16	**1762.49**	**1865.45**
18	**2230.65**	**2311.23**
20	**2753.75**	**2789.45**

Table 9: Concentration of Nickel at Different Depths

Depths [M]	Concentration[Mg/L]
1	**0.49**
2	**0.99**
3	**1.49**
4	**1.99**

5	**2.49**
6	**2.99**
7	**3.49**
8	**3.99**
9	**4.99**
10	**5.01**

Table 10: Concentration of Nickel at Different Time

Time [Per Day]	Concentration[Mg/L]
10	**0.49**
20	**0.99**
30	**1.49**
40	**1.99**
50	**2.49**
60	**2.99**
70	**3.49**
80	**3.99**
90	**4.99**
100	**5.01**

Table 11: Comparison of Theoretical and Experimental Values of Nickel concentration at Different Depths

Depth [M]	**Theoretical values [**Mg/l]	**Experimental values** [Mg/L]
2	**0.49**	**0.51**
4	**0.99**	**1.02**
6	**1.49**	**1.45**
8	**1.99**	**2.11**
10	**2.49**	**2.55**
12	**2.99**	**3.11**
14	**3.49**	**3.67**
16	**3.99**	**4.11**
18	**4.99**	**5.14**
20	**5.01**	**4.99**

Table 12: Comparison of Theoretical and Experimental Values of Nickel concentration at Different Time

Time [Per Day]	**Theoretical values [**Mg/l]	**Experimental values** [Mg/L]
10	**0.49**	**0.51**
20	**0.99**	**1.02**
30	**1.49**	**1.45**

40	**1.99**	**2.11**
50	**2.49**	**2.55**
60	**2.99**	**3.11**
70	**3.49**	**3.67**
80	**3.99**	**4.11**
90	**4.99**	**5.14**
100	**5.01**	**4.99**

Table 13: Concentration of Nickel at Different Time

Depths [M]	Concentration[Mg/L]
3	**1.49**
6	**2.99**
9	**4.99**
12	**5.99**
15	**7.99**
18	**8.99**
21	**10.49**
24	**11.99**
27	**13.49**
30	**14.99**

Table 14: Concentration of Nickel at Different Time

Time [Per Day]	Concentration[Mg/L]
10	**1.49**
20	**2.99**
30	**4.99**
40	**5.99**
50	**7.99**
60	**8.99**
70	**10.49**
80	**11.99**
90	**13.49**
100	**14.99**

Table 15: Comparison of Theoretical and Experimental Values of Nickel concentration at Different Depths

Depths [M]	Theoretical values [Mg/l]	Experimental values [Mg/L]
3	**1.49**	**1.44**
6	**2.99**	**2.88**
9	**4.99**	**4.88**

12	**5.99**	**6.11**
15	**7.99**	**8.14**
18	**8.99**	**8.77**
21	**10.49**	**10.66**
24	**11.99**	**12.11**
27	**13.49**	**13.55**
30	**14.99**	**15.11**

Table 16: Comparison of Theoretical and Experimental Values of Nickel concentration at Different Time

Time [Per Day]	Theoretical values [Mg/l]	Experimental values [Mg/L]
10	**1.49**	**1.44**
20	**2.99**	**2.88**
30	**4.99**	**4.88**
40	**5.99**	**6.11**
50	**7.99**	**8.14**
60	**8.99**	**8.77**
70	**10.49**	**10.66**
80	**11.99**	**12.11**
90	**13.49**	**13.55**
100	**14.99**	**15.11**

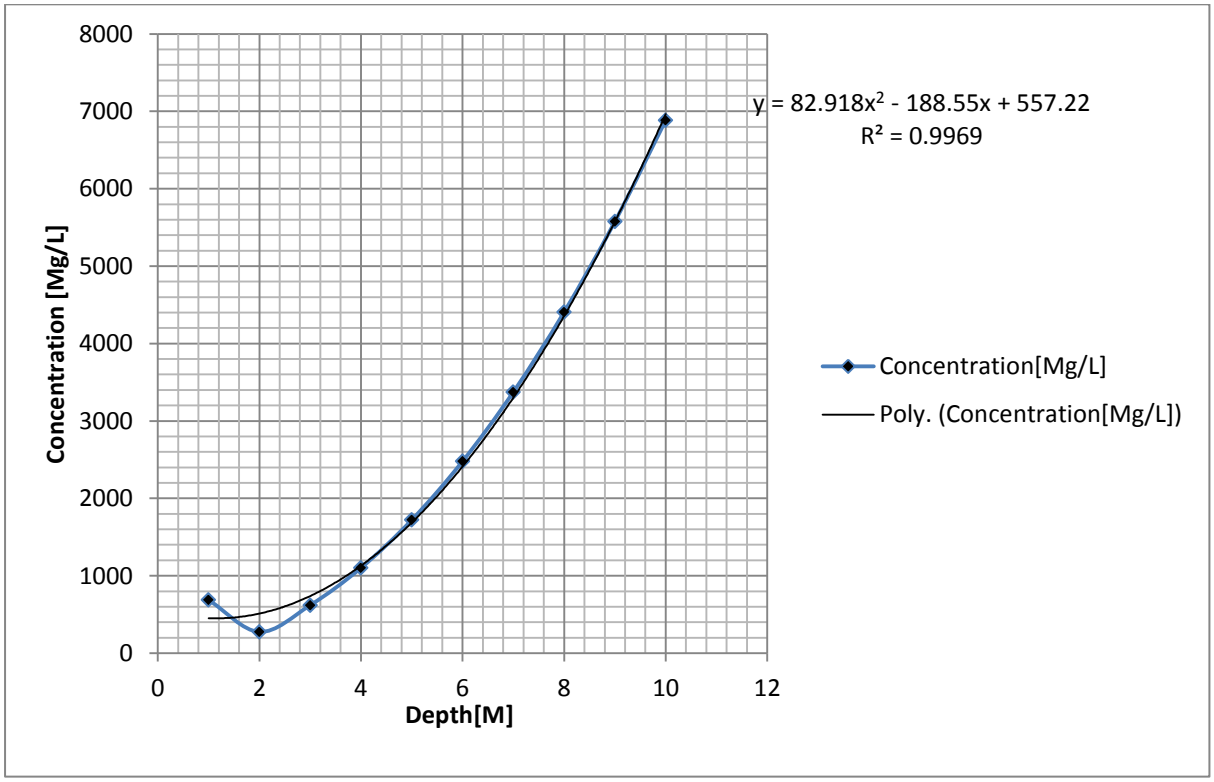

Figure 1: Concentration of Nickel at Different Depths

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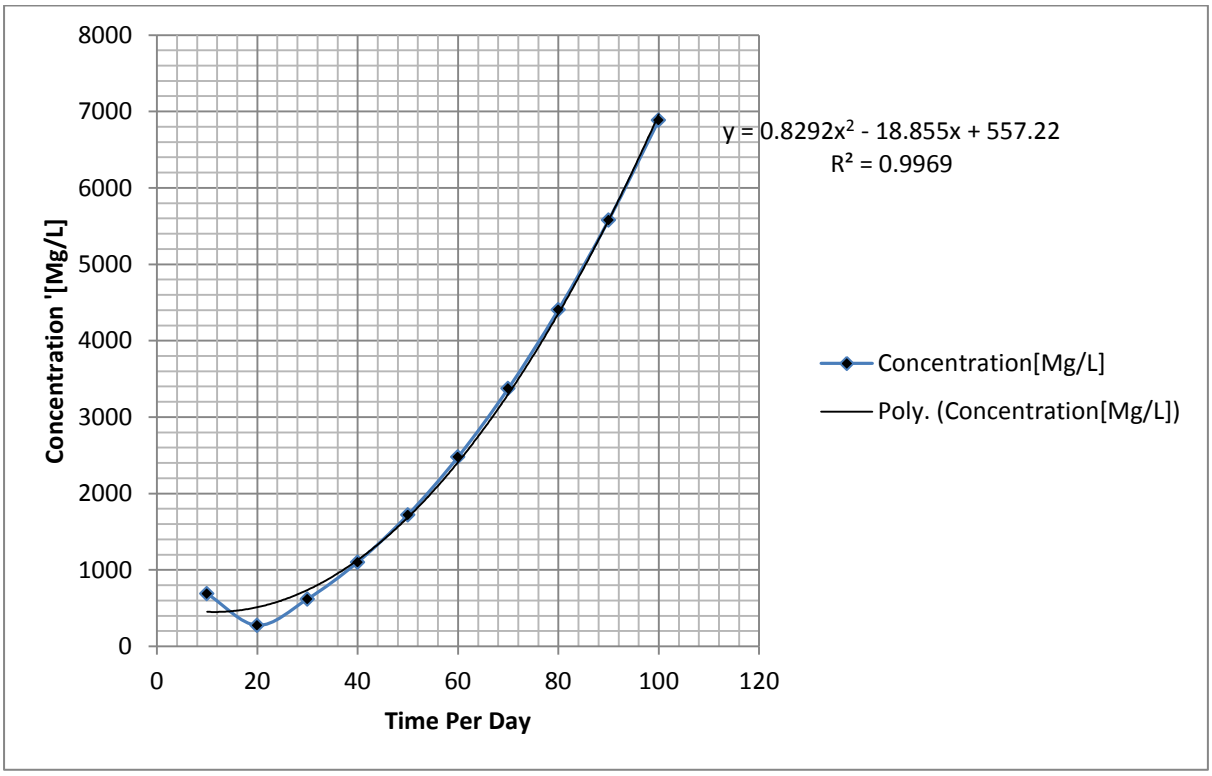

Figure 2: Concentration of Nickel at Different Time

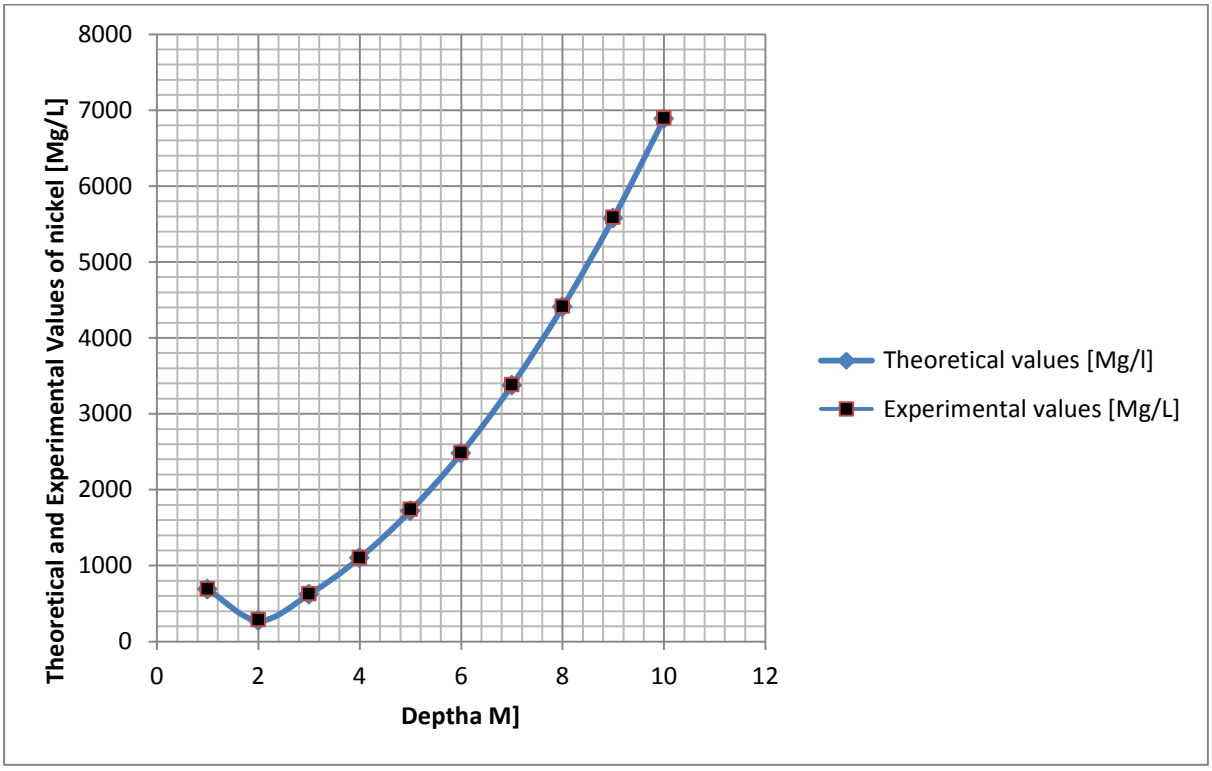

Figure3: Comparison of Theoretical and Experimental Values of Nickel concentration at Different Depths

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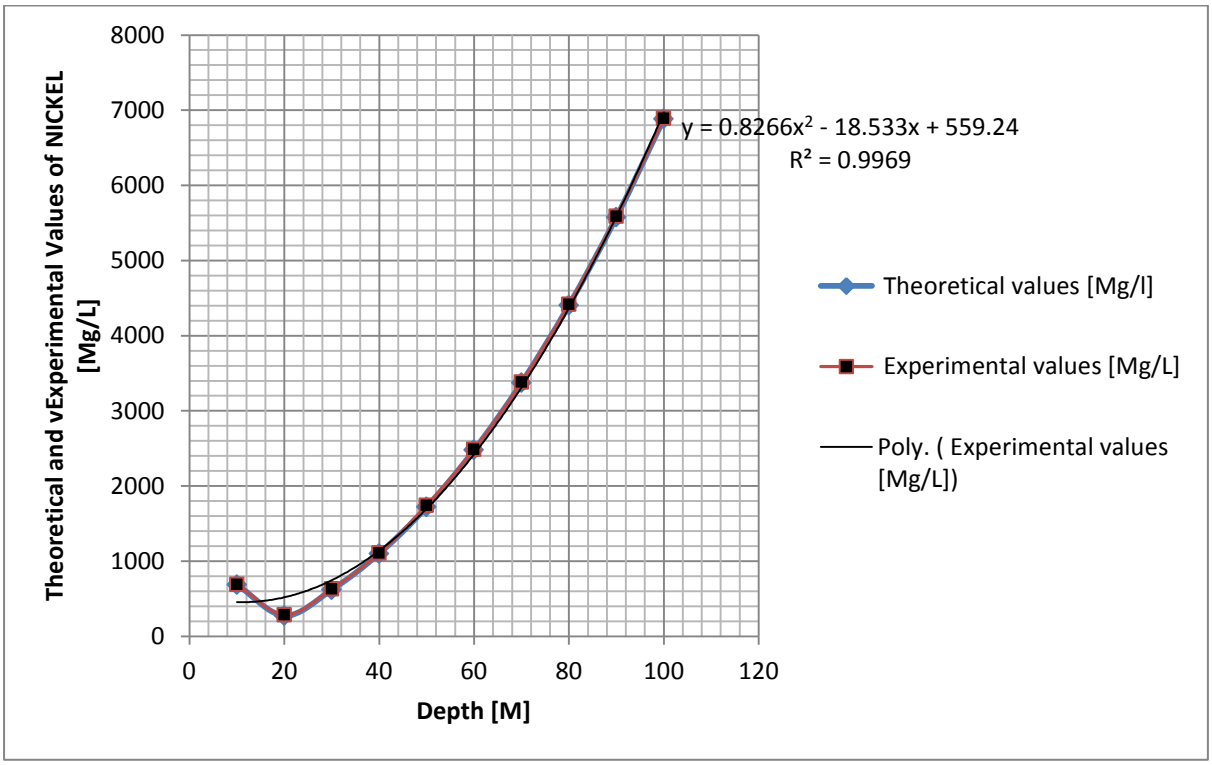

Figure4: Comparison of Theoretical and Experimental Values of Nickel concentration at Different Time

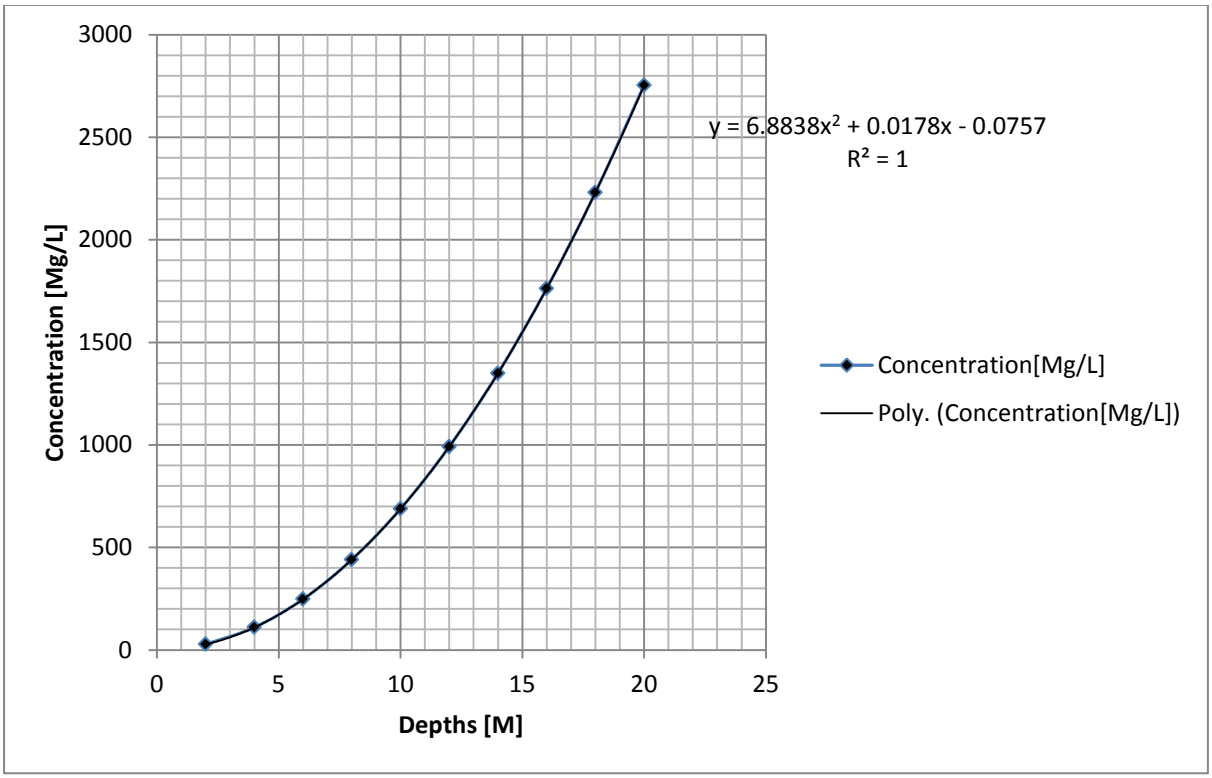

Figure 5: Concentration of Nickel at Different Depths

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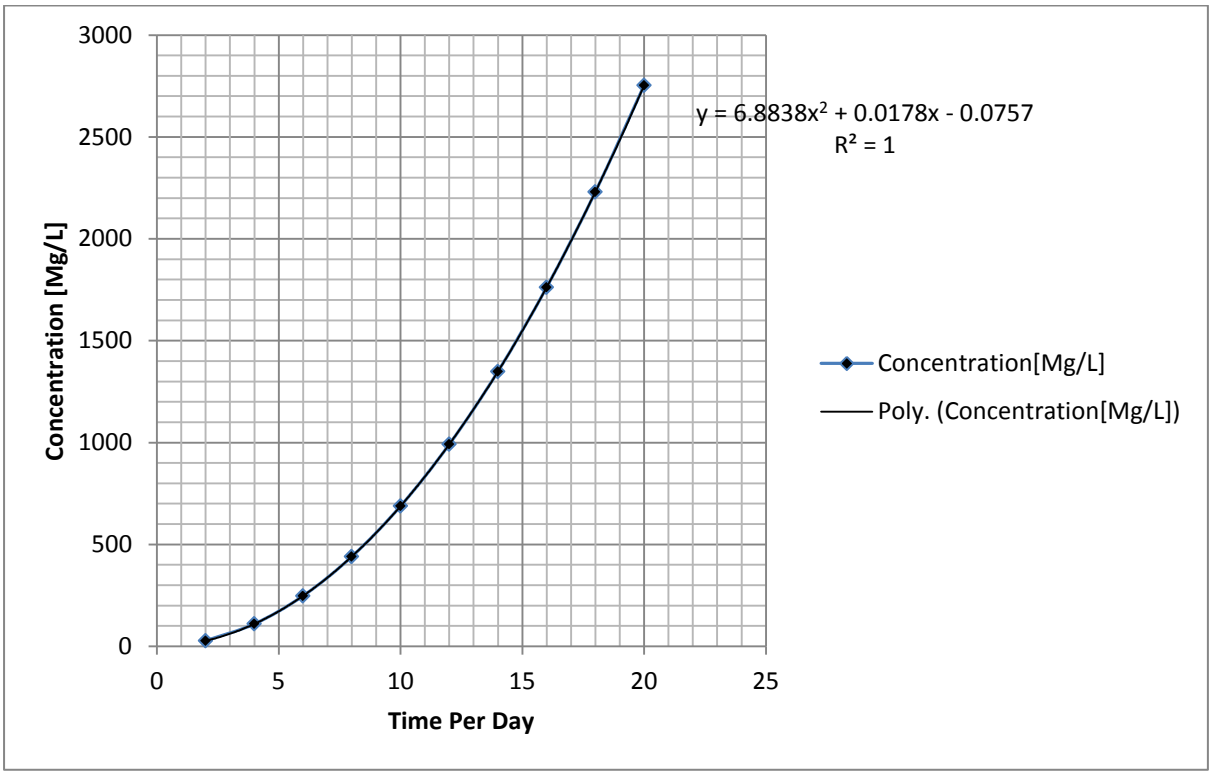

Figure 6: Concentration of Nickel at Different Time

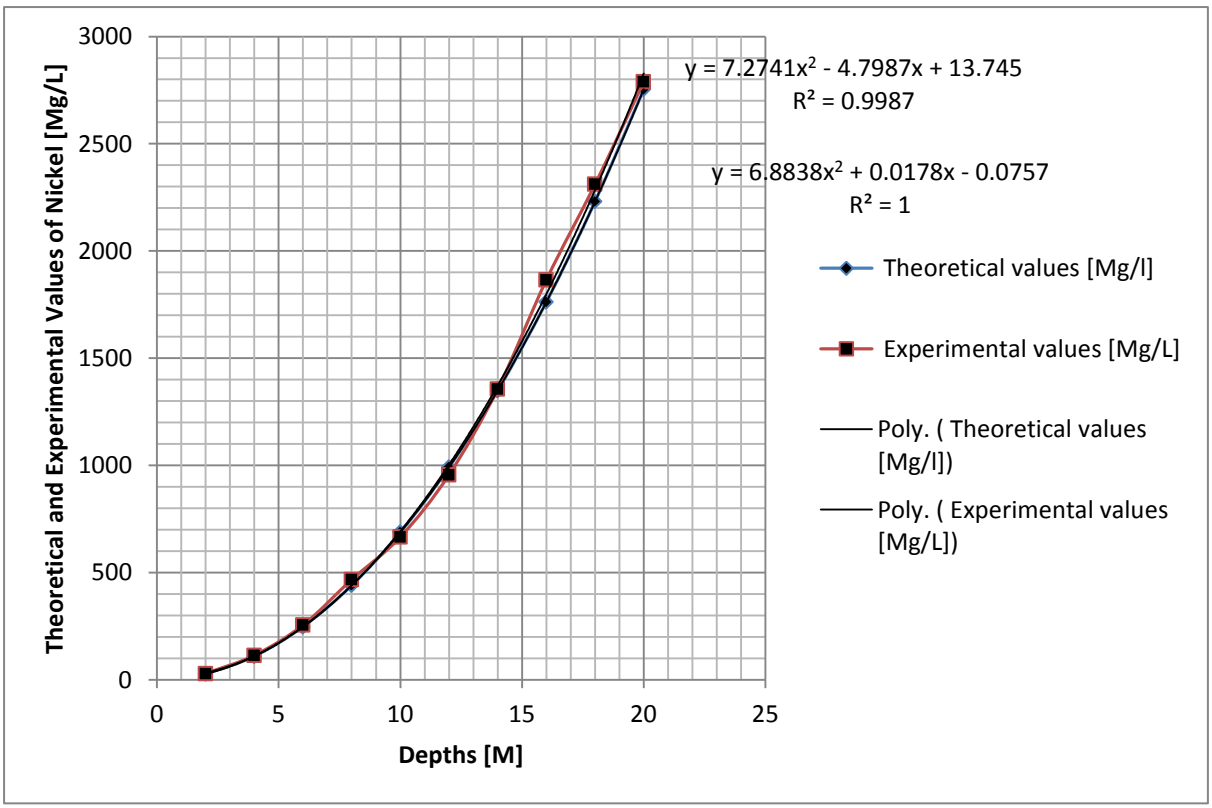

Figure7: Comparison of Theoretical and Experimental Values of Nickel concentration at Different Depths

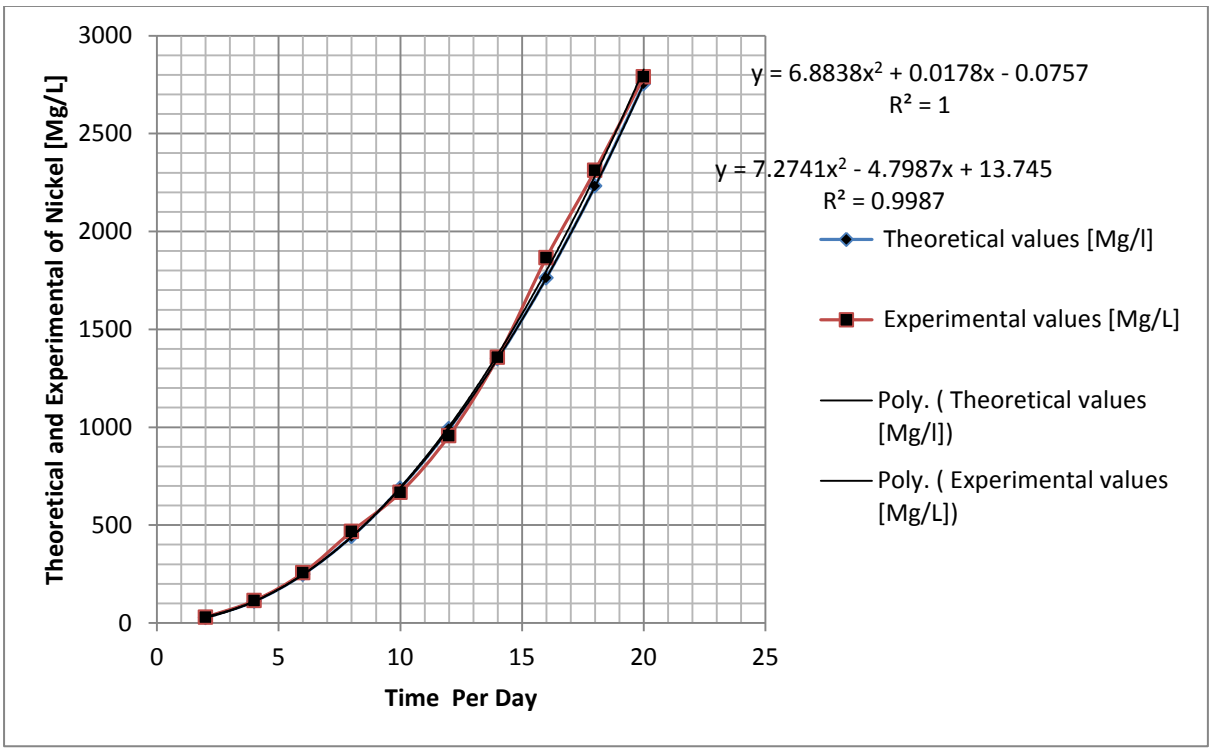

Figure8: Comparison of Theoretical and Experimental Values of Nickel concentration at Different Time

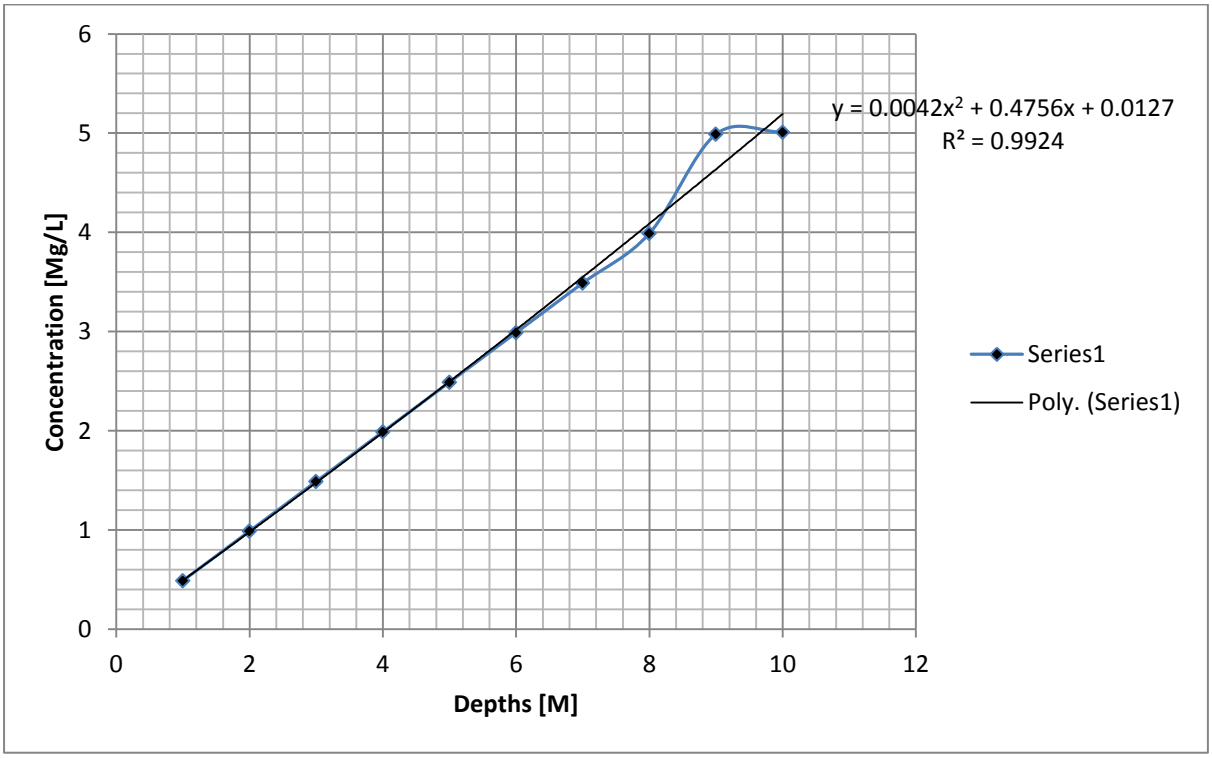

Figure 9: Concentration of Nickel at Different Depths

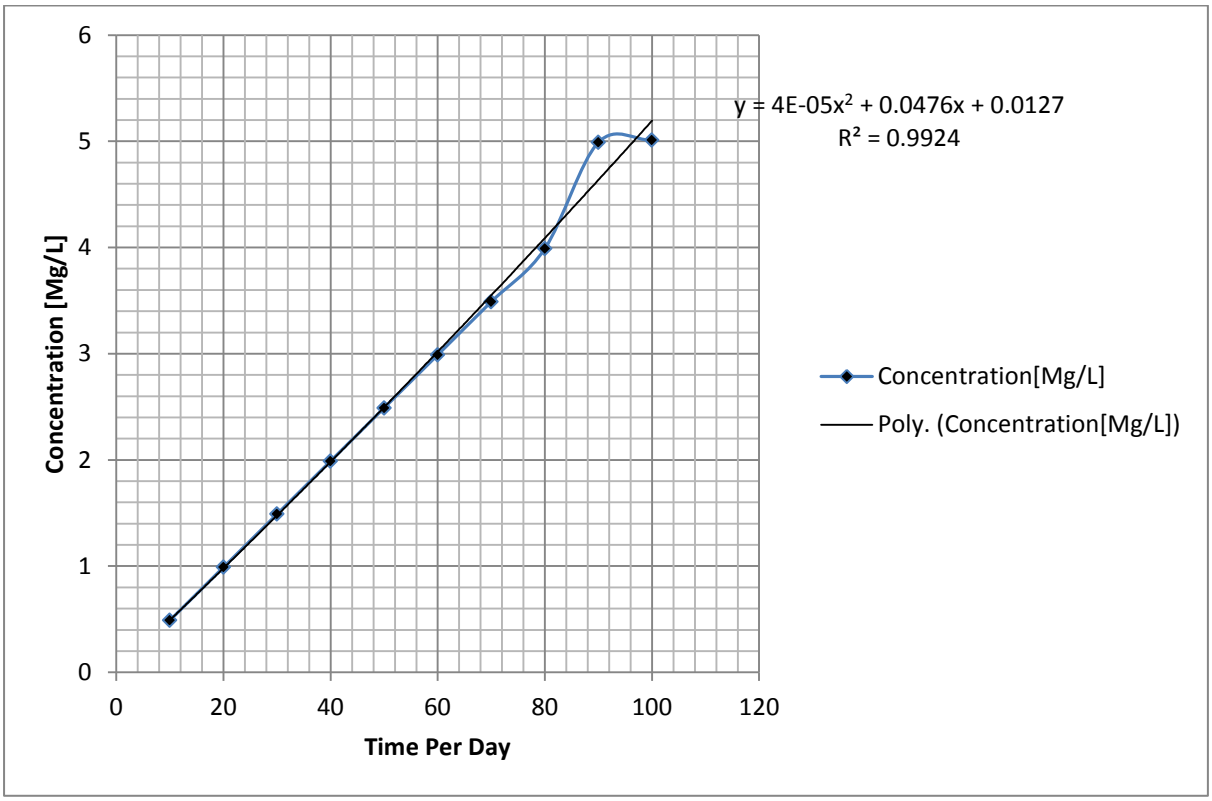

Figure 10: Concentration of Nickel at Different Time

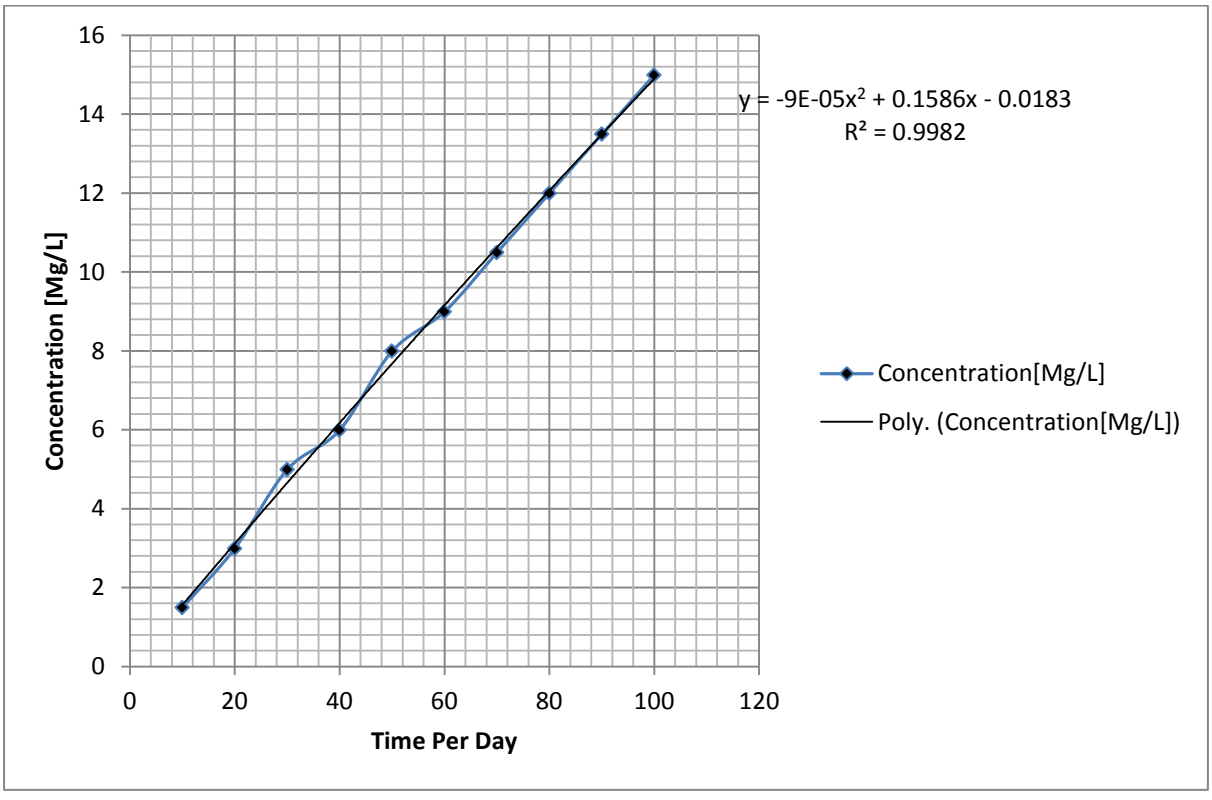

Figure 11: Concentration of Nickel at Different Time

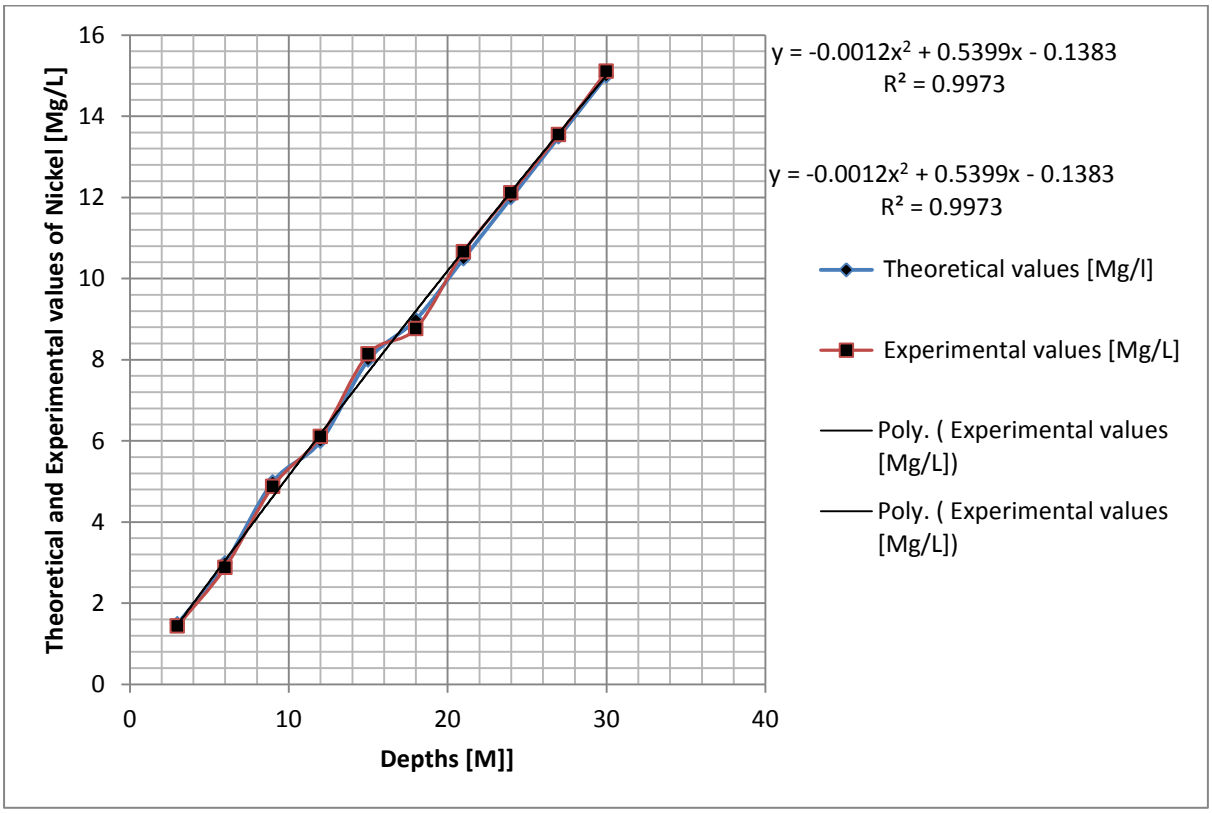

Figure12: Comparison of Theoretical and Experimental Values of Nickel concentration at Different Depths

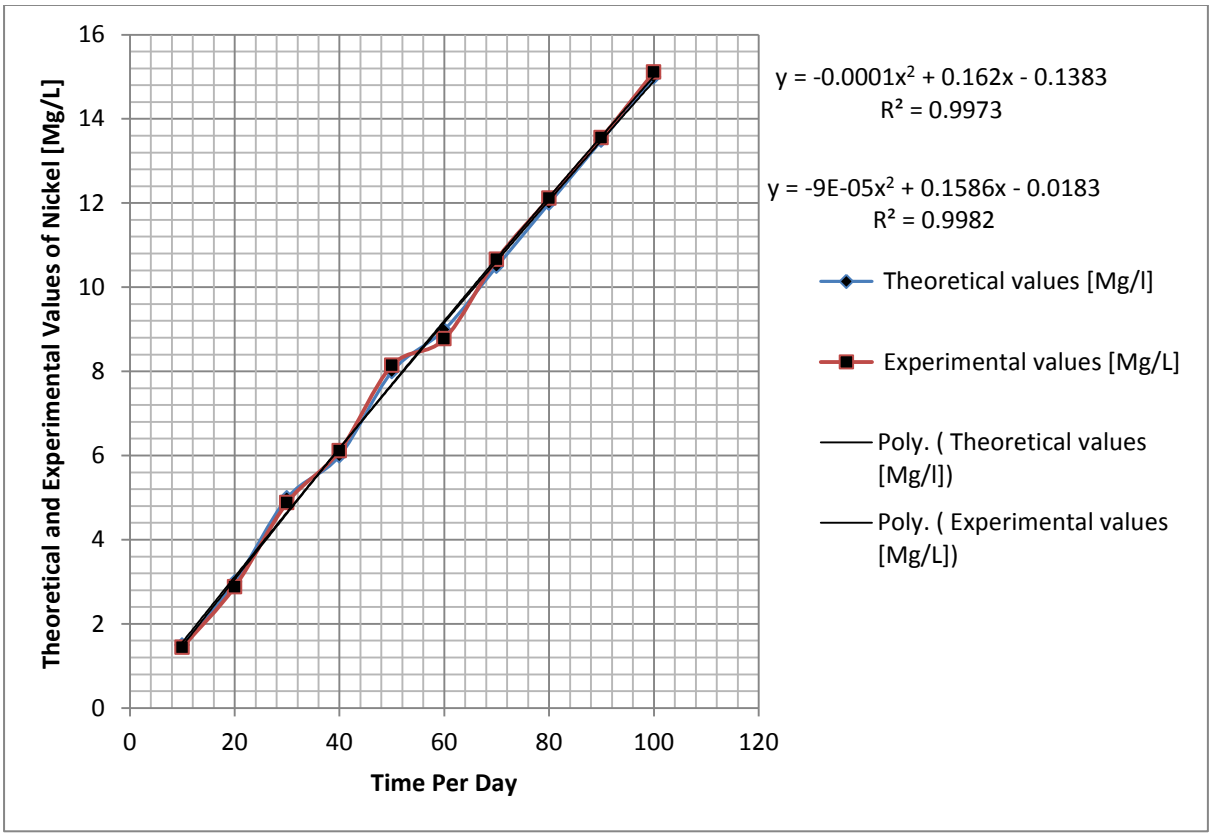

Figure13: Comparison of Theoretical and Experimental Values of Nickel concentration at Different Time

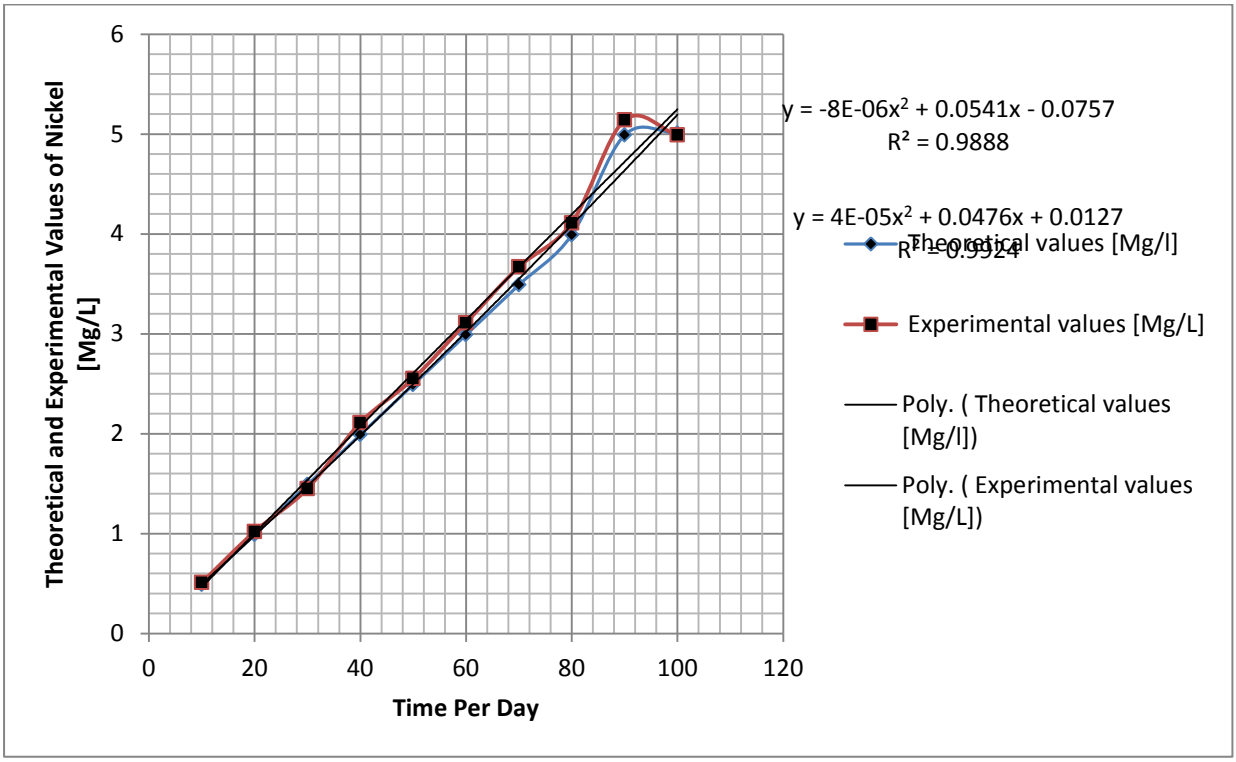

Figure14: Comparison of Theoretical and Experimental Values of Nickel concentration at Different Time

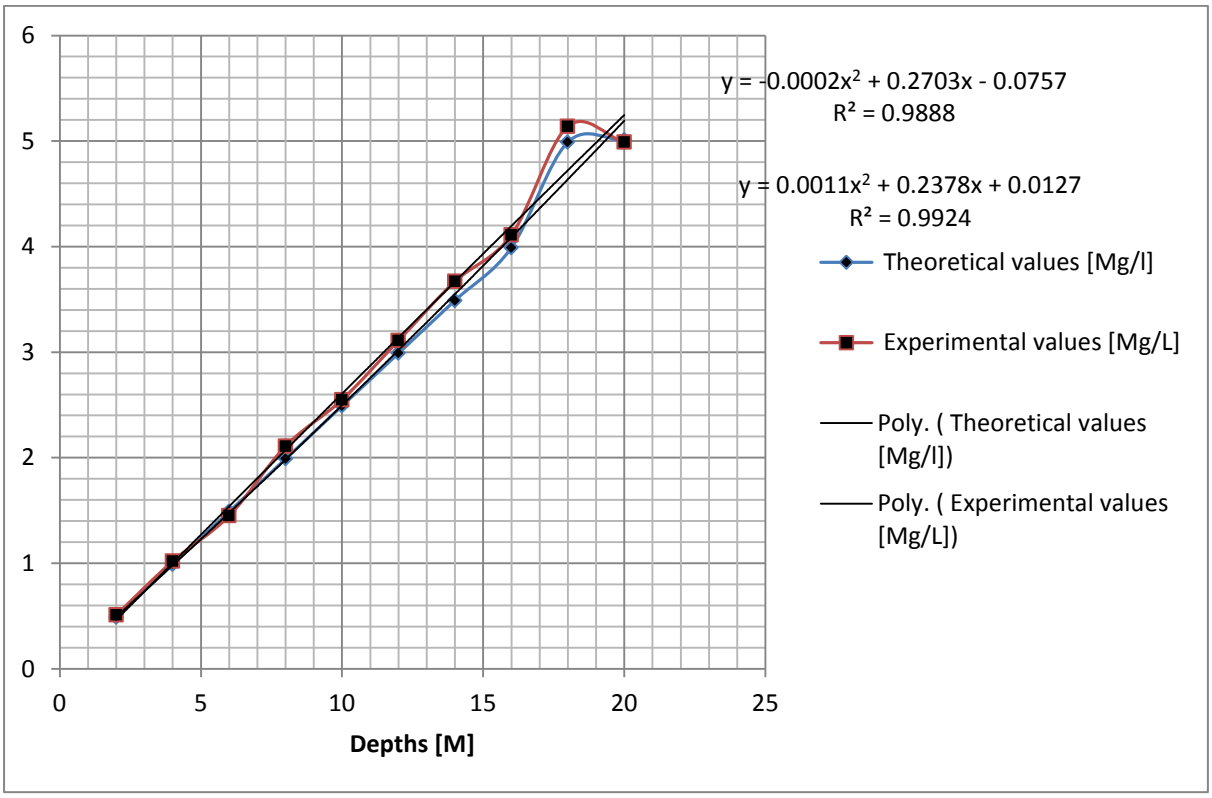

Figure15: Comparison of Theoretical and Experimental Values of Nickel concentration at Different Time

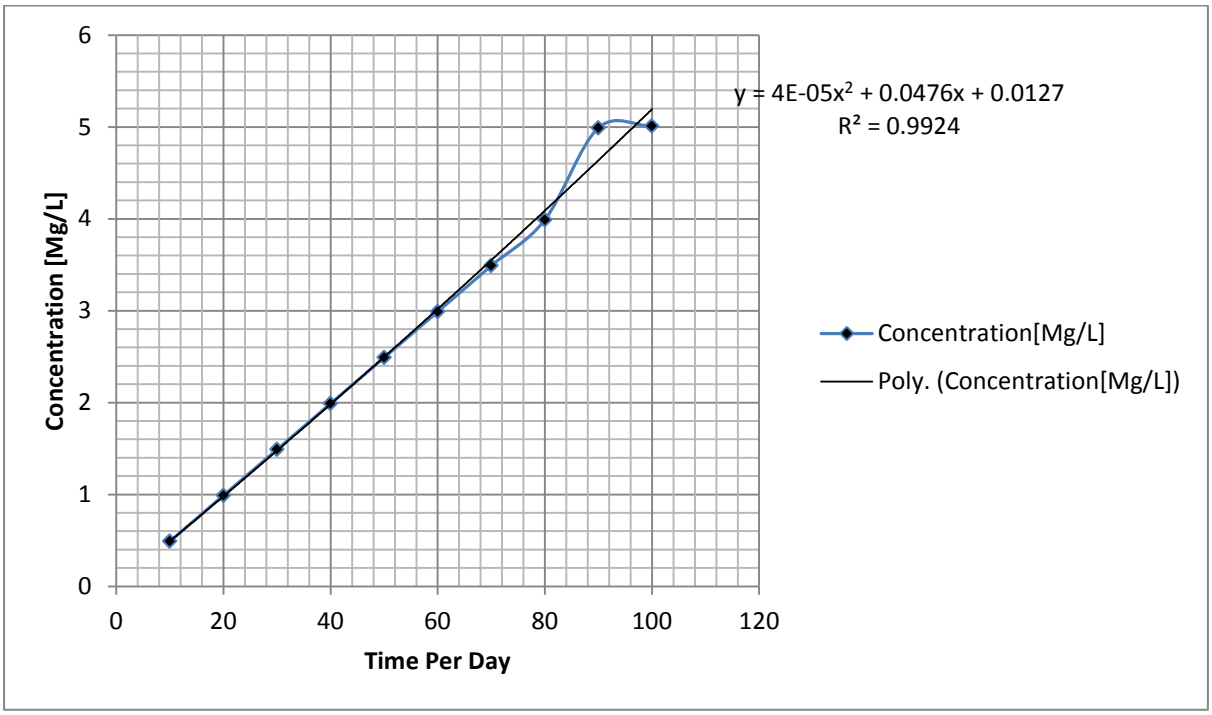

Figure 16: Concentration of Nickel at Different Time

The figures presented shows that all the concentrations deposited in exponential phase, the concentration are influenced by high degree of permeability in the study area, the study area were investigated and it was confirm to have deposit permeability more in penetrating aquiferous zone, but in organic and lateritic soil it rates of permeability is very low compared to silty and fine sand formation, these condition developed high concentration in organic and lateritic soil structure, it has influence the deposition of nickel in the study area as presented express in the figures, higher concentration within a short period of time were observed, the rate of migration within hundred days were found to be high from the results, the rate of permeability deposition even at low level influences the substance base on the rate of regeneration and accumulation within deposited low permeable region of the formation. The rates of nickel increase in concentration within ten metres, it implies that under normal condition regeneration will pressure the substances to aquiferous zone, but some part of the figure presented deposited low concentration compared to other that is very high, the study area were close to a waste dump site, monitoring of this contaminant were carried out in different location, change of concentration with respect to change in distance were observed to influence the rate of concentration. The rate of permeability influences the deposition of dispersion under the pressure of variation of stratification influencing the deposition of permeability in the study area, under this condition the developed model simulated applied different concentration to accommodate the rate of variation, there theoretical values generated produced results that were compare at different location, both parameters compared faviourably well, this condition validated the derived model, experts will definitely find faviour in applying this model to monitor and evaluate the rates of nickel concentration at different location and depths with respect to time of migration in the study area.

4. Conclusion

The deposition of nickel has been found to escalate in the study environment, the study has express the rate of concentration in different location, the rate of permeability in the formation has been found to predominantly deposit the highest formation characteristics in the study locations, such development has pressure the rate of concentration of nickel at higher rate more than the required permitted standard by world health organization, the predominant contaminant in the study environment examined through risk assessment previously carried out, solution to prevent this spread of this contaminant proof abortive as the recommended solution could not prevent the migration of the substances, such development call for serious concern, base on this facts, mathematical modeling and simulation were found appropriate for this ugly scourge, the developed model were base on the investigation carried out in the study area. The result generated from the simulation were compared with experimental values and both parameters developed a best fits expressing validation of the model, experts will find it faviourable by applying this conceptual frame work in monitoring and assessing of nickel deposition and migration in the study location.

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