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Research article

DEVELOPMENT OF MODEL SIMULATION ON ARSENIC DEPOSITION IN SILTY FORMATION AT WASTE DUMP ENVIRONMENT IN OBIO-AKPOR, RIVERS STATE OF NIGERIA

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Abstract

The deposition of arsenic in silty formation has been thoroughly expressed, the rate of migration were confirmed to reflect on the geological setting influencing the deposition and migration process of arsenic, such condition has develop lots of soil and water contaminants in the study area, the reflection from formation characteristics influences was experienced in the transport of process, depositing deltaic formation, the rate of contaminant from arsenic are found to be at high rate, subject to this condition, the migration of arsenic concentration at every stratum are determined by degree of porosity in the study location, previous investigation were carried out but could develop any productive solution to monitor and prevent the contaminants from further spread, base on this factors, modeling and simulation were found to be the best option for preventing this contaminant from further migration, the model were developed through derived governing equation, theoretical values were generated from the simulation, it expressed linear and slight fluctuation with increase in contamination through change in depth and time, the results were compared with other experimental values, both parameters compared faviourably well validating the developed model that will prevent and monitor the rate of arsenic migration in soil and water environment at Obio-Akpor

Keywords: model simulation, arsenic deposition and waste dump environment

1. Introduction

Heavy metal contamination of aquatic ecosystems is becoming a prospective global problem. Developing nations such as Nigeria, lack for mechanisms and sensitive tools to detect and observe water quality and are therefore exposed to heavy metal poisoning (Ochieng et al., 2008). Trace amounts of heavy metals are constantly present in fresh waters from terrigenous sources such as weathering of rocks resulting into geo-chemical recycling of heavy metal elements in these ecosystems (Muwanga, 1997; Zvinowanda et al., 2009). Trace elements may be immobilized within the stream sediments and thus could be involved in absorption, co precipitation, and complex formation (Okafor and Opuene, 2007; Mohiuddin et al., 2010,Eluozo,2013). Sometimes they are co-adsorbed with other elements as oxides Hydroxides of Fe, Mn, or may occur in particulate form (Awofolu et al., 2005; Mwiganga and Kansiime, 2005). Heavy metals may enter into aquatic ecosystems from anthropogenic sources, such as industrial wastewater discharges, sewage wastewater, fossil fuel combustion and atmospheric deposition (Linnik and Zubenko, 2000; Campbell, 2001; Lwanga et al., 2003; El Diwani and El Rafie, 2008; Idrees, 2009). Trace elemental concentrations in stream sediment compartments can be used to reveal the history and intensity of local and regional pollution (Nyangababo et al., 2005a). Sentongo (1998); Matagi (1998) and Kansiime et al., (1995) observed significant pollution load by organic and inorganic substances into the Nakivubo ecosystem. Some work on heavy metal loading of Lake Victoria wetlands, Nakivubo Channel and heavy metal pollution in and around Kampala was recognised (Nyangababo 2003; Nyangababo et al., 2005b; Muwanga and Barifaijo, 2006 and Nabulo et al., 2008). The objectives of the present work were to (1) assess the geochemistry of the Nakivubo stream sediments so as to establish the possibility of secondary pollution of the sediments; (2) establish the association among heavy metals and stream physico-chemical characteristics and (3) determine the source apportionment of heavy metals using cluster and factor analyses (Sekabira, et al 2010: Eluozo,2013).

2. Governing equation

$$R\frac{\partial c}{\partial t} = -V\frac{\partial c}{\partial x} \quad \ldots\ldots\ldots\ldots \quad (1)$$

Let $C = TX$

$$\frac{\partial c}{\partial t} = T^1 X \quad \ldots\ldots\ldots\ldots \quad (2)$$

$$\frac{\partial c}{\partial x} = TX^1 \quad \ldots\ldots\ldots\ldots \quad (3)$$

$$RT^1 X + VTX^1 = \lambda^2 \quad \ldots\ldots\ldots\ldots \quad (4)$$

Let $\frac{RT^1}{T} = V\frac{X^1}{X} = -\lambda^2$ ………………………….. (5)

$$\int \frac{dT}{T} = \int \frac{P^2}{R} dt \quad \ldots\ldots\ldots\ldots \quad (6)$$

$$LnT = -\frac{P^2}{R}t + a_3 \quad \text{..... (7)}$$

$$T = \ell^{-\frac{P^2}{R}t + a_3} \quad \text{..... (8)}$$

$$Y = C_3 \ell^{\frac{-P^2}{R}t} \quad \text{..... (9)}$$

$$\frac{VX^1}{X} = -P^2 \quad \text{..... (10)}$$

$$\frac{dx}{dx} + \frac{P^2}{V}x = 0 \quad \text{..... (11)}$$

Auxiliary equation is

$$M^2 + \frac{P^2}{V} = 0 \quad \text{..... (12)}$$

$$M = \pm i \frac{P}{V} \quad \text{..... (13)}$$

$$X = ACos\frac{P}{\sqrt{V}}x + BSin\frac{P}{\sqrt{V}}y \quad \text{..... (14)}$$

Combine (4) and (13), we have

$$C_2 = TX$$

$$C_2 = C_3 \ell^{-\frac{P^2}{R}t}\left(ACos\frac{P}{\sqrt{V}}t + ASin\frac{P}{\sqrt{V}}x\right) \quad \text{..... (15)}$$

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 arsenic concentration between the unconfined bed through column experiment in the study area.

4. 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 the Arsenic at Different Depths

Depths [M]	Concentration[Mg/L]
3	1.23E+01
6	2.47E+01
9	3.40E+01
12	4.93E+01
15	6.17E+01
18	7.40E+01
21	8.64E+01
24	9.87E+01
27	1.13E+02
30	1.23E+02

Table: 2 concentration of the Arsenic at Different Time

Time [Per Day]	Concentration[Mg/L]
10	1.23E+01
20	2.47E+01
30	3.40E+01
40	4.93E+01
50	6.17E+01
60	7.40E+01
70	8.64E+01
80	9.87E+01
90	1.13E+02
100	1.23E+02

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

Depths [M]	Theoretical values [[Mg/l]	Experimental Values
3	1.23E+01	12.66
6	2.47E+01	24.44
9	3.40E+01	34.66
12	4.93E+01	49.88
15	6.17E+01	60.99
18	7.40E+01	73.88
21	8.64E+01	86.88
24	9.87E+01	98.34
27	1.13E+02	112.21

30	**1.23E+02**	**123.67**

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

Time [Per Day]	Theoretical values [[Mg/l]	Experimental Values
10	**1.23E+01**	**12.66**
20	**2.47E+01**	**24.44**
30	**3.40E+01**	**34.66**
40	**4.93E+01**	**49.88**
50	**6.17E+01**	**60.99**
60	**7.40E+01**	**73.88**
70	**8.64E+01**	**86.88**
80	**9.87E+01**	**98.34**
90	**1.13E+02**	**112.21**
100	**1.23E+02**	**123.67**

Table: 5 concentration of the Arsenic at Different Time

Time [Per Day]	Concentration[Mg/L]
2	**2.40E+00**
4	**4.98E+00**
6	**7.47E+00**
8	**9.96E+00**
10	**1.25E+01**
12	**1.49E+01**
14	**1.74E+01**
16	**2.24E+01**
18	**2.24E+01**
21	**2.61E+01**

Table: 6 concentration of the Arsenic at Different Depths

Depths [M]	Concentration[Mg/L]
3	**2.40E+00**
6	**4.98E+00**
9	**7.47E+00**
12	**9.96E+00**
15	**1.25E+01**
18	**1.49E+01**
21	**1.74E+01**
24	**2.24E+01**
27	**2.24E+01**
30	**2.61E+01**

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

Time [Per Day]	Theoretical values [[Mg/l]	Experimental Values
2	**2.40E+00**	2.22
4	**4.98E+00**	4.88
6	**7.47E+00**	7.55
8	**9.96E+00**	9.44
10	**1.25E+01**	12.66
12	**1.49E+01**	14.45
14	**1.74E+01**	17.66
16	**2.24E+01**	22.55
18	**2.24E+01**	21.66
21	**2.61E+01**	25.88

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

Depths [M]	Theoretical values [[Mg/l]	Experimental Values
3	**2.40E+00**	**2.22**
6	**4.98E+00**	**4.88**
9	**7.47E+00**	**7.55**
12	**9.96E+00**	**9.44**
15	**1.25E+01**	**12.66**
18	**1.49E+01**	**14.45**
21	**1.74E+01**	**17.66**
24	**2.24E+01**	**22.55**
27	**2.24E+01**	**21.66**
30	**2.61E+01**	**25.88**

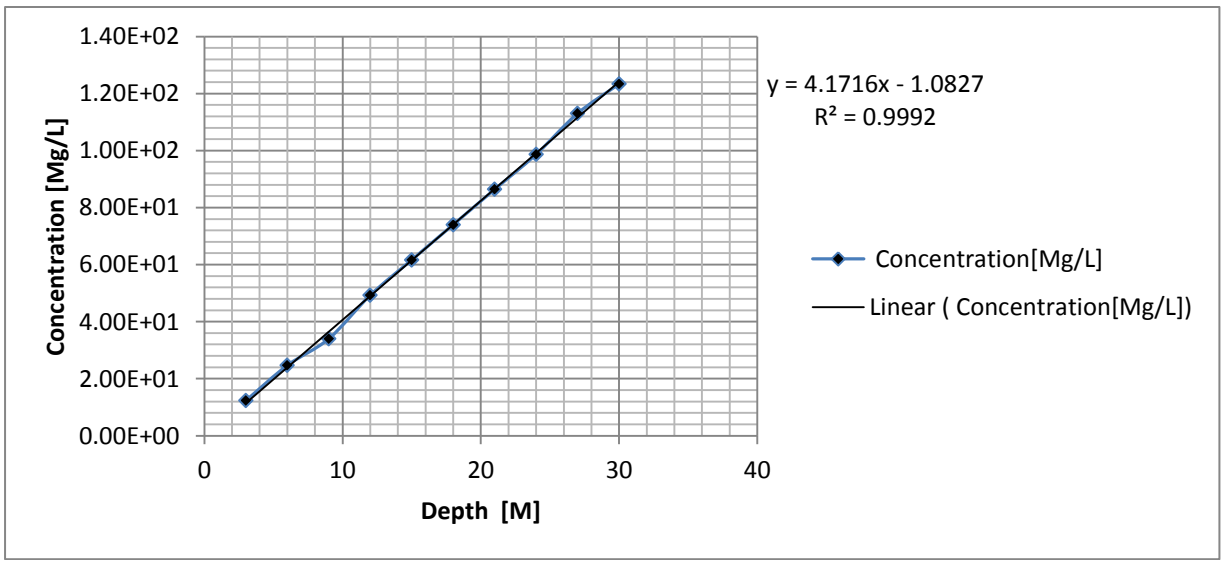

Figure: 1 concentration of the Arsenic at Different Depths

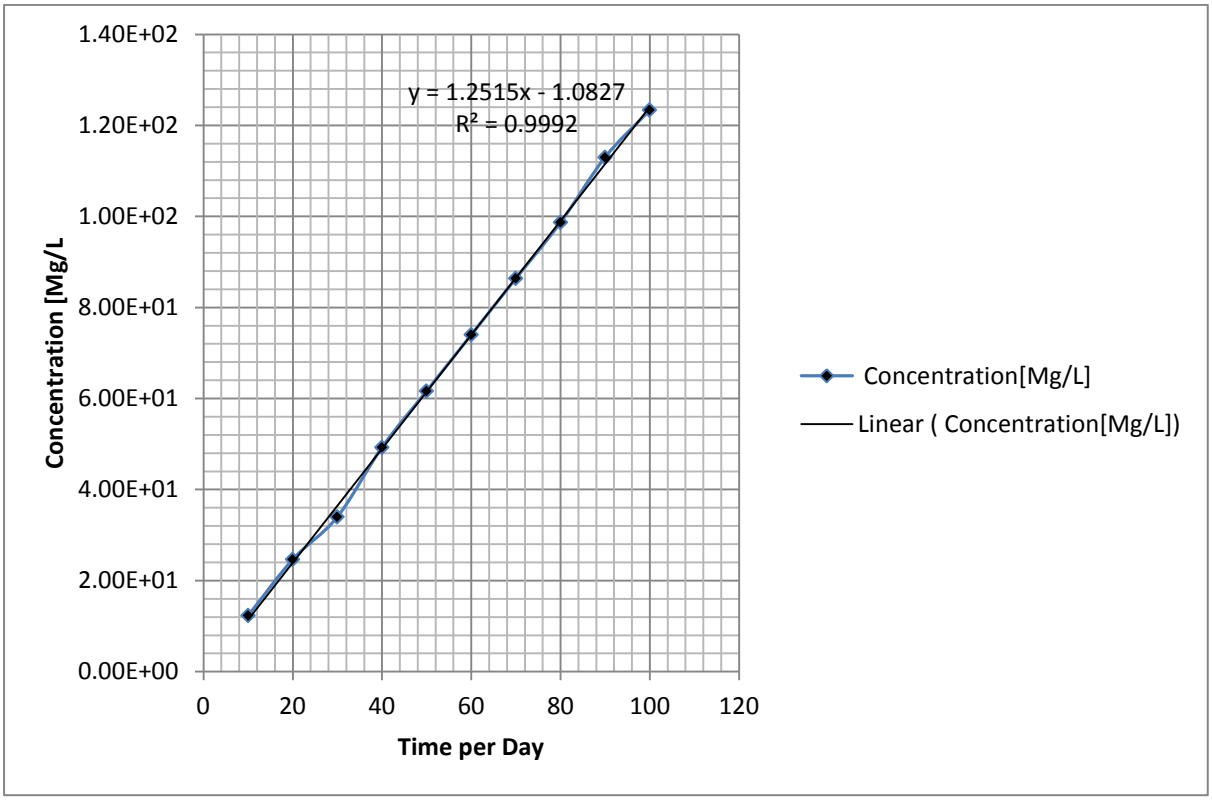

Figure: 2 concentration of the Arsenic at Different Depths

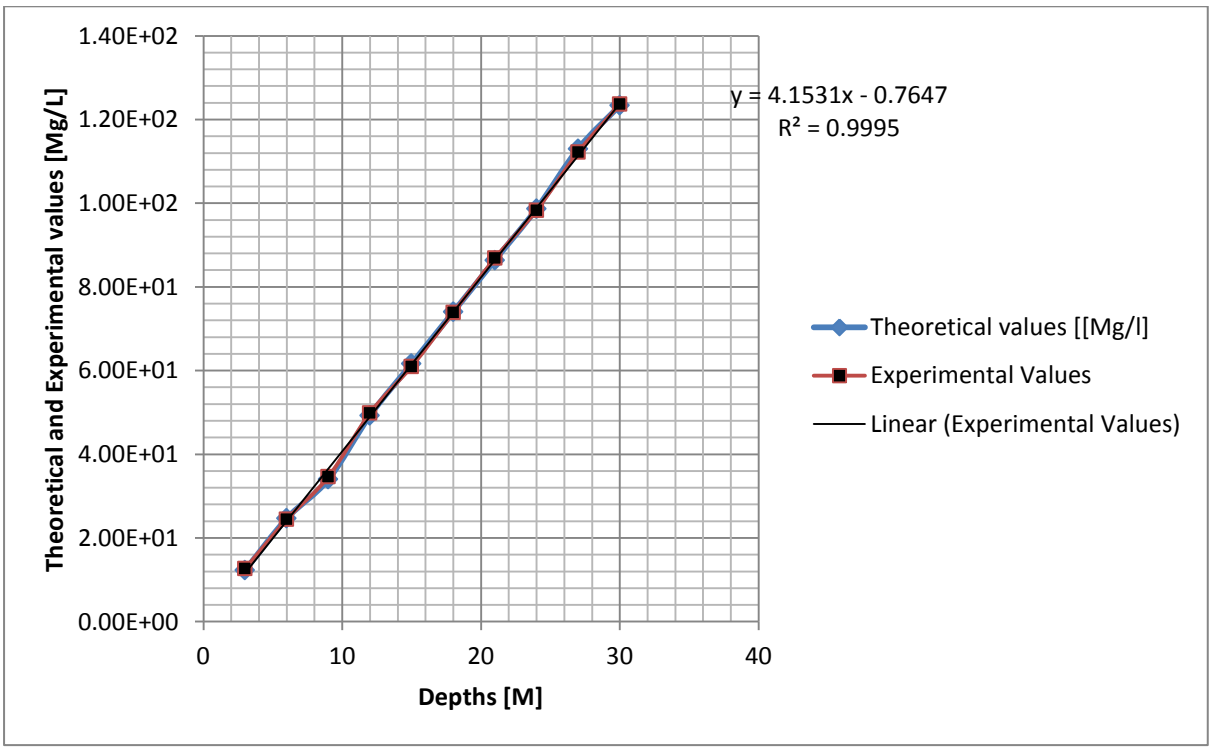

Figure: 3 Comparison of theoretical and experimental values of Arsenic at Different Depths

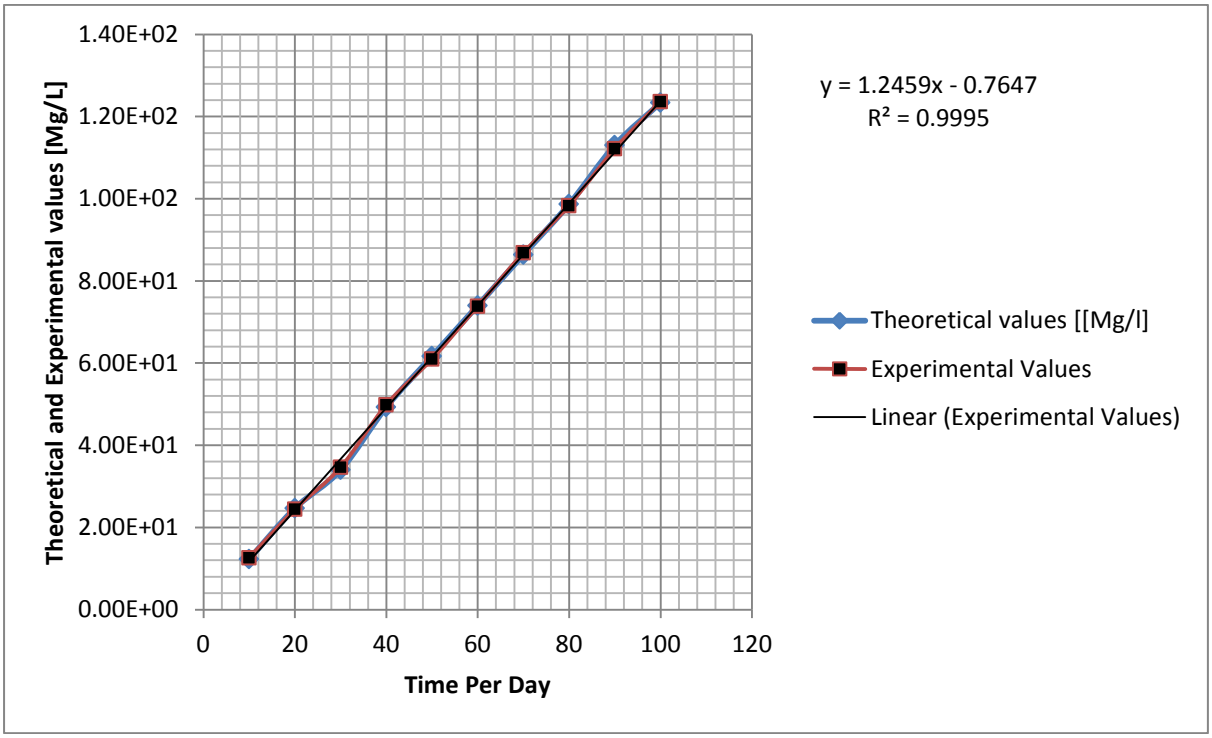

Figure: 4 Comparison of theoretical and experimental values of Arsenic at Different Depths

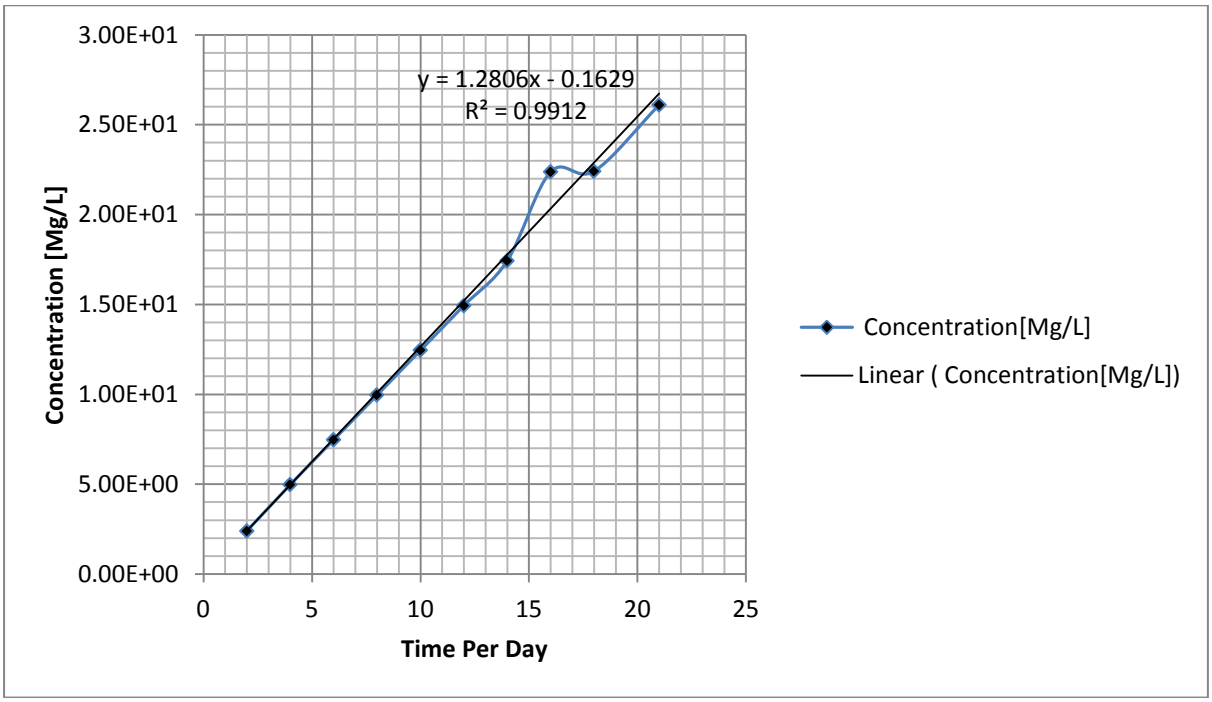

Figure: 5 concentration of the Arsenic at Different Depths

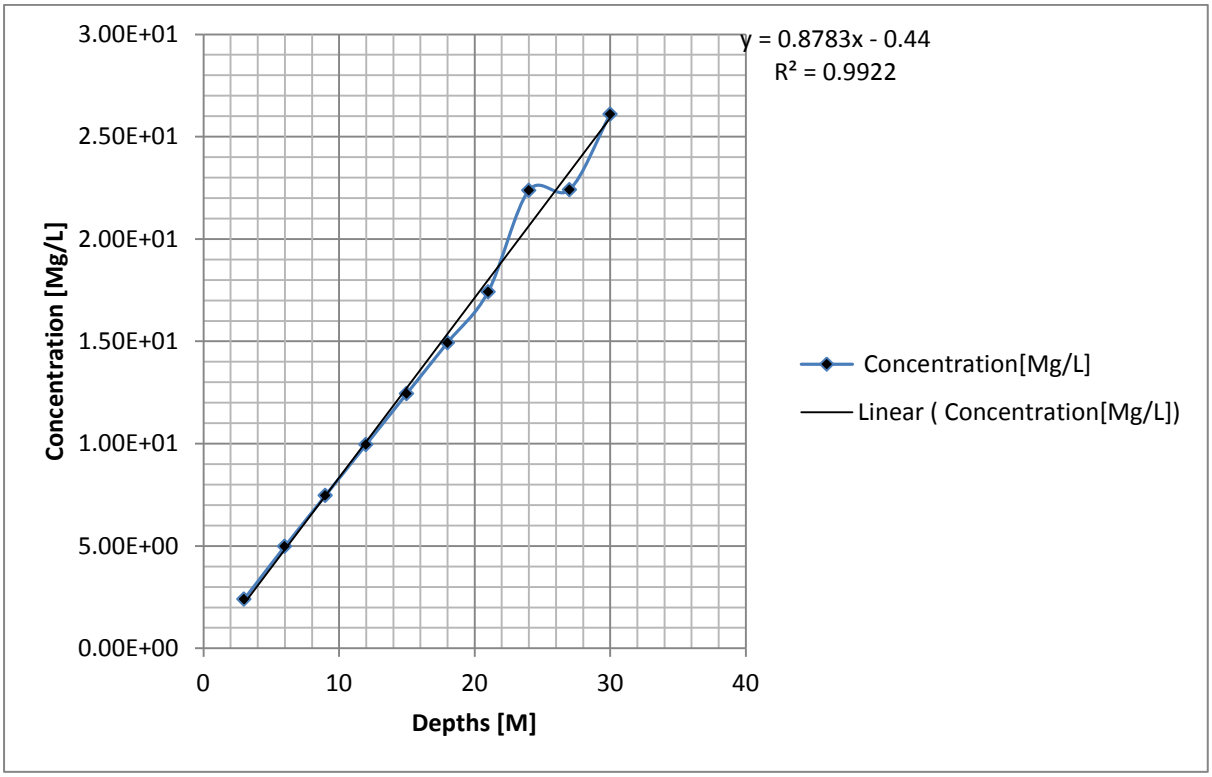

Figure: 6 concentration of the Arsenic at Different Depths

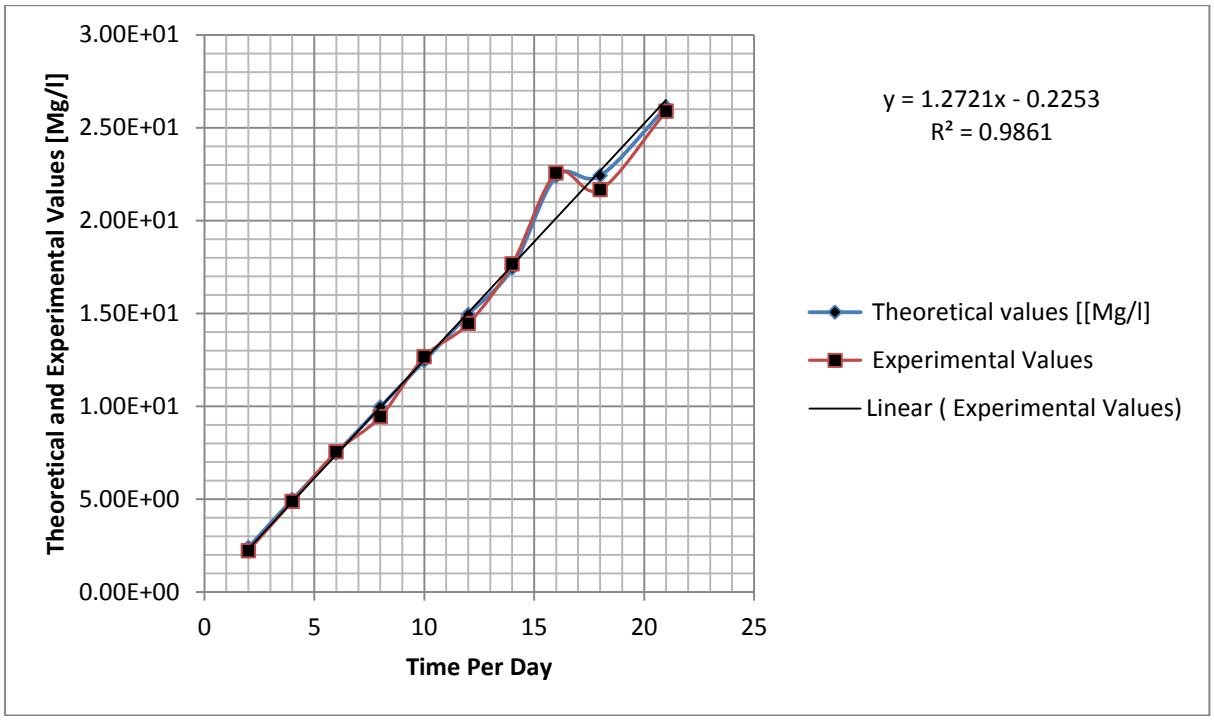

Figure: 7 Comparison of theoretical and experimental values of Arsenic at Different Depths

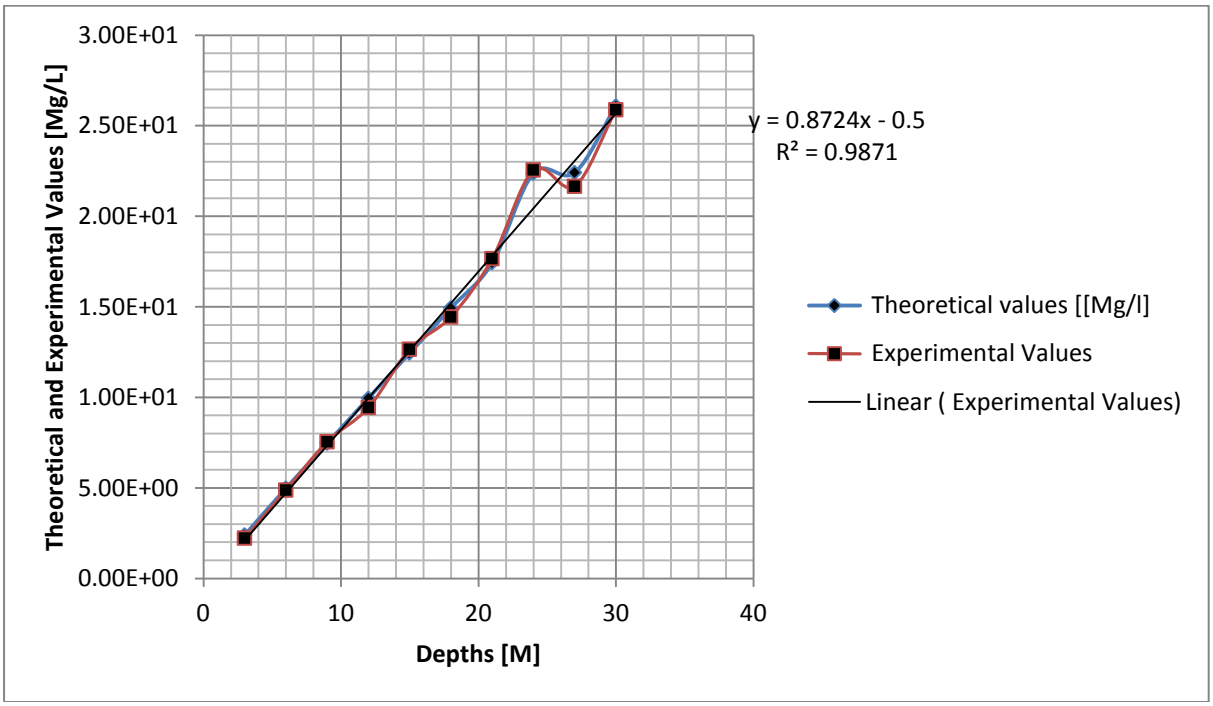

Figure: 8 Comparison of theoretical and experimental values of Arsenic at Different Depths

Figure [1-4] developed linear expressed migration in rapid state to where an optimum values were observed, the rate of concentration experiences variation, but migrate linearly as presented in the figures, such condition were noted base on the rate of transport, aquiferous zone developed the highest concentration, the rate of porosity influences the behaviour of the transport system expressed in the figures, the migration in linear direction to the optimum level can also be attributed to homogeneous flow of fluid between the intercedes of the formation, such condition may also be pressured by uniform stratification and deposition in the study environment. While figure [5-8] express similar condition, but developed slight fluctuation between twenty one at seventy days and twenty four at eighty days respectively, thus it linearly migrate to were the optimum values were recorded at thirty metres between hundred days , migrating at different formation with such motion, it implies that the geologic setting are directly developing impact on the transport process of arsenic, this has been confirmed from the rate of migration presented in the figures, the developed model generated theoretical values from its simulation, the derived solution that produced this values were compare also with other experimental values, both values developed a best fit validating the derived model for the study.

5. Conclusion

The migration of arsenic has generated lots of hazard and it need to be addressed, the study environment are contaminated with arsenic through manmade activities, such development has cause serious ill health in human settlement in the study environment, the pollution were determined from previous investigation carried out, but could not produces better solution that will prevent this pollution contaminating soil and water environment, base on this factors, mathematical model were found appropriate to monitor and prevent further contamination, the model were developed through modified system that determined the variables for the study, such

developed system produced the governing equation derived to generate model that will monitor and prevents this contaminant in the study environment, the derived model were simulated to generate theoretical values, the results were compared with experimental values for model validation, both parameters generated best fit, experts will find this developed model favuorable as tool in monitoring, preventing and evaluation of arsenic migration and deposition in soil and water environments.

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