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Research article

SIMULATION OF POROSITY AND DISPERSION INFLUENCES ON ARSENIC TRANSPORT IN LATERITIC AND SILTY FORMATION IN COASTAL AREA OF TRANS –AMADI DISTRICT OF PORT HARCOURT METROPOLIS

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Abstract

The rate of porosity in the study environment has been found to influences some minerals deposition in the study area, this is between the formations at different rates in coastal area of Amadi Ama. The deposition of arsenic in coastal area were confirmed through previous investigation carried out in the study location, but could not provide better solution to prevent the migration of arsenic in the study area. The developed model was simulated to expressed the behaviour of the system in terms of arsenic migration, the results shows the migration rate of the microbes rapidly to the optimum values deposited in silty formation, homogenous porosity were found to influences arsenic concentration in the study environment, such condition implies that dispersion rate will be pressured by degree of porosity, this conditions were considered in the system that finally produced simulation results, these generated values were compared with experimental values and both parameters compared faviourably well , it defined the validation of the model, experts in the field will definitely applied these concept as a tool to monitor the deposition and migration of arsenic in coastal area of Amadi- Ama.

Keys words: simulation, porosity, dispersions, Arsenic transport: lateritic and silty formation.

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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 fulfil the following criteria (Stetler, 1994): The concept which explains the ultimate destination of rainwater is the sea either directly through run off or indirectly be infiltration and subsurface flow. A system of water movement in the atmosphere or rainfall, dews, hailstones or snowfalls over land as run off. Vertical and horizontal movement underground as infiltration or subsurface and continuous movement of all forms of water is the hydrogeology cycle. In the atmosphere, water vapours condense and may give rise to precipitation. However, not all this precipitation will reach the ground surface; some are intercepted by vegetation cover or surface of building and other structures and then evaporate back into the atmosphere. 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 200 7Eluozo, 2013) 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,Eluozo,3013). 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). Such growth is accompanied by increasing demand for water supply leading to the over-exploitation of the aquifer system and excessive drainage for land reclamation purposes. Contamination of the groundwater by natural means (seawater intrusion) and through anthropogenic means (human activities) cannot be ruled out in the area. The study is aimed at evaluating the quality of groundwater from the coastal plain-sand aquifer Port-Harcourt area with the view of determining its suitability for domestic, irrigational and industrial purposes. The heavy industrial and human activities in the area lead to the present study. The aquifer system in the area is largely unconfined, highly porous and permeable and the possibility of anthropogenic interference cannot be completely ignored, hence the need for this study. 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, Eluozo, 2013).

2. Governing Equation

$$\phi \frac{\partial c}{\partial t} = D \frac{\partial^2 c}{\partial y^2} \qquad \ldots\ldots\ldots\ldots \quad (2)$$

Let $C = T^1 Y$

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

$$\frac{\partial^2 c}{\partial y^2} = TY^{11} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

$$\phi T^1 Y = DTY^{11} = \theta^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

Let $\phi \frac{T^1}{T} = D \frac{Y^{11}}{Y} = -\theta^2$ ………………………….. (5)

$$\int \frac{dT}{T} = \int \frac{-\theta^2}{\phi} dt \qquad \text{.............................. (6)}$$

$$LnT = \frac{-\theta^2}{\phi} t + a_3 \qquad \text{.............................. (7)}$$

$$T = \ell^{\frac{-\theta^2}{\phi} t + a_3} \qquad \text{.............................. (8)}$$

$$T = C_3 \, \ell^{\frac{-\theta^2}{\phi} t} \qquad \text{.............................. (9)}$$

$$D \frac{Y^{11}}{Y} = -\theta^2 \qquad \text{.............................. (10)}$$

$$\frac{\partial^2 y}{\partial y^2} + \frac{\theta^2}{D} y = 0 \qquad \text{.............................. (31)}$$

Auxiliary equation

$$M^2 + \frac{\theta^2}{D} = 0 \qquad \text{.............................. (11)}$$

$$M = \pm i \frac{\theta}{\sqrt{D}} \qquad \text{.............................. (12)}$$

$$\therefore Y = A Cos \frac{\theta}{\sqrt{D}} y + B Sin \frac{\theta}{\sqrt{D}} y \qquad \text{.............................. (13)}$$

Combine (9) and (13), we have

$$C_2 = TY$$

$$C_2 = C_3 \, \ell^{\frac{-\theta^2}{\phi} t} \; A Cos \frac{\theta}{\sqrt{D}} y + A Sin \frac{\theta}{\sqrt{D}} y \qquad \text{.............................. (14)}$$

3. Materials and method

Soil samples from several different boring locations, were collected at intervals between two and three meters each. Soil sample were collected in five different location, applying insitu method of sample collection, the soil sample were collected for analysis, standard laboratory analysis were carried out to determine the Arsenic concentration through column experiment, the result were analyzed to determine the influence on Arsenic in lateritic and silty formation 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 Arsenic at Different Depths

Depths [M]	Concentration
3	2.48
6	4.96
9	7.45
12	9.93
15	12.42
18	14.9
21	17.39
24	19.87
27	22.36
30	24.84

Table 2: Concentration of Arsenic at Different Depths

Time Per Day	Concentration
10	2.48
20	4.96
30	7.45
40	9.93
50	12.42
60	14.9
70	17.39
80	19.87
90	22.36
100	24.84

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

Depths [M]	Theoretical Values	Experimental Values
3	2.48	2.66
6	4.96	4.77
9	7.45	7.33
12	9.93	9.66
15	12.42	12.49
18	14.9	14.88
21	17.39	17.22
24	19.87	19.55
27	22.36	22.22

30	**24.84**	**24.55**

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

Time Per Day	Theoretical Values	Experimental Values
10	2.48	2.66
20	4.96	4.77
30	7.45	7.33
40	9.93	9.66
50	12.42	12.49
60	14.9	14.88
70	17.39	17.22
80	19.87	19.55
90	22.36	22.22
100	24.84	24.55

Table 5: Concentration of Arsenic at Different Depths

Depths [M]	Concentration
2	1.43
4	2.87
6	4.31
8	5.75
10	7.19
12	8.63
14	10.06
16	11.51
18	12.94
20	14.38

Table 6: Concentration of Arsenic at Different Depths

Time Per Day	Concentration
2	1.43
4	2.87
6	4.31
8	5.75
10	7.19
12	8.63
14	10.06
16	11.51
18	12.94
20	14.38

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

Depths [M]	Theoretical Values	Experimental Values
2	1.43	1.49E+00
4	2.87	2.77E+00
6	4.31	4.44E+00
8	5.75	5.55E+00
10	7.19	7.22
12	8.63	8.44
14	10.06	9.88
16	11.51	11.66
18	12.94	12.88
20	14.38	14.45

Table 8: Comparison of Theoretical and Experimental Values of Arsenic concentration at Different Depths

Time Per Day	Theoretical Values	Experimental Values
2	1.43	1.49E+00
4	2.87	2.77E+00
6	4.31	4.44E+00
8	5.75	5.55E+00
10	7.19	7.22
12	8.63	8.44
14	10.06	9.88
16	11.51	11.66
18	12.94	12.88
20	14.38	14.45

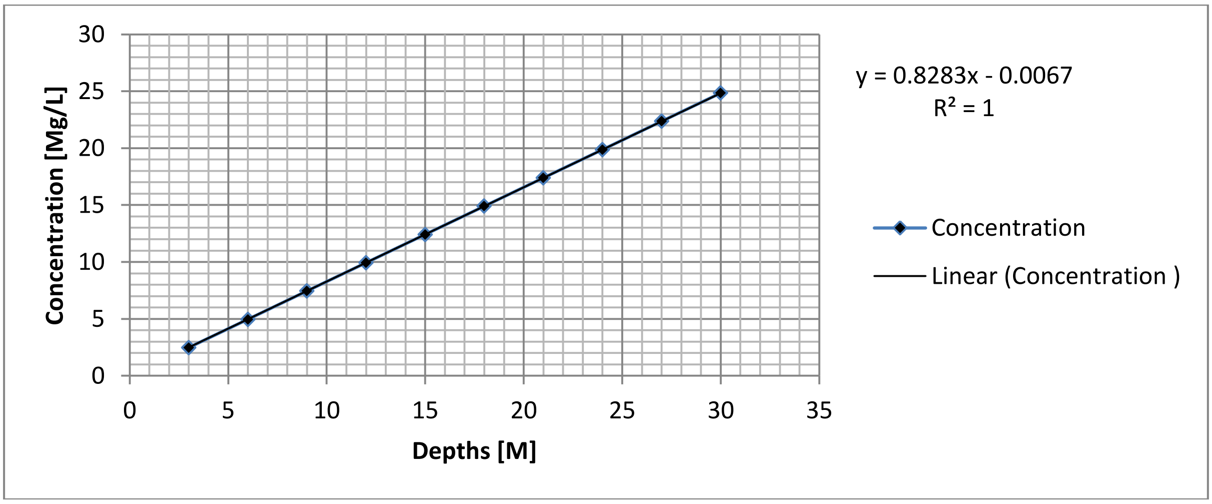

Figure1: Concentration of Arsenic at Different Depths

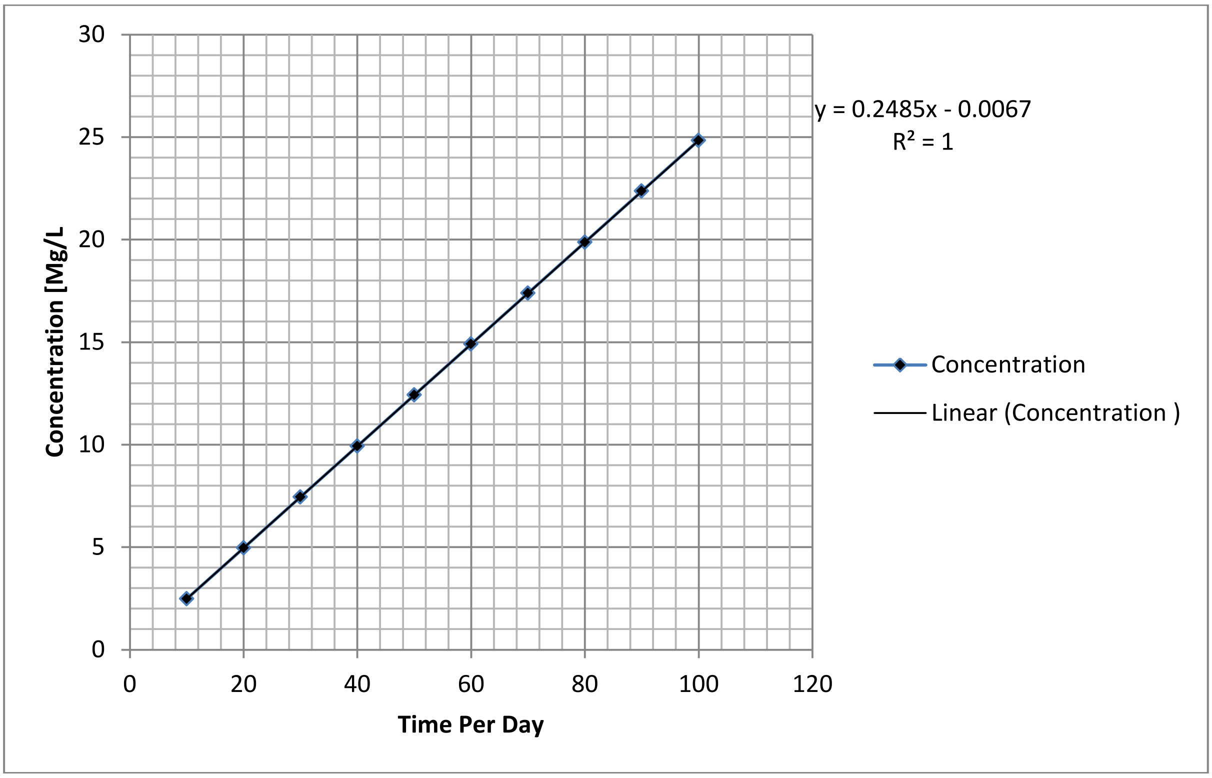

Figure2: Concentration of Arsenic at Different Time

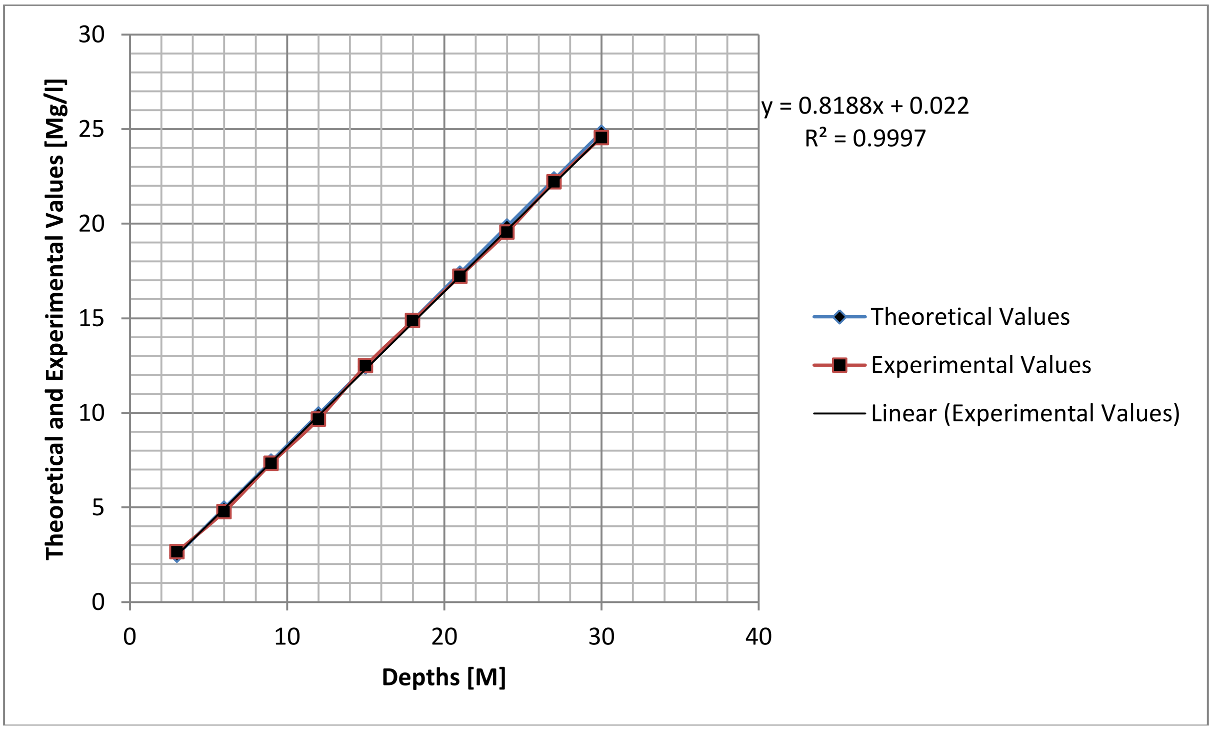

Figure3: Comparison of Theoretical and Experimental Values of Arsenic concentration at Different Depths

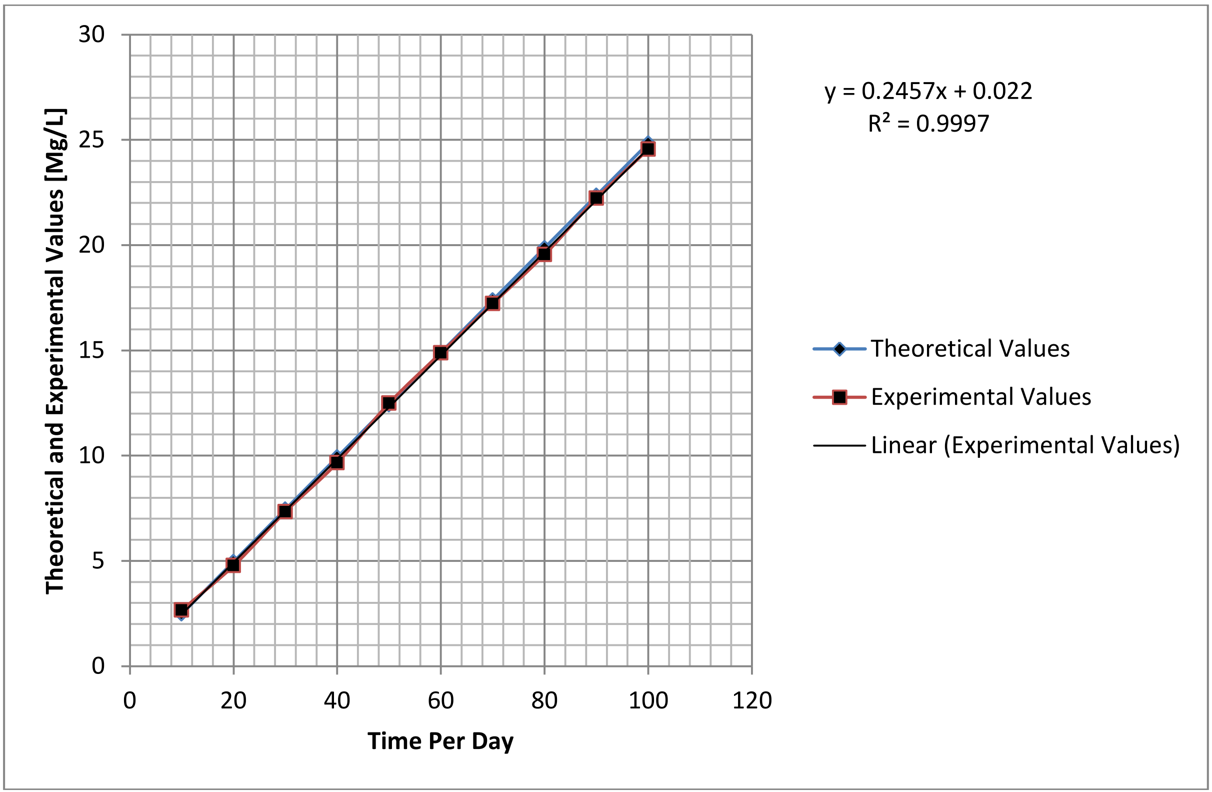

Figure4: Comparison of Theoretical and Experimental Values of Arsenic concentration at Different Time

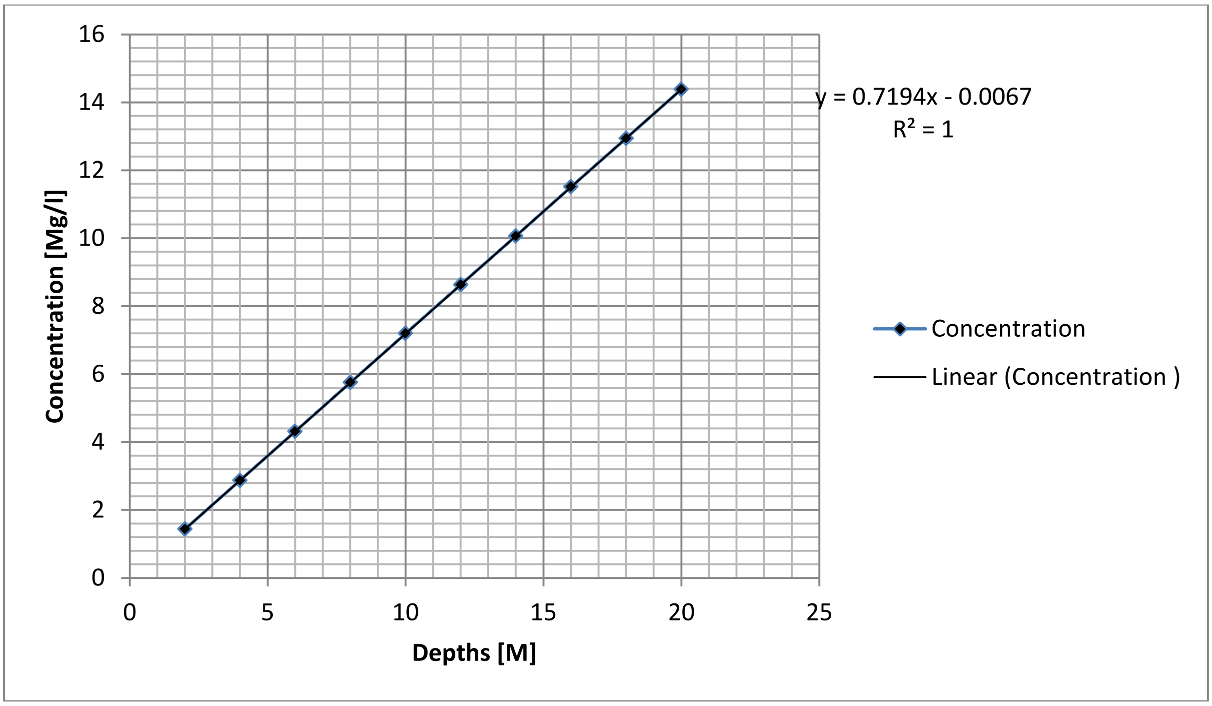

Figure 5: Concentration of Arsenic at Different Time

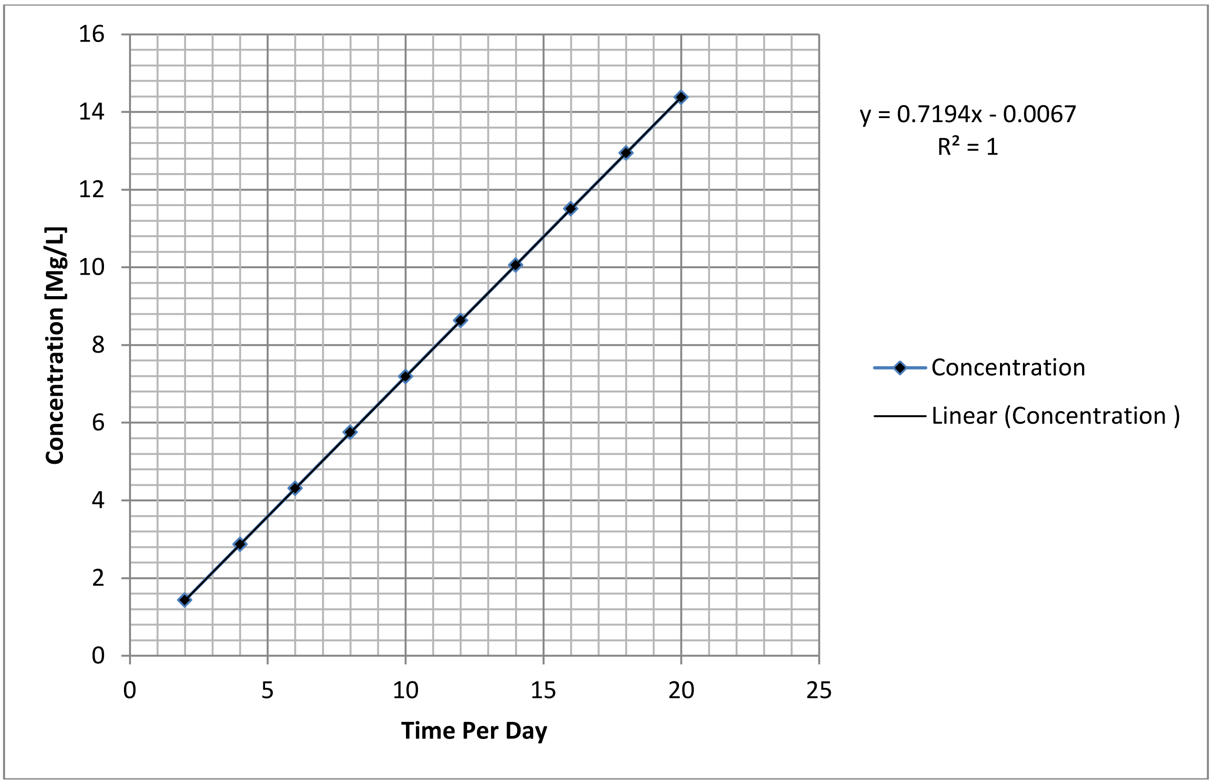

Figure 6: Concentration of Arsenic at Different Time

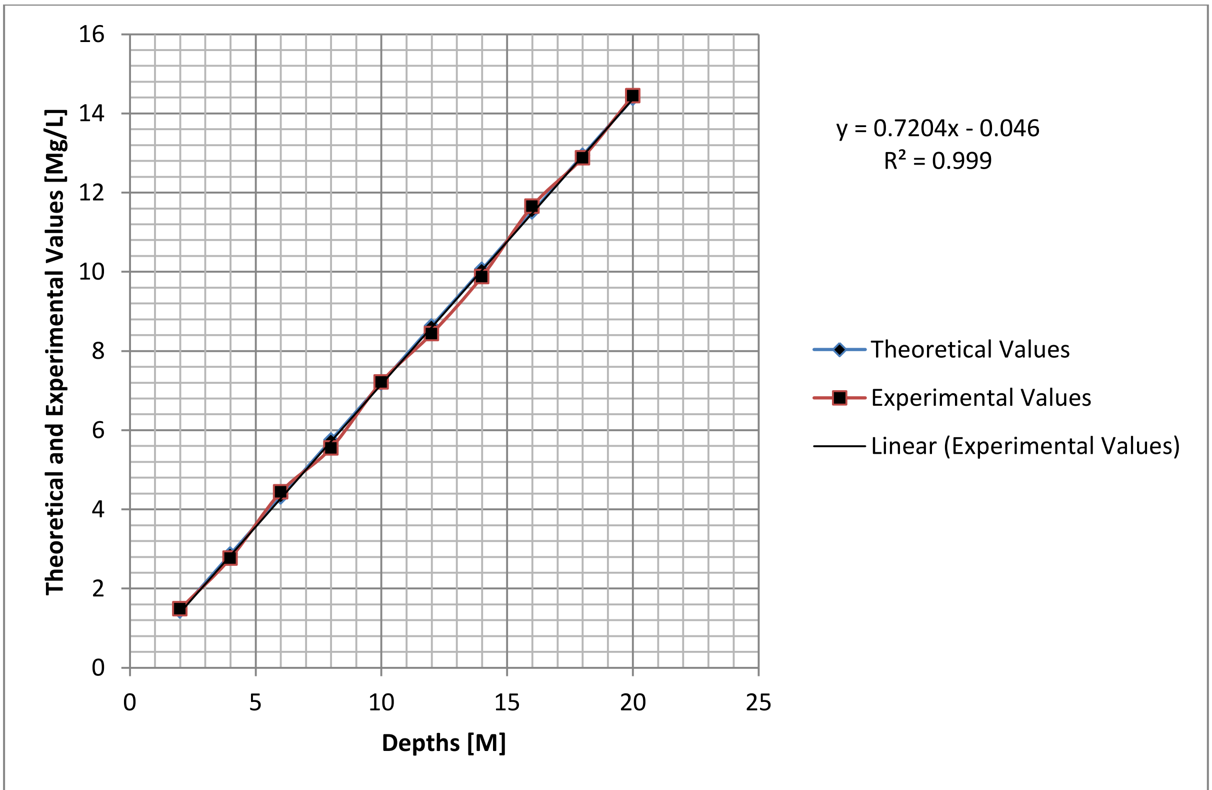

Figure7: Comparison of Theoretical and Experimental Values of Arsenic concentration at Different Depths

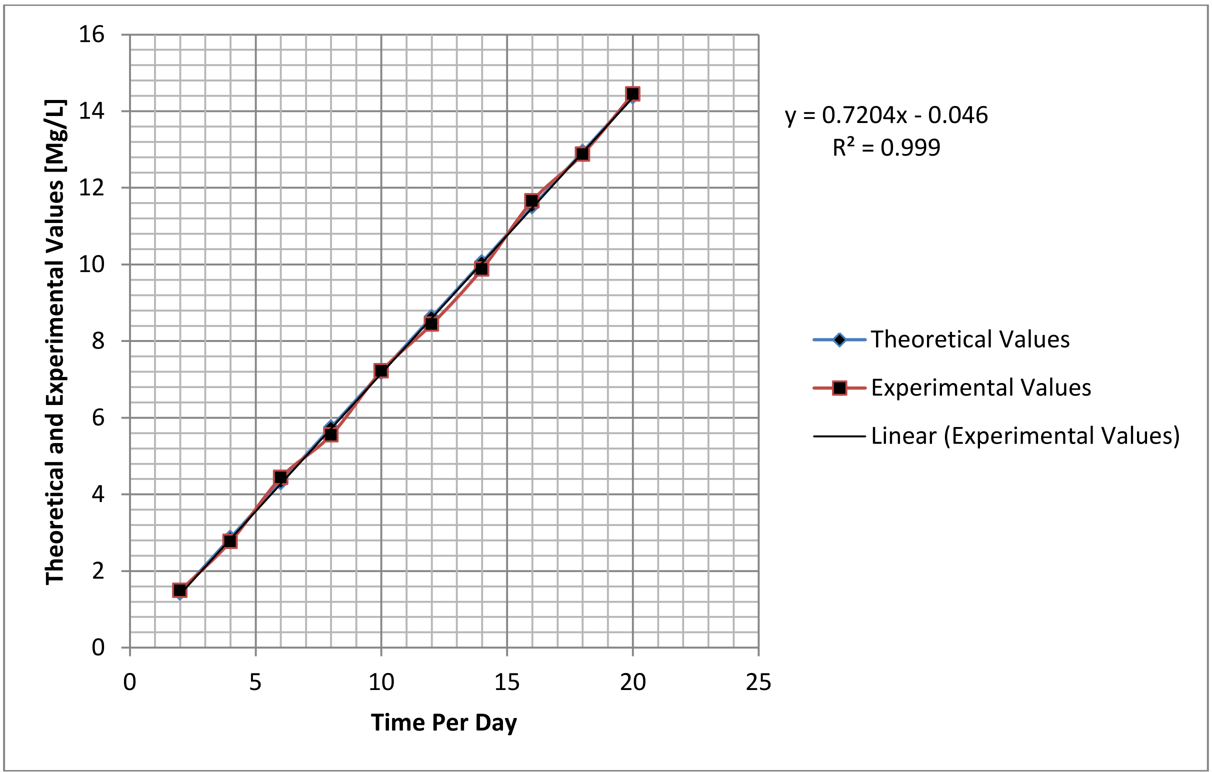

Figure7: Comparison of Theoretical and Experimental Values of Arsenic concentration at Different Time

Figure 1-8 shows the following conditions from the simulation results, linear increase was observed in all the figures, these conditions implies that the deposition of Arsenic experiences homogeneous depositions as well influencing the transport of arsenic in the study areas, the rate of concentration experiences fluctuations even when they migrate in linear condition. Increase in depths and time influences the concentration, the simulation considered the concentration to experiences variations due to the location of the study and other factors experiences the study environment, the concentration varies increase in depths and time, high degree of porosity and dispersions influences was observed in entire study area, formation characteristics influences the migration rates of arsenic, optimum values of arsenic were observed in silty and fine sand formation between twenty and thirty metres, this implies that higher degree of porosity are deposited between those formations.

4. Conclusion

The deposition of arsenic in the study environment has been expressed, the rates of arsenic were influenced by formation characteristics such as porosity and dispersions as a results of formation variations in the study environments, the migration of arsenic were observed to experiences homogenous deposition in the study environment, base on this observation, increase in concentration were influences on change in depths and time, this condition resulted an optimum values to deposit at aquiferous, the rate of concentration are determined by this deposited formation influences, the rate of dispersion were considered in the study environment because of the deposition of porosity observed to deposit high predominant degree in the entire study location, therefore the rate of dispersion were influenced by this conditions. The study is imperative because experts in the field will monitor the migration of arsenic through this concept to determine the rate of arsenic migration in the study area.

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