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Research article

SIMULATING CADMIUM DEPOSITION ON HOMOGENEOUS PERMEABILITY IN SILTY AND FINE SAND FORMATION IN OKEHI, RIVERS STATE OF NIGERIA

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Abstract

Unhealthy environments has been a serious threat to human lifespan, this is due contaminants from different direction, most unhealthy crises are cause by manmade, the negligence of human in controlling waste has cause lots of hazard resulting to long time negative impact and death, heavy metal deposition in soil and water environment were observed in the study location, the result confirmed serous long time effect on human settlement, but was neglected , this ugly situation continue and it resulted to high contaminant in soil and water environment, such observation call for immediate action to prevent further pollution , base on this factors, mathematical model were found favuorable to generate model that can be applied in prevent further spread of this contaminants, the develop model were simulated to monitor the rate of migration at different strata, higher concentration were observed at aquiferous zone due to high rate of permeability in the study area, such influences increase fast migration within a short period of time, the theoretical results were compared with experimental values, both parameter develop a favuorable fit , the model were validated from such favuorable comparison, experts in the field will no doubt use this expressed model as a tool in preventing cadmium contamination in soil and water environment.

Keywords: cadmium deposition, permeability, fine and silty formation

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1. Introduction

The regional geology has been mapped and described by Wells and O'Brien (1994a and 1994b bread 2005) and is also summarized by Whitaker and Green (1978). Early work on the volcanic rocks wasp documented by Stevens (1968), and more detailed geologic information and mapping in the study area provided by Willey (1992). The regional geomorphology was interpreted by Ollier and Harworth (1994). The area is dominated by two main rock units: a near-horizontal to gently dipping Middle Jurassic sedimentary sequence of the Moreton-Clarence Basin, part of the Great Artesian Basin, and the mid-Tertiary Main Range Volcanics (MRV), extending up to 50 km westward from Toowoomba. These strata unconformable overlie a concealed basement of Palaeozoic rocks, the New England Orogen (**I**brahim,2006, Bread, 2005, Bread, et al, 2005, Briggs, 2008).The primary environmental issue facing the whole world, in terms of subsurface environment, is the protection of good quality groundwater and the clean-up or remediation of already contaminated groundwater resources (**I**brahim,2006).. Before 1976, US citizens had used open dumping of wastes which invariably resulted into soil contamination, groundwater pollution, and adverse health hazards, including cancer in children traceable to contamination by industrial chemicals. This led to public outcry and environmental regulations promulgated by both federal and state governments. In a developing country like Nigeria where the practice of waste containment is nonexistent, deadly health hazards from soil or groundwater pollution by harmful elements like mercury (Hg), potassium (K), sodium (Na), zinc (Zn), lead (Pb), etc are a reality especially when the country steps into proper development of her natural mineral resources To impede the transport processes of these contaminants, compacted clay liners are normally used as an integral component of the lining systems to cover landfills, municipal and hazardous waste impoundments, and also to cap new or old waste disposal units (Daniel and Benson, 1990; Albrecht and Benson, 2001 Shackelford, 1994, 2000). Considering advection as a major transport process, the most significant factor affecting the performance of compacted clays is hydraulic conductivity. Apart from hydraulic conductivity, diffusion is a very important transport mechanism especially if the seepage velocity is or approaches zero (Shackelford and Daniel, 1991, Shackelford, 1990, 1993). Contaminants travel along the pathway of least resistance, and narrow permeable channels usually govern their movement. Defining these transport pathways is of paramount importance, and is difficult using traditional methods of drilling and sampling because the volume explored is small, sampling is slow, and the cost of sampling is often prohibitive.

2. Governing equation

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

Let $C = TX$

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

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

$$RT^1X + VTX^1 = \lambda^2 \qquad \text{.............................. (4)}$$

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

$$\int \frac{dT}{T} = \int \frac{P^2}{R}dt \qquad \text{.............................. (6)}$$

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

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

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

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

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

Auxiliary equation is

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

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

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

Combine (4) and (13), we have

$$C_2 = TX$$

If $T = \frac{d}{v}$ and $x = v.t$ we have the final expression as:

$$\boxed{C_2 = C_3\,\ell^{-\frac{P^2}{R}t}\left(ACos\frac{P}{\sqrt{V}}\frac{d}{v} + ASin\frac{P}{\sqrt{V}}V.t\right)} \qquad \text{......................... (15)}$$

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 Cadmium 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 Cadmium at Different Depths

Depths [M]	Cadmium Concentration[Mg/L]
3	1.00E-02
6	2.50E-02
9	1.10E-02
12	5.00E-02
15	6.30E-02
18	7.60E-02
21	8.90E-02
24	9.50E-02
27	1.10E-01
30	1.30E-01

Table: 2 concentration of the Cadmium at Different Depths

Time [Per Day]	Cadmium Concentration[Mg/L]
10	1.00E-02
20	2.50E-02
30	1.10E-02
40	5.00E-02
50	6.30E-02
60	7.60E-02
70	8.90E-02
80	9.50E-02
90	1.10E-01
100	1.30E-01

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

Depths [M]	Cd Theoretical values [[Mg/l]	Cd Experimental Values
3	1.00E-02	0.013
6	2.50E-02	0.028
9	1.10E-02	0.015
12	5.00E-02	0.07
15	6.30E-02	0.068
18	7.60E-02	0.075
21	8.90E-02	0.084
24	9.50E-02	0.091
27	1.10E-01	0.12
30	1.30E-01	0.14

Table: 4 Comparison of theoretical and experimental values of Cadmium at Different Depths

Time [Per Day]	Cd Theoretical values [[Mg/l]	Cd Experimental Values
10	1.00E-02	0.013
20	2.50E-02	0.028
30	1.10E-02	0.015
40	5.00E-02	0.07
50	6.30E-02	0.068
60	7.60E-02	0.075
70	8.90E-02	0.084
80	9.50E-02	0.091
90	1.10E-01	0.12
100	1.30E-01	0.14

Table: 5 concentration of the Cadmium at Different Depths

Depths [M]	Cd Theoretical values [[Mg/l]
3	9.53E-03
6	1.90E-02
9	2.80E-02
12	3.80E-02
15	4.70E-02
18	5.70E-02
21	6.70E-02
24	7.60E-02
27	8.60E-02
30	9.50E-02

Table: 6 concentration of the Cadmium at Different Depths

Time [Per Day]	Cd Theoretical values [[Mg/l]
10	9.53E-03
20	1.90E-02
30	2.80E-02
40	3.80E-02
50	4.70E-02
60	5.70E-02
70	6.70E-02
80	7.60E-02
90	8.60E-02
100	9.50E-02

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

Depths [M]	Cd Theoretical values [[Mg/l]	Cd Experimental Values
3	9.53E-03	0.0093
6	1.90E-02	0.021
9	2.80E-02	0.031
12	3.80E-02	0.04
15	4.70E-02	0.052
18	5.70E-02	0.061
21	6.70E-02	0.069
24	7.60E-02	0.075
27	8.60E-02	0.085
30	9.50E-02	0.094

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

Time [Per Day]	Cd Theoretical values [[Mg/l]	Cd Experimental Values
2	9.53E-03	0.0093
4	1.90E-02	0.021
6	2.80E-02	0.031
8	3.80E-02	0.04
10	4.70E-02	0.052
12	5.70E-02	0.061
14	6.70E-02	0.069
16	7.60E-02	0.075
18	8.60E-02	0.085
21	9.50E-02	0.094

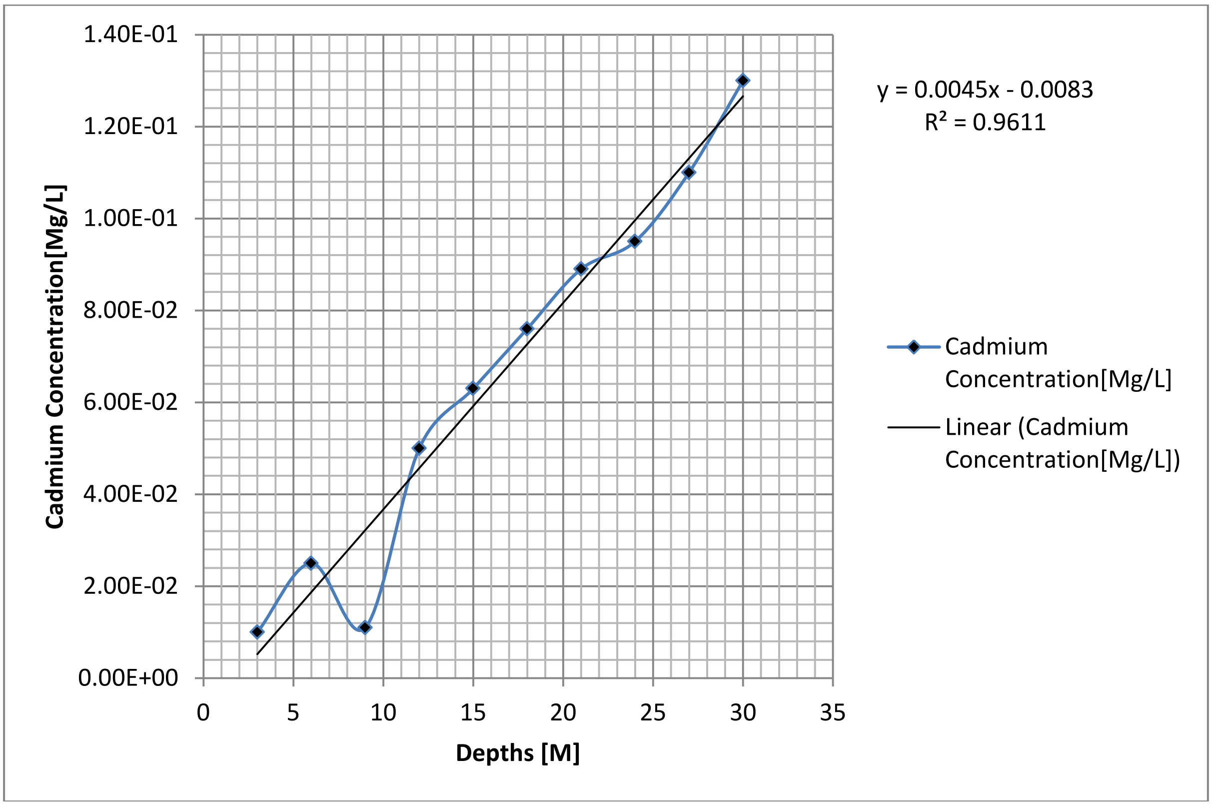

Figure: 1 concentration of the Cadmium at Different Depths

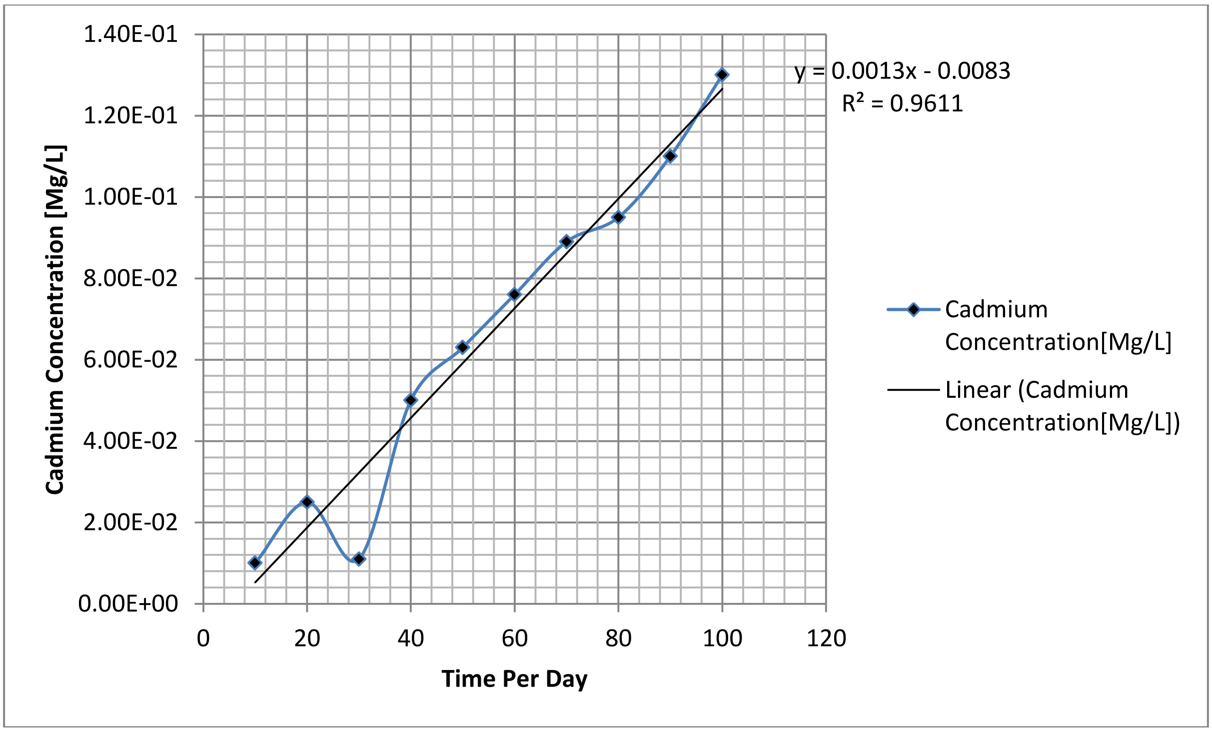

Figure: 2 concentration of the Cadmium at Different Depths

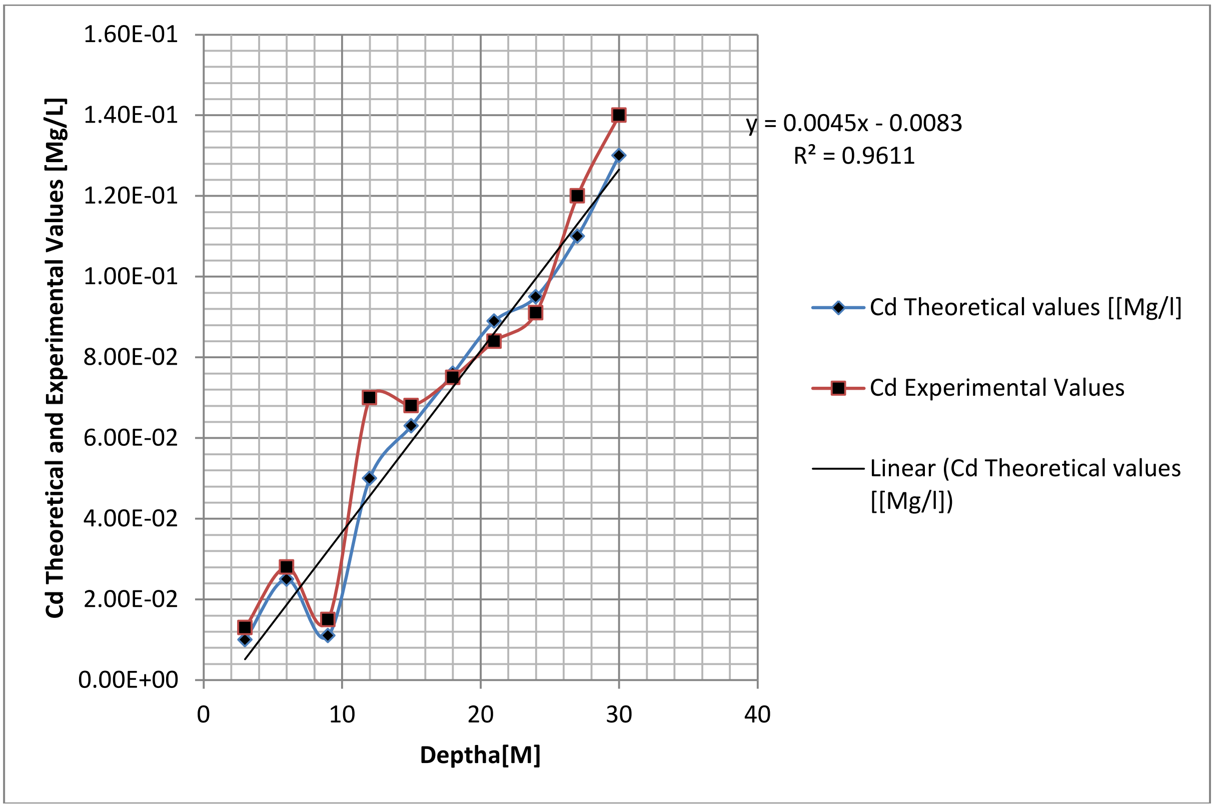

Figure: 3 Comparison of theoretical and experimental values of Cadmium at Different Depths

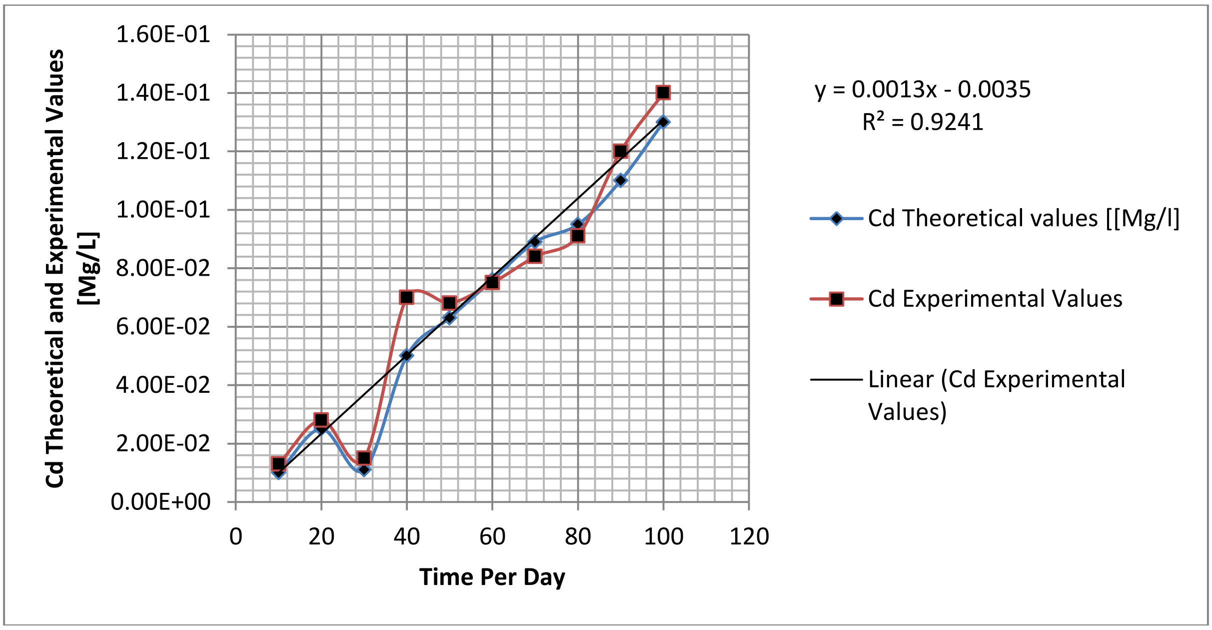

Figure: 4 Comparison of theoretical and experimental values of Cadmium at Different Depths

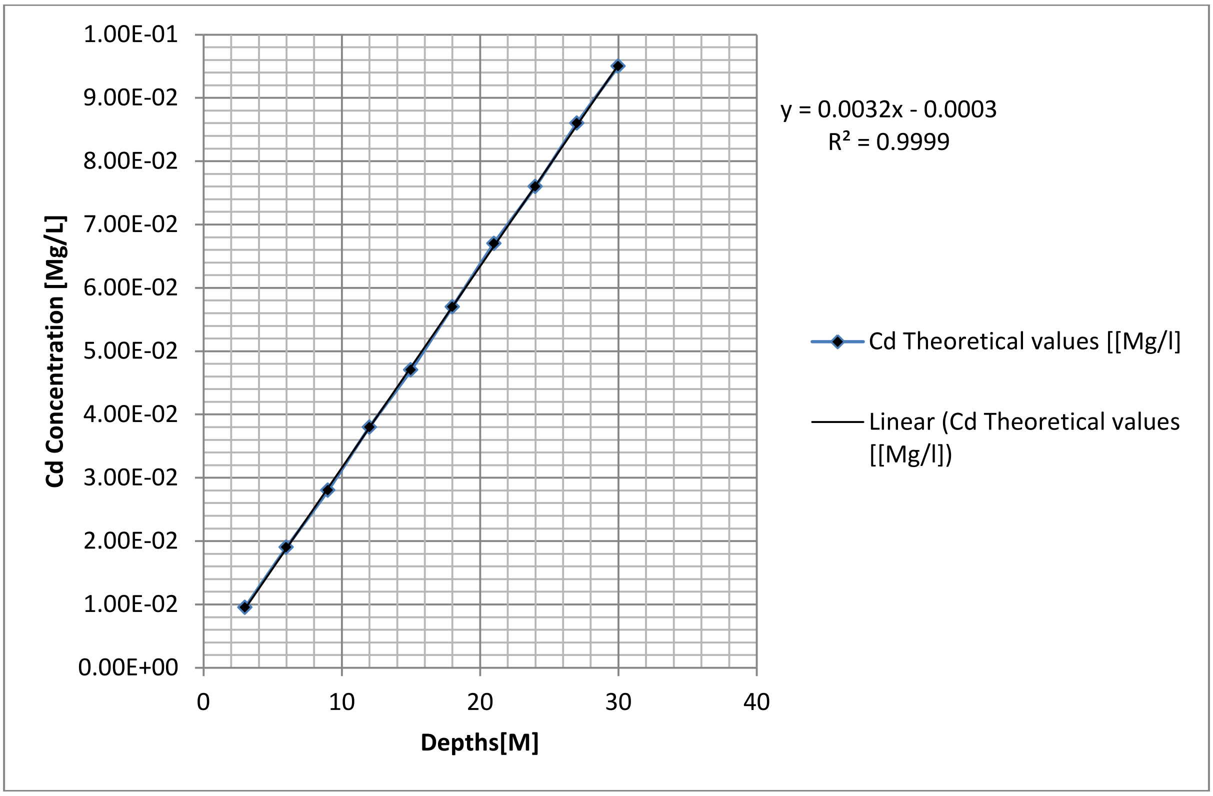

Figure: 5 concentration of the Cadmium at Different Depths

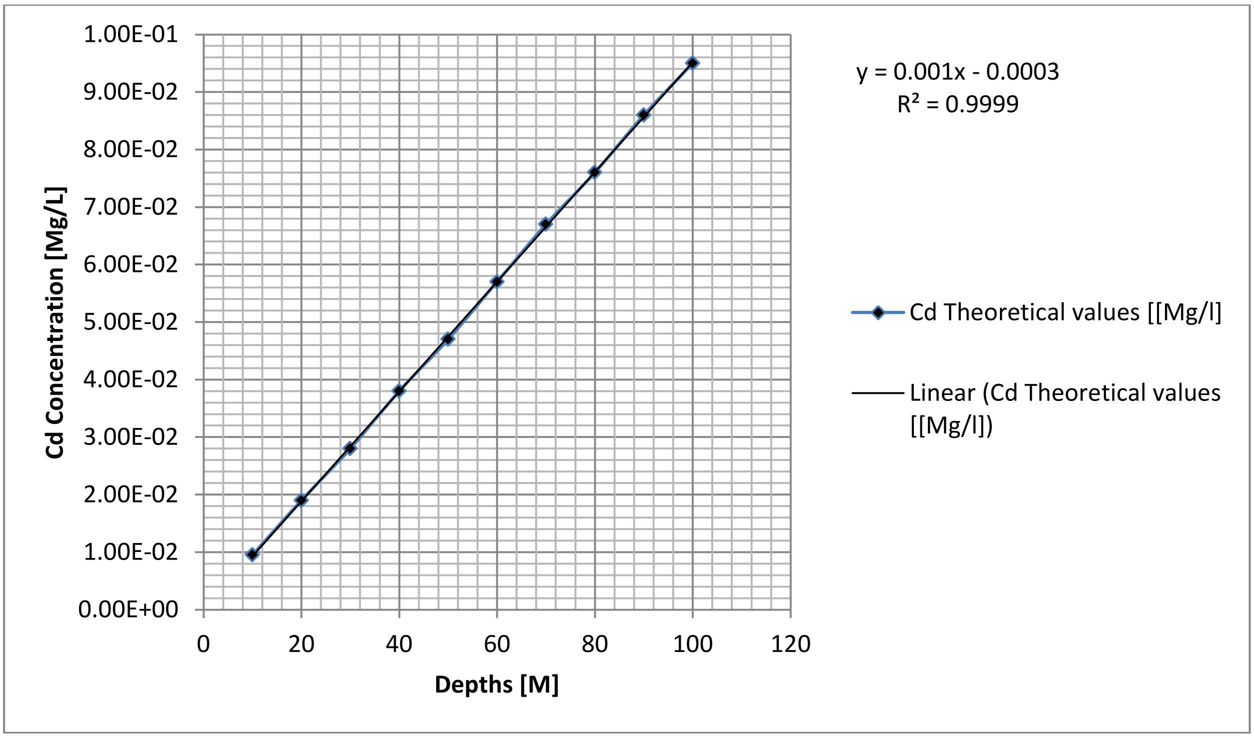

Figure: 6 concentration of the Cadmium at Different Depths

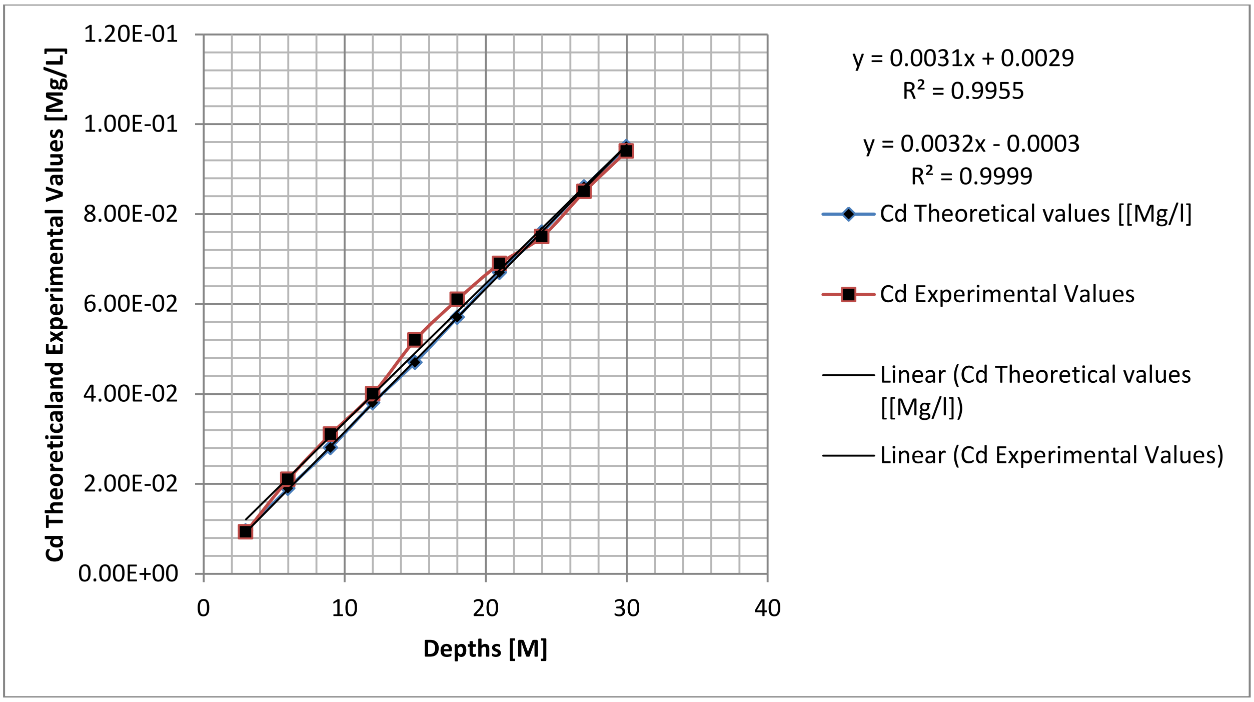

Figure: 7 Comparison of theoretical and experimental values of Cadmium at Different Depths

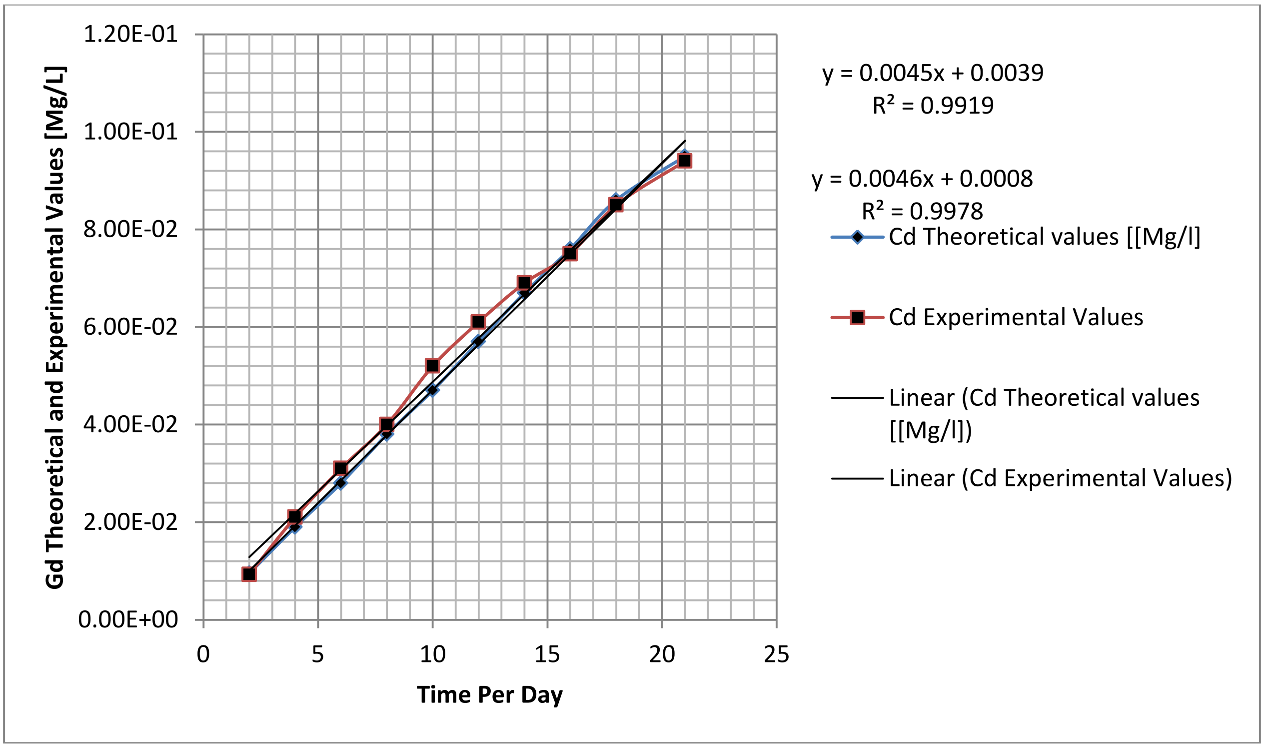

Figure: 8 Comparison of theoretical and experimental values of Cadmium at Different Depths

The figure [1-4] presented shows that the concentration gradually increase experiencing fluctuation to the point where an optimum values was recorded at thirty metres within the period of hundred days. The region experiences serious fluctuation from change in depth in lateritic to silty formation, but the focus of this study are base on the region where high degree of porosity are deposited in the study area this condition affected the time of migration of the substances, the rate of transport at those region of the formation were observed to be faster in migration, these condition were experiences through an increase reflecting on the formation characteristics influences increase in hydraulic conductive in the deposited formation, these are base on the rate of permeability in study area. Such condition influence the transport of cadmium in those location while figure [5-8] express linear migration to the point where an optimum value were recorded at thirty metres, within interval of hundred days, this implies that the contaminant are migrating in the formation base on the level of structural deposition, this implies that homogeneous setting in the study area may have influences the rate of transport process of cadmium, further pressure may be from rate of permeability in the study environments. The figures are simulated from derived governing equation that were formulated to monitor cadmium transport in permeable formations, deriving the equation, it produced a developed model that were simulated to produces theoretical values, the results were compare with experimental values, both parameters developed a favuorable fits, this comparison validated the model in the study area.

5. Conclusion

The migration of cadmium in silty and fine sand formation has been expressed, the study were to monitor the rate of cadmium at different strata to ground water aquiferous zone, the rate cadmium contamination was at paramount level developing serious negative impact on human through several ill health on them, several investigation was carried out but could not produces positive results, this condition call for better solution, modeling and simulation were found better option to establish concrete method that will prevent or engineer out the ugly scourge , results from the simulated model were compared with experimental values, both parameters developed a favuorable fit, the rate of permeability were observe to be the paramount parameter the has pressured the rate of cadmium migration to ground water aquifers, few observation of fluctuation within some region were experiences, these are base on the slight fluctuation of stratification depositing within few region of the formation. Experts will definitely apply this concept as a useful tool in preventing further migration of cadmium in aquiferous zone.

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