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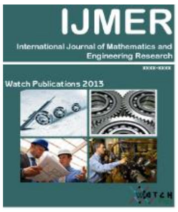

PREDICTING VARIATION OF FLOW NET DEPOSITED IN SEMI PERMEABLE FORMATION; ABUA COASTAL LOCATION, NIGER DELTA OF NIGERIA

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Abstract

Predicting the variation of flow net deposition was to monitor the behaviour of fluid in semi permeable deposited environment, the study was carried out to express several deposition of fluid flow in various strata, this development detailed the rate of flow net within the intercedes of the formation, the behaviour of flow net in semi permeable formation were reflected in the simulation values through graphical representation, the study was developed through mathematical modelling which applied this derived application, this expresses linear and vacillation phase on flow net, these were experienced in the figures showing the deposition of flow in the study area. The parameters also express the type of formation deposited in the study location, this implies that the rate of hydraulic conductivity can be determined from the simulation values; experts will definitely apply this concept in monitoring and evaluation of flow net in the study environment.

Keywords: *predicting, flow net semi permeable and formation.*

INTRODUCTION

The Niger Delta is situated at the southern end of Nigeria bordering the Atlantic Ocean. History told us that the proto delta developed in the northern part of the basin during the campanian transgression and ended with the Daleocene transgression whereby the formation of the modern delta began during the Ecocene and it continued into present day where generate the third circle that the modern Niger Delta was formed. Meanwhile before now, the beginning deposition of the Niger Delta are the Albian sediment which consisted of stone over lain conformably by cenoniana and younger upper cretaceous sediments, these deposit were laid from during a predominantly marine depositional circle. Furthermore, the first cycle was concluded by a phase of folding, faulting and uplifting occurring in santonian time and which definitely affect particularly in general Abakaliki anticurrium (Kogbe, 1989).The delta of deltaic environment of the Niger Delta Region strategraphic possible should explain the variable of the static water level in the Delta Region, explaining these variables can only be known through groundwater development i.e. construction and design once a borehole has been drilled, the water level in the borehole should be measured using a dipper, this should be done immediately after drilling, and also once water levels in the borehole have recorded (MacDonald and et al, 2005). The vertical distribution of groundwater are based on the interstices occupied partially by water and partially by air, in the zone of saturation, all interstices are filled with water under hydrostatic pressure. On most of the land masses of the earth, a single zone of aeration overlies a single zone of saturation and extends upward to the ground surface. In the zone of aeration, vadose water occurs. This general zone may be further subdivided into the soil water zone, the intermediate vadose zone, and the capillary zone. The saturated zone extends from the upper surface of saturation down to underlying impermeable rock. In the absence of overlying impermeable strata, the water table, or phreatic surface, forms the upper surface the zone of saturation. This is known to be surface atmospheric pressure and appears as the level at which water stand in a well permeating the aquifer (Todd, 2004).The static level of water in wells penetrating the zone of saturation is called the water table. The water table is often described as the subdued replica of the surface topography. It is generally higher under the hills and lower under the valleys, and a contour map of the water table in any area may look the surface topography (Garg, 2005) .Thus, the water is the surface of a water body which is constantly adjusting itself towards an equilibrium condition, with the water moving from the higher points to the lower points. If there were no recharge to or outflow from the groundwater in a basin, the water table would eventually become horizontal. But few basins have uniform recharge conditions at the surface as some areas receive more rain than others; and some portions of the basin have more permeable soil. Thus, when intermittent recharge does occur, mounds and ridges in the water table under the areas of greatest recharge; subsequent creates additional mounds perhaps at other point in the basin and the flow pattern is further changed. Meanwhile various other factors, such as variation in permeability of aquifer; impermeable strata, influence of lakes, stream and well, etc. do make the water table constantly adjusting toward equilibrium (i.e. horizontal). Because of the low flow rates in most of the aquifers, this equilibrium is rarely altered before additional disturbance occur. This is subject to the variable of the water table in the Niger Delta environment due to all these conditions causes of variable in the region (Garg, 2005). According to Garg (2004) in water table or gravity wells, when an artesian well be driven and water pumped heavily so as to cause a sufficient draw down. When the water level in the well decreases, the water level in the neighbourhood will also fall down, forming what is called inverted cone of depression all around the well, the base of this cone is a circle of radius R, known as the circle of influence; and the inclined side is known as the draw down curve. The formation in the Niger Delta are known to be unconfined aquifers, based on the water contours beneath the ground and deposit of different types of formation which may have been predominant in the terrain resulted to having variable in the regions. Aghunnath (2006) in context state that if a well is drilled into an artesian aquifer, the water level rises in the well to its natural level at the recharged surface called the piezometric surface. If the piezometric surface is above the ground level at the location of the well, the well is called flowing artesian well since the water flows out of the well like a spring, and if the piezometric surface is below the ground level at the location. In such situation, the well is known to be non-flowing artesian well. In practice, a well can be drilled through 2-3 artesian aquifers (if multiple artesian aquifers exist at different depths below ground level). Sometimes a small band of impervious strata lying above the main ground water table (GWT) holds part of the water percolating from above.

Governing equation

$$\phi \frac{d^2v}{dt^2} + \beta \frac{dv}{dt} + K\frac{dv}{dt} = 0 \quad \text{.............. (1)}$$

Nomenclature

v	=	Velocity [LT1]
ϕ	=	Porosity [-]
β	=	Void Ratio [-]
K	=	Permeability [LT1]
T	=	Time [T]

$$\phi \frac{d^2v}{dt^2} + (\beta + K)\frac{dv}{dt} = 0 \quad \text{.................... (2)}$$

Let $v = \sum_{n=0}^{\infty} \alpha_n x^n$

$$v^1 = \sum_{n=1}^{\infty} n\alpha_n x^{n-1}$$

$$v^{11} = \sum_{n=2}^{\infty} n(n-1)\alpha_n x^{n-2}$$

$$\phi \sum_{n=2}^{\infty} (n-1)\alpha_n x^{n-2} + (\beta + K)\sum_{n=1}^{\infty} n\alpha_n x^{n-1} = 0 \quad \text{............... (3)}$$

Replace n in the 1st term by n+2 and in the 2nd term by n+1, so that we have;

$$\phi \sum_{n=0}^{\infty} (n+2)(n+1)\alpha_{n+2} x^n + (\beta + K)\sum_{n=0}^{\infty} (n+1)\alpha_{n+1} x^n = 0 \quad \text{............ (4)}$$

i.e.

$$\phi \sum_{n=0}^{\infty} (n+2)(n+1)\alpha_{n+2} x^n + (\beta + K)\sum_{n=0}^{\infty} (n+1)\alpha_{n+1} = 0 \quad . \quad \text{................ (5)}$$

$$\alpha_{n+2} = -\frac{(\beta + K)(\alpha + 1)(\alpha_{n+1})}{\phi_{(n+2)(n+1)}} \quad \text{...................... (6)}$$

$$\alpha_{n+2} = -\frac{(\beta + K)\alpha_{n+1}}{\phi_{(n+2)}} \quad \text{...................... (7)}$$

For $n = 0,\ \alpha_2 = -\frac{(\beta + K)\alpha_1}{2\phi}$ .... (8)

For $n = 1,\ \alpha_3 = -\frac{(\beta + K)\alpha_2}{3\phi} = \frac{(\beta + K)^2 \alpha}{2\phi \cdot 3\phi}$ .... (9)

For $n = 2,\ \alpha_4 = -\frac{(\beta + K)\alpha_3}{4\phi} = \frac{(\beta + K)}{4\phi} \bullet \frac{(\beta + K)\alpha_1}{3\phi \cdot 2\phi} - \frac{(\beta + K)}{4\phi \cdot 3\phi \cdot 2\phi}$ .... (10)

For $n = 3,\ \alpha_5 = -\frac{(\beta + K)}{5\phi} + \frac{(\beta + K)^4 a_1}{5\phi \cdot 4\phi \cdot 3\phi \cdot 2\phi}$ .... (11)

For $n: \alpha_n = \dfrac{(-1)^n(\beta+K)^{n-1}a_1}{\phi^{n-1}n!}$ .... (12)

$$C(x)=\alpha_0+\alpha_1 t-\alpha_2 t^2+\alpha_3 t^3-\alpha_4 t^4+\alpha_5 t^5+......\alpha_n{}^n \quad (13)$$

$$= \alpha_0+\alpha_1 t-\frac{(\beta+K)\alpha_1 t^2}{2!\phi}+\frac{(\beta+K)\alpha_1 t^3}{3!\phi 2}-\frac{(\beta+K)t^4}{4!\phi 3}+\frac{(-1)^n(\beta+K)\alpha_1 t^5}{5!\phi 4}+... \quad (14)$$

$$C(x)=\alpha_0+\alpha_1\left[t-\frac{(\beta+K)t^2}{2!\phi}+\frac{(\beta+K)t^3}{3!\phi 2}-\frac{(\beta+K)t^4}{4!\phi 3}+\frac{(\beta+K)^4 t^5}{5!\phi 4}+...\right]. \quad (15)$$

$$C(t)=\alpha_0+\alpha_1\ell^{-\frac{(\beta+K)}{\phi}t} \quad (16)$$

If $t=\dfrac{d}{v}$

$$C(t)=\alpha_0+\alpha_1\ell^{-\frac{(\beta+K)}{\phi}\frac{d}{v}} \quad (17)$$

While $d=v\bullet t$, this also implies that it can be expressed as:

$$C(t)=\alpha_0+\alpha_1\ell^{-\frac{(\beta+K)}{\phi}v\bullet t} \quad (18)$$

MATERIALS AND METHOD

Standard laboratory experiment where performed to monitor velocity of flow net at different formation, the soil deposition of the strata were collected in sequences base on the structural deposition at different locations, this samples collected at different location generate variation at different depth producing different flow net at different strata, the experimental result are applied to be compared with the theoretical values to determine the validation of the model.

RESULT AND DISCUSSION

Results and discussion are presented in tables 1- 8 including figures representation of conynebacterium concentration.

Table 1: Predictive Values of Velocity of Flow at Different Depth

Depth [M]	Velocity of Flow in Silty Bed
3	7.22E-04
6	1.44E-03
9	2.16E-03
12	2.89E-03
15	3.61E-03
18	4.36E-03
21	5.05E-03
24	5.78E-03
27	6.50E-03
30	7.22E-03
33	7.94E-03
36	8.67E-03
39	9.39E-03

The study express the behaviour of the system in terms of migration at different flow net in the soil, these characterize various influences on direction of flow between the intercedes of the formation, the flow net of formation express various velocity in the formation, based on these factors, the behaviour of flow net are through these following expression. Figure one and two shows how the system experiences linearly migration of flow net, the direction of flow net may be influenced by structure sorting of the grain size deposition in different bed. This may have pressure the direction of flow net in linear phase. While figure two deposition are different from one, the direction flow were observed to have been pressured by the fluctuation deposition of porous medium, the direction of flow express these vacillation phase where the flow maintained exponential state between three and twelve metres, sudden decrease were observed from fifteen and eighteen metres, thus fluctuation also were experiences between twenty one and twenty seven metres, while linear flow net were finally observed from twenty seven to thirty nine metres figure five and six express similar behaviour like that of three and four, exponential migration of flow net were experiences between ten and fifty days, the velocity of flow net within some certain region were reflected through deposition of the stratification, sudden decrease on velocity were experienced between fifty to hundred and twenty days, linear in homogeneous setting were experienced from ninety to hundred and forty days, the velocity of flow express the type of structural strata that deposit in the formation thus indicating that their hydraulic conductivity are very low. more so exponential phase were observed in figure six, the direction of flow net experienced linear migration, this condition can attributed to homogeneous setting including it rate of hydraulic conductivity, the study express various influence on flow net in the formation, their relationship with other formation characteristics, the expression of flow net are reflected on the strata , this implied that the develop model monitor this direction of flow to determine yield coefficient in such deltaic formation

Table 2: Predictive and validate Values of Velocity of Flow at Different Depth

Depth [M]	Predicted Values Velocity of Flow	Validate Velocity of Flow
3	7.22E-04	7.87E-04
6	1.44E-03	1.55E-03
9	2.16E-03	2.44E-03
12	2.89E-03	3.23E-03
15	3.61E-03	3.98E-03
18	4.36E-03	4.89E-03
21	5.05E-03	5.54E-03
24	5.78E-03	6.14E-03
27	6.50E-03	6.98E-03
30	7.22E-03	7.55E-03
33	7.94E-03	8.21E-03
36	8.67E-03	9.15E-03
39	9.39E-03	9.77E-03

Table 3: Predictive Values of Velocity of Flow at Different Depth

Depth [M]	Velocity of Flow in Silty Bed
3	7.15E-05
6	1.45E-04
9	2.17E-04
12	2.90E-04
15	3.65E-05
18	4.38E-05
21	5.11E-06
24	5.84E-05
27	6.50E-06
30	7.31E-06
33	8.04E-06
36	8.77E-06
39	9.50E-06

Table 4: Predictive and validate Values of Velocity of Flow at Different Depth

Depth [M]	Predicted Values Velocity of Flow	Validate Velocity of Flow
3	7.15E-05	7.24E-05
6	1.45E-04	1.64E-04
9	2.17E-04	2.23E-04
12	2.90E-04	3.01E-04
15	3.65E-05	3.89E-05
18	4.38E-05	4.55E-05
21	5.11E-06	5.34E-06
24	5.84E-05	6.11E-05
27	6.50E-06	6.77E-06
30	7.31E-06	7.45E-06
33	8.04E-06	8.34E-06
36	8.77E-06	8.87E-06
39	9.50E-06	9.98E-06

Table 5: Predictive Values of Velocity of Flow at Different Depth

Time Per Day	Velocity of Flow in Silty Phreatic Bed
10	4.24E-03
20	8.49E-03
30	1.27E-02
40	1.69E-02
50	2.12E-02
60	2.54E-02
70	2.97E-02
80	3.39E-02
90	3.32E-02
100	4.20E-02
110	4.67E-02
120	5.00E-02

Table 6: Predictive and validate Values of Velocity of Flow at Different Depth

Time Per Day	Predicted Values Velocity of Flow	Validate Velocity of Flow
10	4.24E-03	4.34E-03
20	8.49E-03	8.76E-03
30	1.27E-02	1.44E-02
40	1.69E-02	1.88E-02
50	2.12E-02	2.45E-02
60	2.54E-02	2.77E-02
70	2.97E-02	3.12E-02
80	3.39E-02	3.66E-02
90	3.32E-02	3.78E-02
100	4.20E-02	4.66E-02
110	4.67E-02	4.88E-02
120	5.00E-02	5.23E-02

Table 7: Predictive Values of Velocity of Flow at Different Depth

Time Per Day	Velocity of Flow in Silty Bed
10	4.29E-04
20	8.59E-04
30	1.28E-03
40	1.71E-03
50	2.14E-03
60	2.57E-04
70	3.00E-04
80	3.43E-04
90	3.86E-04
100	4.29E-04
110	4.72E-04
120	5.15E-04

Table 8: Predictive and validate Values of Velocity of Flow at Different Depth

Time Per Day	Predicted Values Velocity of Flow	Validate Velocity of Flow
10	4.29E-04	4.67E-04
20	8.59E-04	7.88E-04
30	1.28E-03	1.12E-03
40	1.71E-03	1.66E-03
50	2.14E-03	2.09E-04
60	2.57E-04	2.45E-04
70	3.00E-04	2.89E-04
80	3.43E-04	3.23E-04
90	3.86E-04	3.77E-04
100	4.29E-04	4.12E-04
110	4.72E-04	4.55E-04
120	5.15E-04	4.89E-04

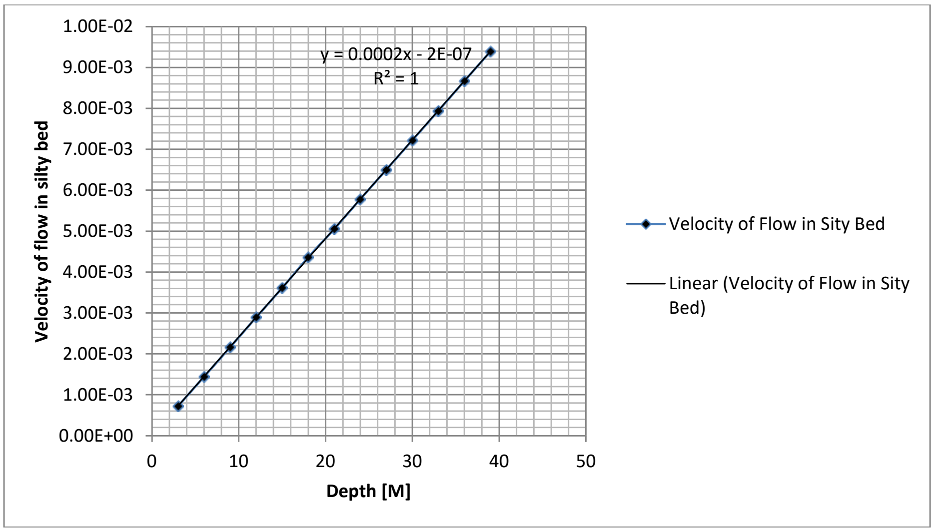

Figure 1: Predictive Values of Velocity of Flow at Different Depth

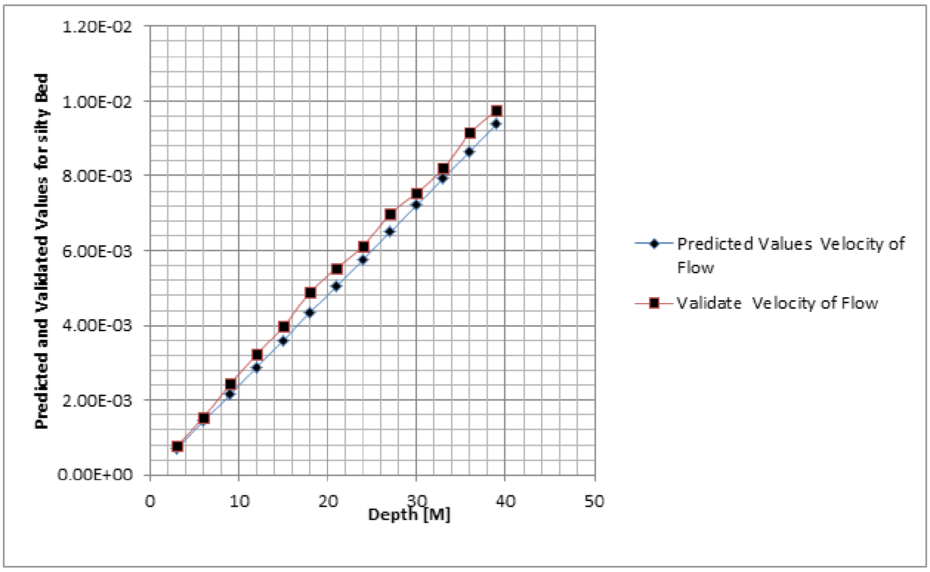

Figure 2: Predictive and validate Values of Velocity of Flow at Different Depth

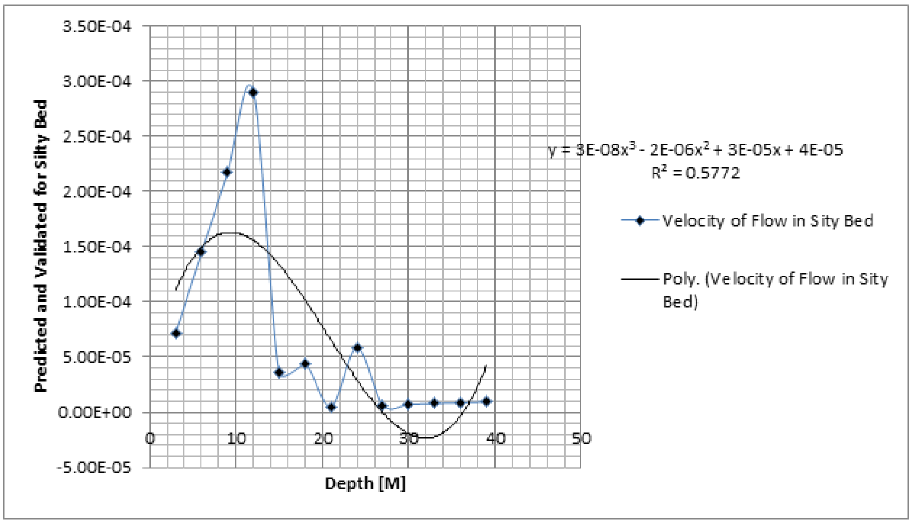

Figure 3: Predictive Values of Velocity of Flow at Different Depth

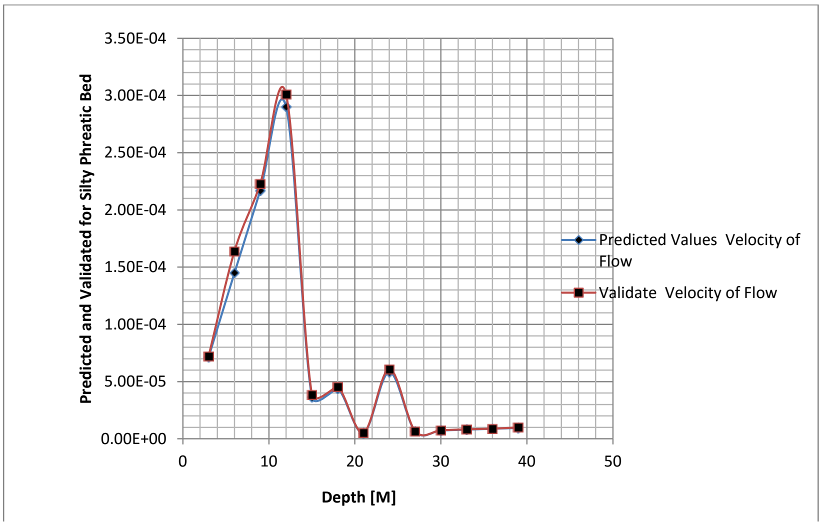

Figure 4: Predictive and validate Values of Velocity of Flow at Different Depth

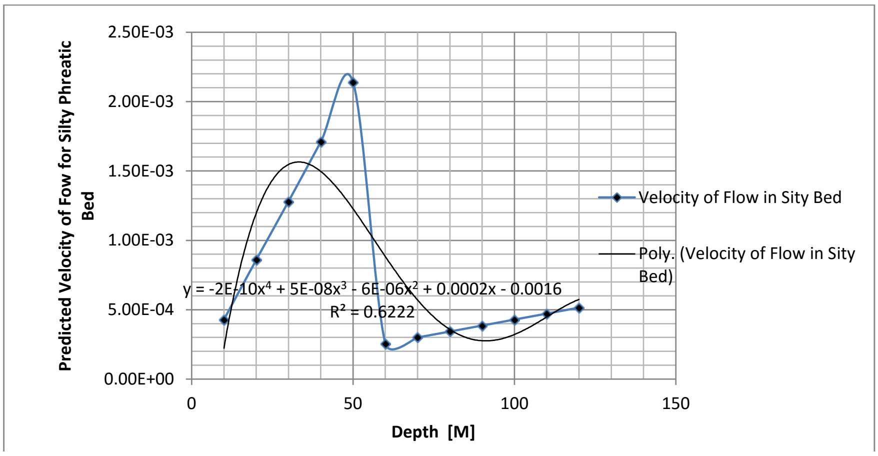

Figure 5: Predictive Values of Velocity of Flow at Different Time

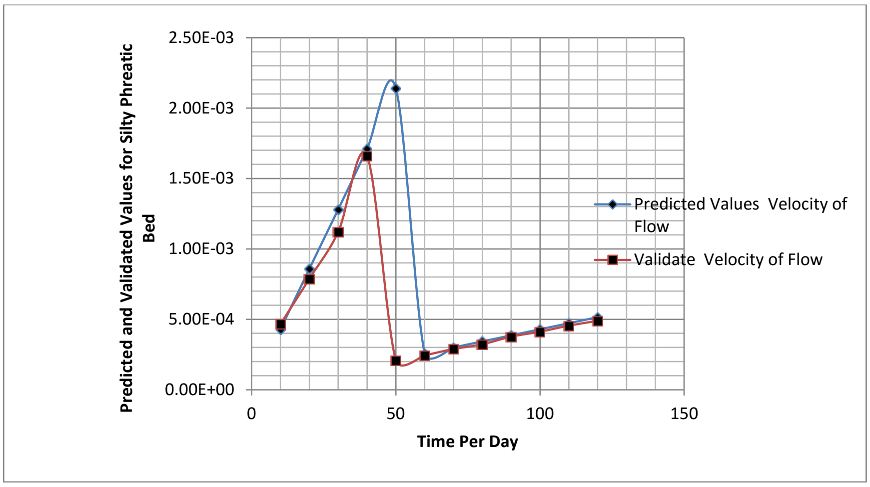

Figure 6: Predictive and validate Values of Velocity of Flow at Different Time

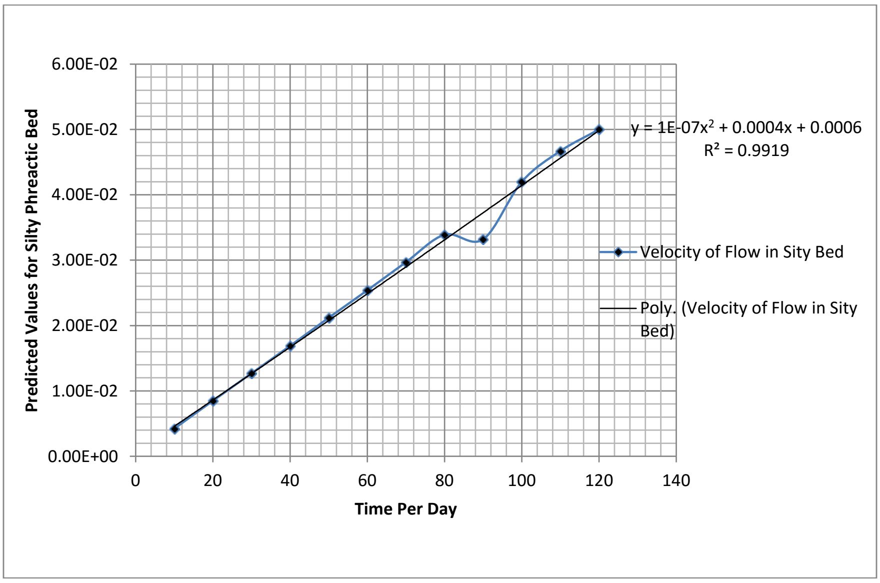

Figure 7: Predictive Values of Velocity of Flow at Different Time

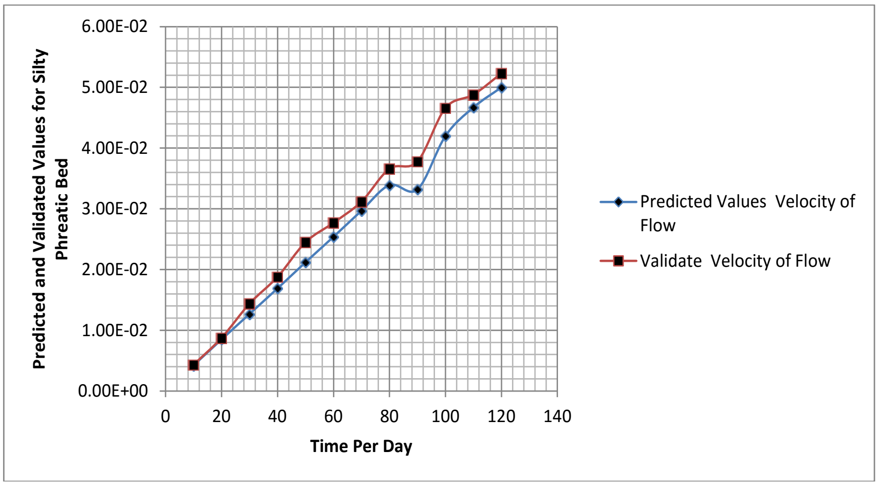

Figure 8: Predictive and validate Values of Velocity of Flow at Different Time

CONCLUSION

Flow net depositions in semi permeable environment were expressed through these mathematical modelling methods. The study were to examine the behaviour of flow net in pore distribution within the structural stratatification of such soil in deltaic formation, variation on exponential state including vacillation strata setting were observed through the simulation parameters. Such deposition are noted to reflect on the sort depositional structure were fluid flow pass through the macropores of the formations, these application were conceptualize to determined other approach of monitoring and evaluation of flow net in the deltaic formations. The velocity rates found in the study area were observed to reflect on the rate of structural strata that deposit in the study environment. The rate of hydraulic conductivity were observed through the simulation parameters, theoretical and experimental values were compared to developed faviourable fits, both parameters express best fits validating the developed modelling and simulation values.

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