International Journal of Emerging Engineering Research and Technology
Volume 6, Issue 2, 2018, PP 37-46
ISSN 2349-4395 (Print) & ISSN 2349-4409 (Online)

Predicting Heterogeneous Velocity of Flow on Penetrating Confined Bed Influenced by Permeability and Porosity

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ABSTRACT

This paper monitors the deposition of heterogeneous velocity of flow in sand gravel formation. The system tries to predict the influences from predominant formation characteristics, the developed model from the derived solution where to evaluate the rate at which the heterogeneous structured deposition reflect on the dynamics of velocity of flow in sand grave formation, the system generated simulation values that express fluctuation of velocity at different depth to phreatic beds, the derived model simulation values were subjected to validation, both parameters developed favorable fits, lots of works done by some researchers do monitored velocity of flow on stratum, which cannot evaluate the comprehensive velocity of flow in predominant sand grave depositions, fluctuation observed from the study show the geological setting from the heterogeneous structure strata observed from the study area, the research is imperative because the dynamic deposition of fluid flow velocity has been monitored, signification influences has been expressed from the developed model, the study will definitely be relevant to experts due to its thorough evaluation in the system including that on penetrating confined bed in study location.

Keywords: *predicting, Heterogeneous velocity, permeability and porosity.*

INTRODUCTION

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 Eluozo et al 2012a Eluozo and Nwofor 2012).

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 Eluozo et al 2012c; Eluozo et al 2012d Eluozo et al 2012f) .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 (Akpila and Eluozo 2012). 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 (Eluozo 2012). Thus, when intermittent recharge does occur, mounds and ridges in the water table under the areas of greatest recharge; subsequent recharge 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) (Eluozo 2012a Eluozo 2012b; Ikenyiri 2012a Ikenyiri 2012b). 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 neighborhood 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 23 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 (Eluozo 2012b;2012c).

GOVERNING EQUATION

$$\bar{V}\frac{\partial h}{\partial z} = \frac{Kh^2}{\phi}\frac{\partial h^2}{\partial z^2} \qquad (1)$$

Substituting solution $h = ZT$ into equation (1), we have:

$$\bar{V}\; Z^1T = \frac{Kh^2}{\phi}Z^1T \qquad (2)$$

$$V\frac{T^1}{T} = \frac{Kh}{\phi}\frac{Z^1}{Z} \qquad (3)$$

$$V\frac{T^1}{T} = \frac{Kh}{\phi}\left[\frac{Z^1}{Z}\right] \qquad (4)$$

$$V\frac{T^1}{T} = \frac{Z^1}{Z} \qquad (5)$$

Considering when in $Z = \to 0$

$$V\frac{T^1}{T} = \frac{Kh}{\phi}\frac{Z^1}{Z} = \lambda^2 \qquad (6)$$

$$V\frac{T^1}{T} = -\lambda^2 \qquad (7)$$

$$V\frac{Z^1}{Z} = \lambda^2 \qquad (8)$$

$$V\frac{T^1}{T} = \lambda^2 \qquad (9)$$

This implies that equation (9) can be expressed as:

$$\frac{Kh}{\phi}\frac{Z^1}{Z} = \lambda^2 \qquad (10)$$

$$\frac{Kh}{\phi}\frac{Z^1}{Z} = \frac{dy}{dz} = \lambda^2 \qquad (11)$$

$$VT\frac{dy}{dz} = \lambda^2 \qquad (12)$$

$$\frac{dy}{dz} = \frac{\lambda^2}{VT} \qquad (13)$$

$$dy = \left[\frac{\lambda^2}{VT}\right]dz \qquad (14)$$

$$\int dy = \int\frac{\lambda^2}{VT}dz \qquad (15)$$

$$dy = \frac{\lambda^2}{VT}dz \qquad (16)$$

$$\frac{dy}{dz} = \frac{\lambda^2}{VT} \qquad (17)$$

$$dy = \frac{\lambda^2}{VT}dz \qquad (18)$$

$$\int dy = \int\frac{\lambda^2}{VT}dz + C_1 \qquad (19)$$

$$y = \frac{\lambda^2}{VT}\int dz + C_1 \qquad (20)$$

$$\frac{\lambda^2}{VT}z + C_1 \qquad (21)$$

$$\Rightarrow y = \frac{\lambda^2}{VT}z + C_1 \qquad (22)$$

Applying quadratic expression we have:

$$Z = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \tag{23}$$

Where $a = \lambda^2, b = \overline{V}, c = C_1$

$$Z = \frac{-\left(\lambda^2\right) \pm \sqrt{\lambda^2 - 4\overline{V}c}}{2\overline{V}} \tag{24}$$

$$Z = \frac{-\lambda + \sqrt{\lambda^2 - 4\overline{V}c}}{2\overline{V}} \tag{25}$$

$$Z = \frac{-\lambda - \sqrt{\lambda^2 - 4\overline{V}c}}{2\overline{V}} \tag{26}$$

Substituting (26) into the following boundary conditions

$$Z = 0 \quad h = 0 \tag{27}$$

Therefore

$$Z_{(t)} = C_1 \ell^{-M_1 Z} + {}^{M_2 Z} \tag{28}$$

$$C_1 \, Cos M_1 Z + Sin \, M_2 Z \tag{29}$$

$$y = \frac{\lambda^2}{VT} = C_1 \tag{30}$$

$$h(z,t) = \left(C_1 \, Cos M_1 z \; Sin \, M_2 z\right) \tag{31}$$

But if $T = \frac{d}{V}$

Therefore, equation (31) will be expressed as:

$$h(z,t) = \left(C_1 \, Cos M_1 \frac{\lambda^2}{VT} \frac{d}{V} + Sin \, M_2 \frac{\lambda^2}{VT} \frac{d}{V}\right) \tag{32}$$

Also if Z = V.T Therefore the expression equation in [32] can be written as:

$$h(z,t) = \left(C_1 \, Cos M_1 V.T \frac{d}{V} + Sin \, M_2 \frac{\lambda^2}{VT} V.T\right) \tag{32}$$

MATERIALS AND METHOD

Standard laboratory experiments were performed to monitor the velocity of flow at depositions in different formation. The soil strata were collected in sequences base on the structural deposition at different locations. The samples collected at different locations generated variation at different depths producing different velocity of through pressure flow at different strata. The experimental results are applied and compared with the theoretical values to determine the model validation.

RESULT AND DISCUSSION

Table1. *Velocity of flow at Different Depth*

Depth [M]	Velocity of Flow[M/s]
3	9.86E-03
6	5.95E-03
9	7.73E-03
12	5.94E-03
15	3.28E-02
18	3.54E-02
21	3.80E-02
24	2.06E-02
27	2.32E-02
30	2.57E-02

Table2. *Velocity of flow at Different Time*

Time Per Day	Velocity of Flow[M/s]
10	9.86E-03
20	5.95E-03
30	7.73E-03
40	3.94E-04
50	1.28E-04
60	1.54E-04
70	1.80E-04
80	2.06E-03
90	2.32E-03
100	2.57E-03

Table3. *Predictive and Measure values for Velocity of flow at Different Depth*

Depth [M]	Predicted Velocity of Flow[M/s]	Measured Velocity of Flow[M/s]
3	9.86E-03	9.56E-03
6	5.95E-03	5.77E-03

9	7.73E-03	7.45E-03
12	5.94E-03	3.88E-03
15	3.28E-02	3.33E-02
18	3.54E-02	3.66E-02
21	3.80E-02	3.85E-02
24	2.06E-02	2.21E-02
27	2.32E-02	2.44E-02
30	2.57E-02	2.45E-02

Table4. *Predictive and Measure values for Velocity of flow at Different Time*

Time Per Day	Predicted Velocity of Flow[M/s]	Measured Velocity of Flow[M/s]
10	9.86E-03	9.56E-03
20	5.95E-03	5.77E-03
30	7.73E-03	7.45E-03
40	5.94E-04	5.88E-04
50	4.28E-04	4.33E-04
60	3.54E-04	3.66E-04
70	3.80E-04	3.85E-04
80	2.06E-03	2.21E-03
90	2.32E-03	2.44E-03
100	2.57E-03	2.45E-03

Table5. *Velocity of flow at Different Depth*

Depth [M]	Velocity of Flow[M/s]
3	7.60E-03
6	1.52E-03
9	1.50E-03
12	3.05E-03
15	3.82E-04
18	4.58E-04
21	5.35E-04
24	6.11E-04
27	6.88E-05
30	7.64E-05

Table6. *Velocity of flow at Different Time*

Time Per Day	Velocity of Flow [M/s]
10	7.60E-04
20	1.52E-03
30	1.50E-03
40	3.05E-03
50	3.82E-04
60	4.58E-04
70	5.35E-04
80	6.11E-05
90	6.88E-05
100	7.64E-05

Table7. *Predictive and Measure values for Velocity of flow at Different Depth*

Depth [M]	Predicted Velocity of Flow[M/s]	Measured Velocity of Flow [M/s]
3	7.60E-03	7.44E-03
6	1.52E-03	1.66E-03
9	1.50E-03	1.57E-03
12	3.05E-03	3.11E-04
15	3.82E-04	3.77E-04
18	4.58E-04	4.66E-04
21	5.35E-04	5.55E-04
24	6.11E-04	6.22E-05
27	6.88E-05	6.66E-05
30	7.64E-05	7.87E-05

Table8. *Predictive and Measure values for Velocity of flow at Different Time*

Time Per Day	Predicted Velocity of Flow[M/s]	Measured Velocity of Flow [M/s]
10	7.60E-04	7.44E-04
20	1.52E-03	1.66E-03
30	1.50E-03	1.57E-03
40	3.05E-03	3.11E-03
50	3.82E-04	3.77E-04
60	4.58E-04	4.66E-04
70	5.35E-04	5.55E-04
80	6.11E-05	6.22E-05
90	6.88E-05	6.66E-05
100	7.64E-05	7.87E-05

Table9. *Velocity of flow at Different Depth*

Depth [M]	Velocity of Flow [M/s]
3	2.93E-03
6	3.87E-03
9	5.81E-03
12	7.75E-03
15	9.68E-04
18	8.28E-04
21	8.35E-04
24	7.55E-04
27	6.74E-03
30	5.93E-03
33	5.13E-03
36	5.32E-03

Table10. *Velocity of flow at Different Time*

Time Per Day	Velocity of Flow[M/s]
10	2.83E-03
20	3.77E-03
30	5.61E-03
40	7.65E-03
50	9.66E-05
60	8.58E-04
70	8.55E-04
80	7.65E-04
90	6.54E-02
100	5.43E-02
110	5.33E-02
120	5.52E-02

Table11. *Predictive and Measure values for Velocity of flow at Different Depth*

Depth [M]	Predicted Velocity of Flow [M/s]	Measured Velocity of Flow [M/s]
3	2.93E-03	2.88E-03
6	3.87E-03	3.77E-03
9	5.81E-03	5.78E-03
12	7.75E-03	7.67E-03
15	9.68E-04	9.56E-04
18	8.28E-04	8.32E-04
21	8.35E-04	8.44E-04
24	7.55E-04	8.65E-04
27	6.74E-03	6.88E-03
30	5.93E-03	5.88E-03
33	5.13E-03	5.24E-03
36	5.32E-03	5.44E-03

Table12. *Predictive and Measure values for Velocity of flow at Different Time*

Time Per Day	Predicted Velocity of Flow [M/s]	Measured Velocity of Flow [M/s]
10	2.83E-03	2.78E-03
20	3.77E-03	3.91E-03
30	5.61E-03	5.89E-03
40	7.65E-03	7.88E-03
50	9.66E-05	9.77E-05
60	8.58E-04	8.88E-04
70	8.55E-04	8.45E-04
80	7.65E-04	7.66E-04
90	6.54E-02	6.88E-02
100	5.43E-02	5.95E-02
110	5.33E-02	5.23E-02
120	5.52E-02	5.47E-02

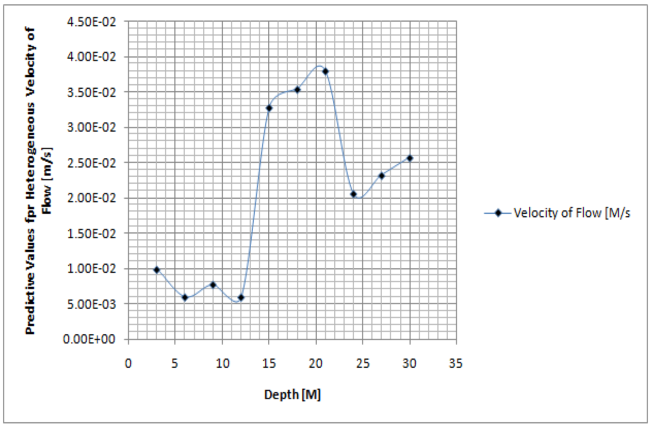

Figure1. *Velocity of flow at Different Depth*

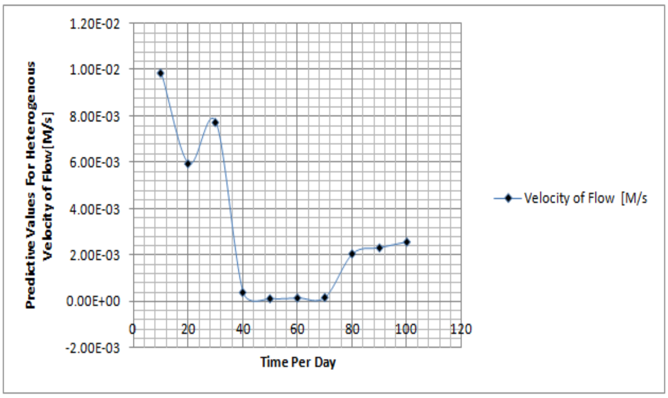

Figure2. *Velocity of flow at Different Depth*

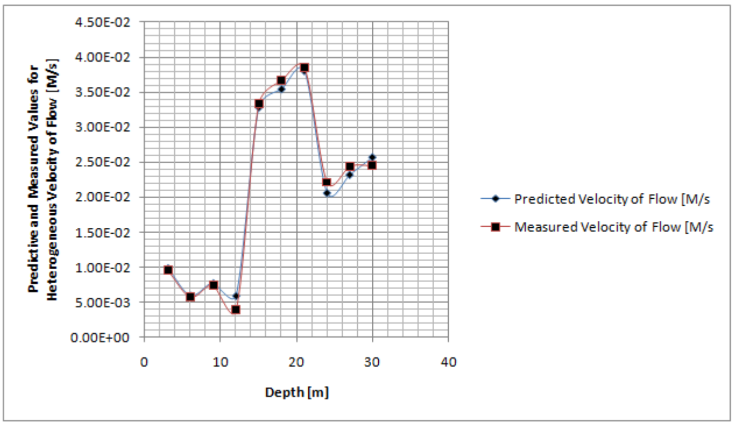

Figure3. *Predictive and Measure values for Velocity of flow at Different Depth*

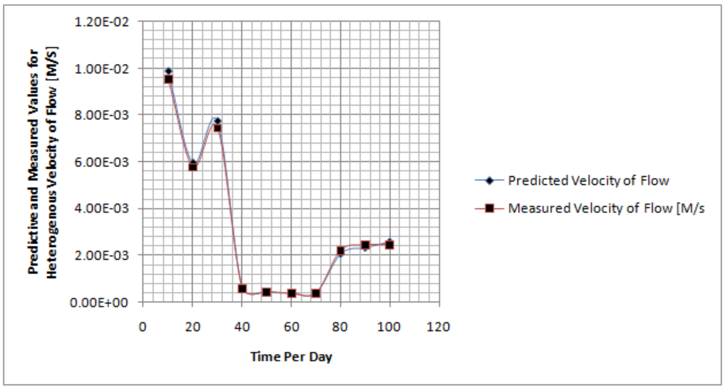

Figure4. *Predictive and Measure values for Velocity of flow at Different Time*

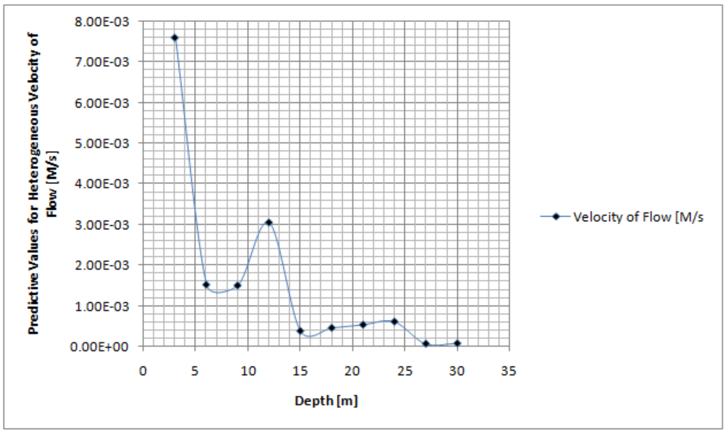

Figure5. *Velocity of flow at Different Depth*

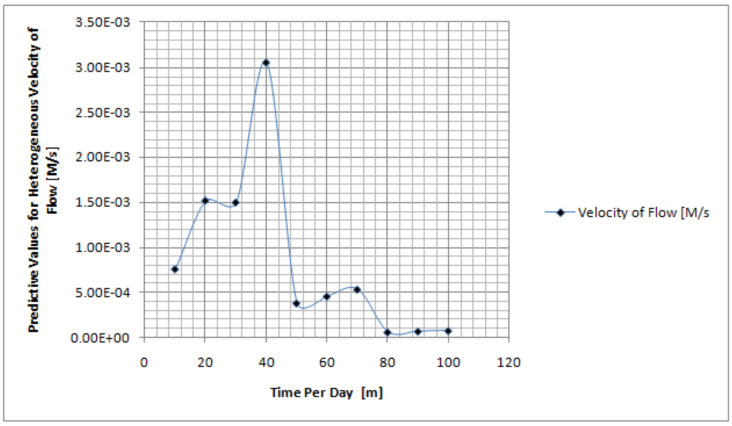

Figure6. *Velocity of flow at Different Time*

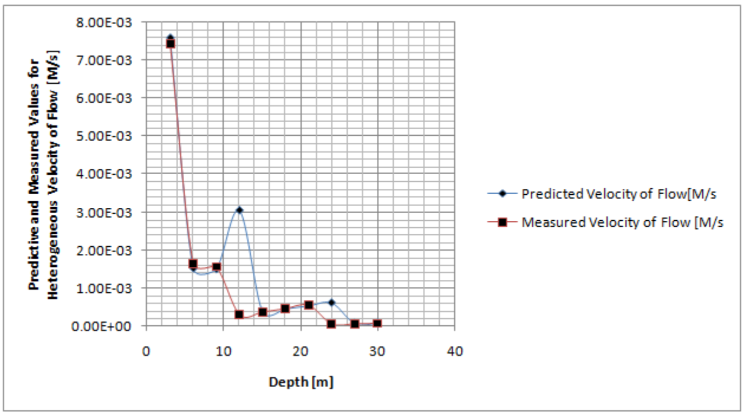

Figure7. *Predictive and Measure values for Velocity of flow at Different Depth*

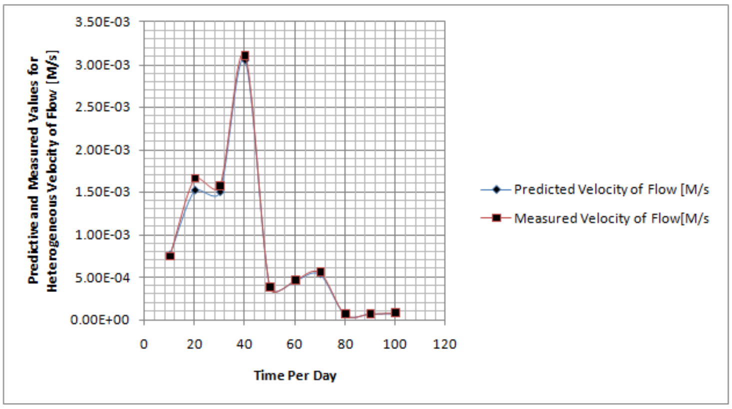

Figure8. *Predictive and Measure values for Velocity of flow at Different Time*

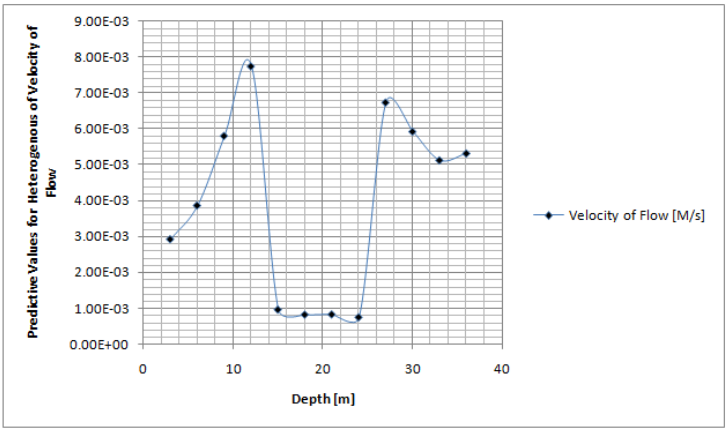

Figure9. *Velocity of flow at Different Depth*

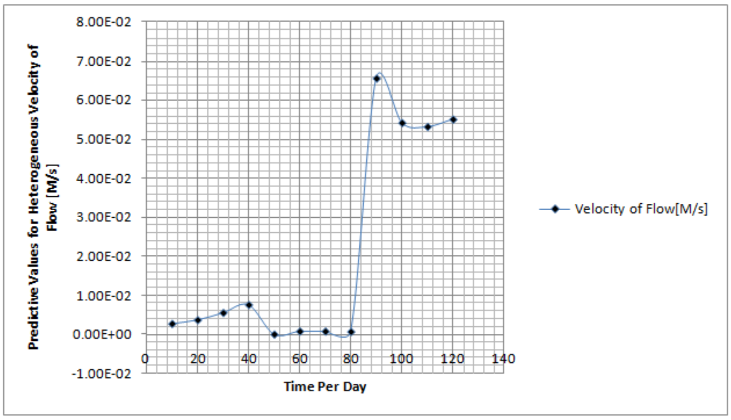

Figure10. *Velocity of flow at Different Time*

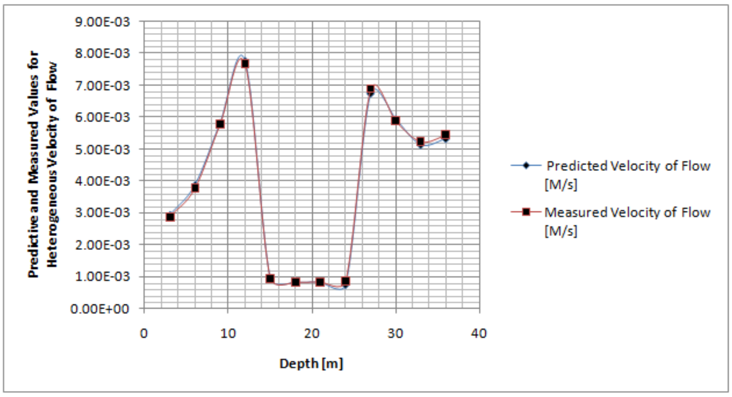

Figure11. *Predictive and Measure values for Velocity of flow at Different Time*

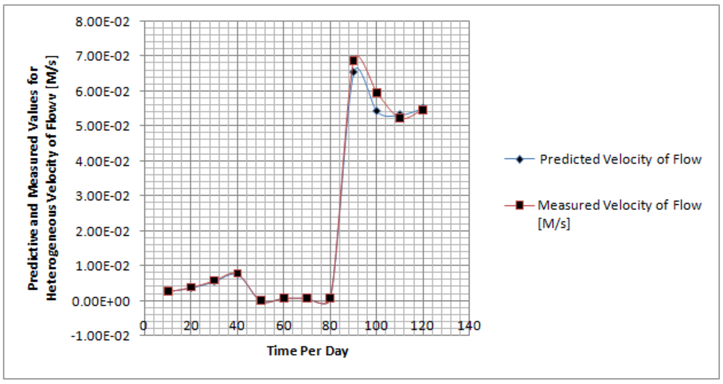

Figure12. *Predictive and Measure values for Velocity of flow at Different Time*

The study has express several ways that has reflected the deposition of velocity in heterogeneous setting, figure [1] shows fluctuation observed between 3- 15m sudden increase were observed where the optimum were recorded at 21m, but decrease where finally observed to the minimum rate of flow recorded at 30m. the figure also observed sudden increase in 3m where fluctuation were experienced, while sudden decrease were experienced with oscillation between 40-80days, but maintained slight constant flow, figure 3 and 4 expressed their best fits by observing various level of flows within the intercedes of the strata. Figure 5 experienced exponential phase at 3m thus observed sudden decrease with vacillation between 6-30m where the low rate of flow where recorded. Figure 6 in similar condition from 5 maintained vacillations between 10 - 40days thus observed optimum flow at 60days and experienced sudden decrease in flow with slight fluctuation to minimum rate recorded at 100days, figure 7 and 8 maintained best fits comparing the predictive and measured rate of flow. Figure 9 developed gradual increase in flows and suddenly experiences decrease where the minimum flow rates were experienced between 9-20m,sudeen increase were observed to the optimum thus developing slight fluctuation between 27-30m, while figure 10 experienced gradual increase of flow with slight fluctuation between 10-80days, exponential increase in flow where experiences at 90m with slight fluctuation between 100-120, figure 11 and 12 experiences best fits comparing the predictive and measured values.

CONCLUSION

The study has monitor the heterogeneity of flow on various structure of sand gravel deposition, the study consider the geological deposition in the environment and the dynamic in the structure strata, it also include the predominant formation characteristics observed in the study environment, these parameter were found to create serious impact on velocity of slow in heterogeneous velocity in sand gravel formation. Predictive model developed from derived solution where generated for simulation, the predictive values obtained from simulation where subjected to model validation, both parameters experienced favorable fits, these has express the behaviour of structured strata in heterogeneous setting, it has also streamline the rate of predominant formation characteristic in sand grave deposition on heterogeneous setting.

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Citation: *S. Eluozo and K. Oba, "Predicting Heterogeneous Velocity of Flow on Penetrating Confined Bed Influenced by Permeability and Porosity", International Journal of Emerging Engineering Research and Technology, vol. 6, no. 2, pp. 37-46, 2018.*