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Modelling and Simulation to Monitor Heterogeneity Deposition of Permeability Influenced by Porosity in Fine Sand Formation, Yenagoa Coastal Location

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Abstract: This paper expresses the rate of permeability flow monitored at various locations in deltaic environment of Yenagoa. The depositions of permeability were to determine the rate of Phreatic deposition including yield rate in the study location. Monitoring permeability in heterogeneous fine sand formation in Phreatic bed has not been thorough carried out in deltaic formations, the negligence of yield rate prediction has been generating design failure in ground water and well design, monitoring and evaluation of ground water flow system has not been thorough determined, these has developed lots of abortive wells due to negligence in water well construction, base on these conditions, modeling approach to predict the variation depositions of permeability were found imperative, the derived model generated predictive values, these were simulated to produce theoretical values validated with experimental data, both parameters developed faviouravly fits, experts in ground water engineering will found the model useful in their design and construction of water wells.

Keywords: Modeling and Simulation, Heterogeneity Permeability, Porosity, Fine Sand Formation

1. Introduction

The study of water resources has been carried out in several ways by different experts, this include watershed with advancing to streams, and groundwater recharge. It can be examined through prediction from stream hydrograph separation as it examined [1, 2 and 3]. The appliance of base-flow discharge for estimation of recharge is pedestal on a water-budget applications, these is through recharge equated to discharge. The methods are through Base-flow discharge, however, it is not necessary or directly equated to recharge, but it is due to pump age, including evapotranspiration and underflow to deep aquifers found to be important. For certainty, it is observed that there are other discharge components. These should be predictable autonomously [16, 17]. Base on these conditions, the application of Bank storage may make difficult hydrograph examination, because water discharging from bank storage is generally derived from Short-term vacillations in surface-water flow thus not from areal aquifer recharge, this could result in over prediction of recharge. A variety of approaches are applied for hydrograph separation, this include digital filtering [11] expressed recession curve displacement techniques [12]. Over longer times recharge can be predictable by rundown of approximation over shorter times. Current advancement, it has been made on the application of chemical and isotopic method to deduce the foundations of stream flow from end constituents; these include rainfall, soil water, groundwater, and bank storage [5, 6, and 7]. This concept is data intensive, but it makes available information that is functional in conducting hydrograph separation. [6, 13 and 14] applied sodium concentrations in a two-component integration model to decide the subsurface contribution to three alpine streams in Colorado. As a substitute to stream gauge, heat can be applied as a tracer to supply information on when surface water is flowing in ephemeral streams, it will give other information about the estimation on infiltration from surface-water bodies [13, 14, and 15]. These Examine variations of depths, it also depends on time scales, sediment types, and anticipated water fluxes beneath the stream. Modeling Watershed (rainfall/runoff) is applied to approximate recharge rates over huge areas. [12, 13, 14 15 and 16] assess many watershed models, and it definitely provides normal recharge estimates as a residual term in the water-budget equations [1, 2, 3, and 4]. More so Unsaturated- zone techniques for predicting recharge are applied typically in semiarid and arid regions, where the unsaturated zone is usually thick. These procedures are explained in detail [7, 8, 9, and 10]. The recharge calculates approximately in general the application of smaller spatial scales than those calculated from surface-water or groundwater approaches. Unsaturated-zone procedures make available approximation of potential recharge that is a foundation on drainage rates beneath the root zone; nevertheless, in some conditions, drainage is sidetracked laterally thus does not arrive at the water level [16, 17, and 18].

2. Governing Equation

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

Nomenclature
v = Velocity [LT-[1]]
ϕ = Porosity [-]
β = Void Ratio [-]
K = Permeability [LT^{-1}]
T = Time [T]

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

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

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

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

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

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

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

i.e. $\varphi\sum_{n=0}^{\infty}(n+2)(n+1)\alpha_{n+2}x^n + (\beta+K)\sum_{n=0}^{\infty}(n+1)\alpha_{n+1} = 0$ (5)

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

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

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

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

For

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

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

$$\text{For } n:\ \alpha_n = \frac{(-1)^n(\beta+K)^{n-1}a_1}{\varphi^{n-1}n!} \quad (12)$$

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

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

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

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

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

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

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

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

3. Materials and Method

Standard laboratory experiment where performed to monitor permeability of Flow using the standard method for the experiment at different formation, the soil deposition of the strata were collected in sequences base on the structural deposition at different locations, this samples were collected at different location generated variations at different depths producing different permeability of flow through pressure flow at different strata, the experimental result were compared with the theoretical values for validation of the model.

4. Results and Discussion

Results and discussion are presented in tables including graphical representation for permeability on fine sand formation.

Table 1. *Permeability of flow at Different Depth.*

Depth [M]	Permeability of flow
3	7.33E-04
6	1.51E-03
9	2.26E-03
12	2.79E-03
15	3.65E-03
18	4.56E-03
21	5.15E-03
24	5.44E-03
27	6.55E-03
30	7.32E-03
33	7.84E-03
36	8.64E-03
39	9.49E-03

Table 2. *Predicted and Validate Permeability of Flow at Different Depth.*

Depth [M]	Predicted Velocity of Flow	Validated Permeability of Flow
3	7.33E-04	7.24E-04
6	1.51E-03	1.64E-03
9	2.26E-03	2.34E-03
12	2.79E-03	2.82E-03
15	3.65E-03	3.72E-03
18	4.56E-03	4.65E-03
21	5.15E-03	5.20E-03
24	5.44E-03	5.38E-03
27	6.55E-03	6.71E-03
30	7.32E-03	7.44E-03
33	7.84E-03	7.87E-03
36	8.64E-03	8.66E-03
39	9.49E-03	9.54E-03

Table 3. *Permeability of flow at Different Depth.*

Depth [M]	Permeability of Flow
3	7.41E-05
6	1.55E-04
9	2.27E-04
12	2.70E-04
15	3.61E-05
18	4.48E-05
21	5.21E-05
24	5.64E-05
27	6.52E-06
30	7.41E-06
33	8.24E-06
36	8.57E-06
39	9.50E-06

Table 4. *Predicted and Validate Permeability of Flow at Different Depth.*

Depth [M]	Predicted Velocity of Flow	Validated Velocity of Flow
3	7.41E-05	8.49E-05
6	1.55E-04	1.21E-04
9	2.27E-04	2.35E-04
12	2.70E-04	2.56E-04
15	3.61E-05	3.67E-05
18	4.48E-05	4.54E-05
21	5.21E-05	5.34E-05
24	5.64E-05	5.79E-05
27	6.52E-06	6.67E-06
30	7.41E-06	7.54E-06
33	8.24E-06	8.30E-06
36	8.57E-06	8.68E-06
39	9.50E-06	9.61E-06

Table 5. *Permeability of flow at Different Depth.*

Time [T]	Permeability of Flow
10	4.44E-03
20	8.69E-03
30	1.57E-02
40	1.69E-02
50	2.42E-02
60	2.54E-02
70	2.77E-02
80	3.69E-02
90	3.65E-02
100	4.57E-02
110	4.87E-02

Table 6. *Predicted and Validate Velocity of Flow at Different Depth.*

Time [T]	Permeability of Flow	Validated Permeability of Flow
10	4.44E-03	4.31E-03
20	8.69E-03	8.57E-03
30	1.57E-02	1.52E-02
40	1.69E-02	1.74E-02
50	2.42E-02	2.44E-02
60	2.54E-02	2.64E-02
70	2.77E-02	2.89E-02
80	3.69E-02	3.53E-02
90	3.65E-02	3.78E-02
100	4.57E-02	4.54E-02
110	4.87E-02	4.87E-02

Table 7. *Permeability of flow at Different Depth.*

Time [T]	Permeability of Flow
10	4.19E-04
20	8.49E-04
30	1.18E-03
40	1.51E-04
50	2.24E-04
60	2.57E-04
70	3.10E-04
80	3.33E-04
90	3.56E-04
100	4.49E-04
110	4.62E-04
120	5.25E-04

Table 8. *Predicted and Validate Velocity of Flow at Different Depth.*

Time [T]	Predicted Permeability of Flow	Validated Permeability of Flow
10	4.19E-04	4.25E-04
20	8.49E-04	8.46E-04
30	1.18E-03	1.22E-03
40	1.51E-04	1.52E-04
50	2.24E-04	2.28E-04
60	2.57E-04	2.63E-04
70	3.10E-04	3.15E-04
80	3.33E-04	3.45E-04
90	3.56E-04	3.54E-04
100	4.49E-04	4.39E-04
110	4.62E-04	4.68E-04
120	5.25E-04	5.31E-04

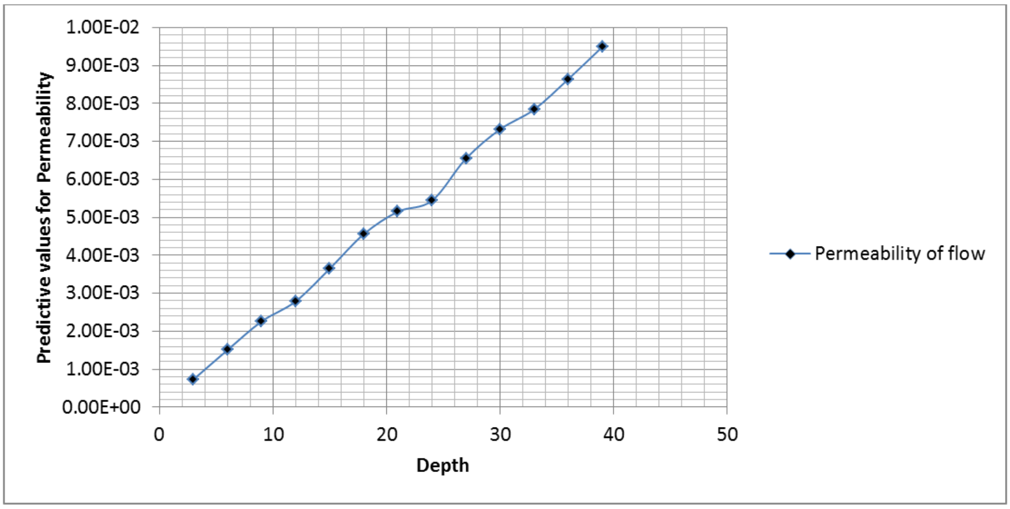

Figure 1. *Permeability of flow at Different Depth.*

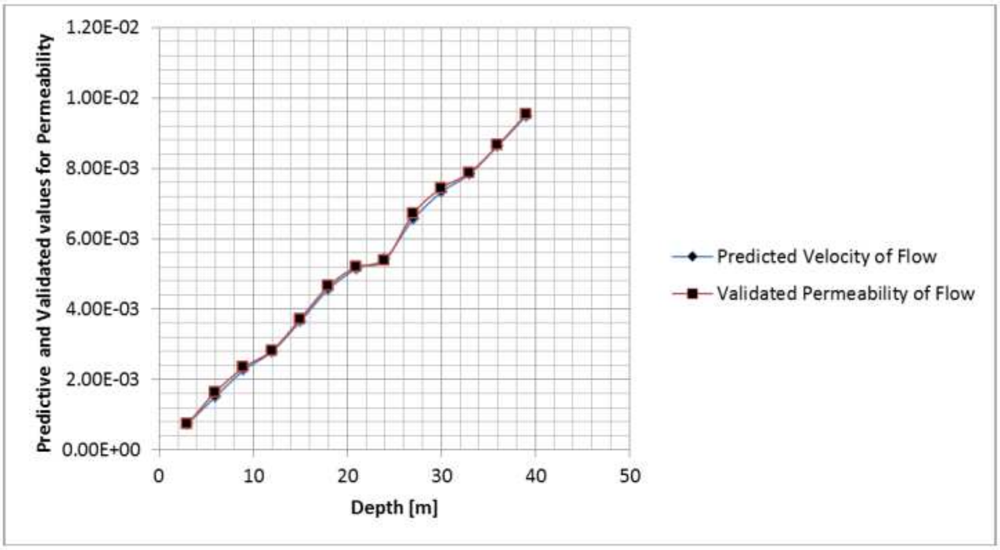

Figure 2. *Predicted and Validate Permeability of Flow at Different Depth.*

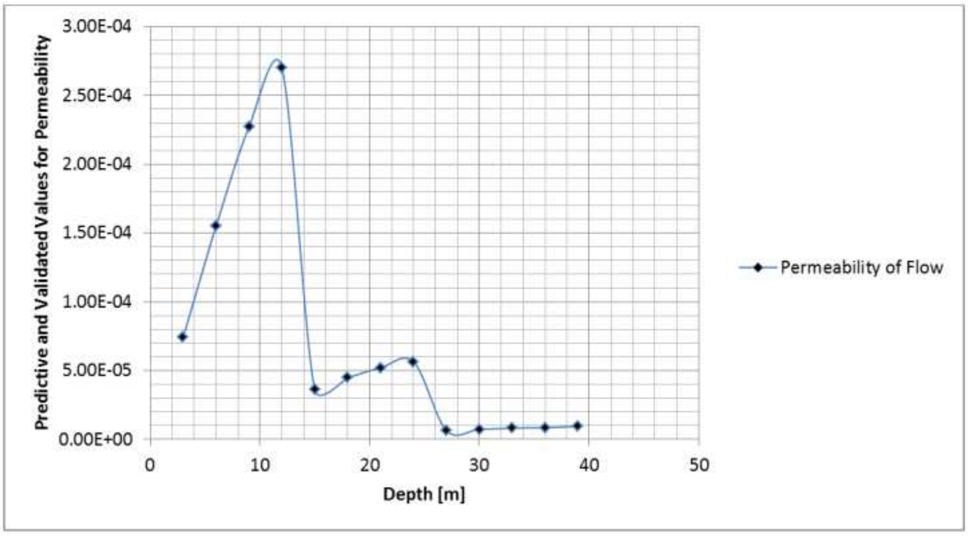

Figure 3. *Permeability of flow at Different Depth.*

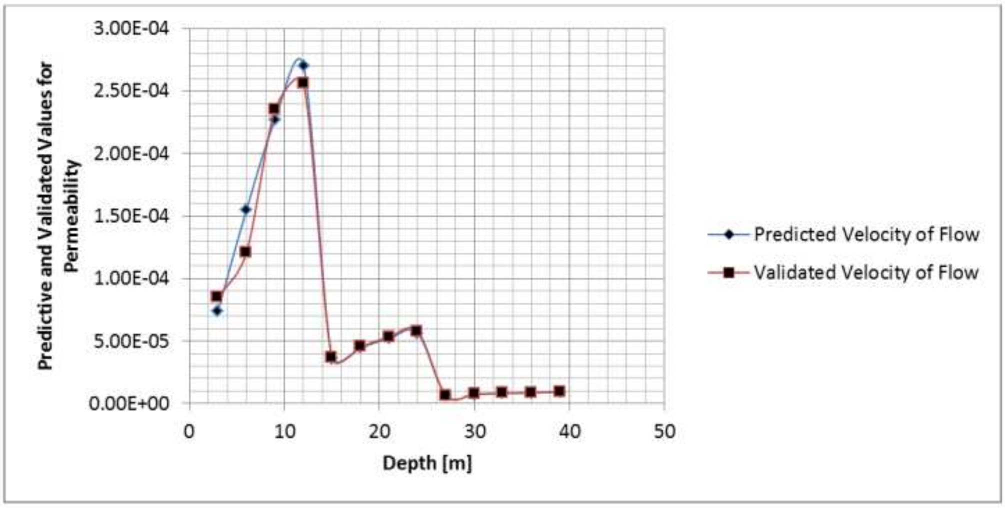

Figure 4. *Predicted and Validate Permeability of Flow at Different Depth.*

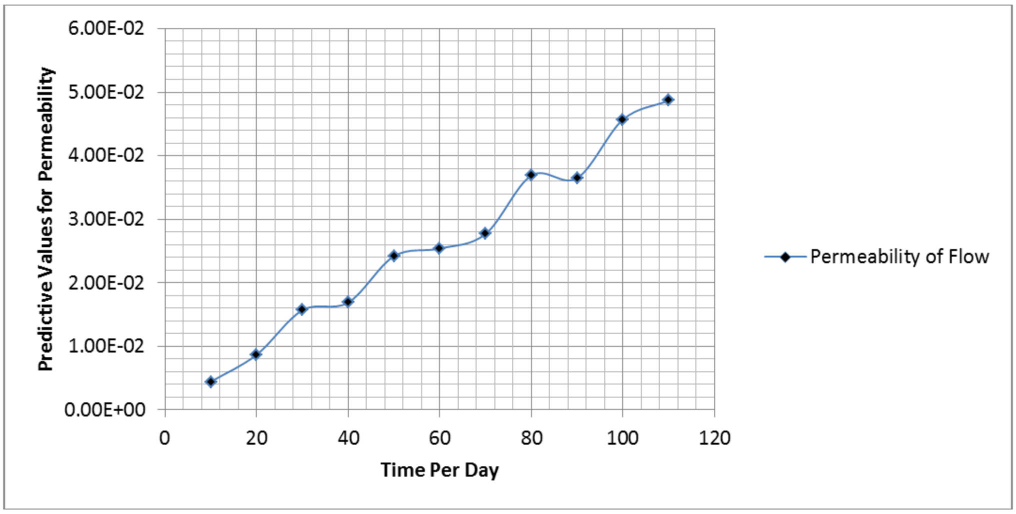

Figure 5. *Permeability of flow at Different Depth.*

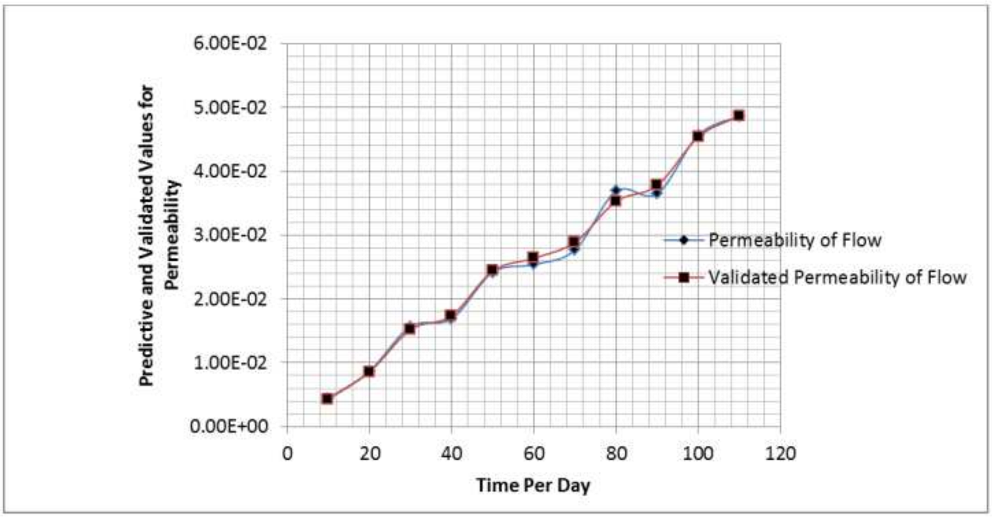

Figure 6. *Predicted and Validate Permeability of Flow at Different Depth.*

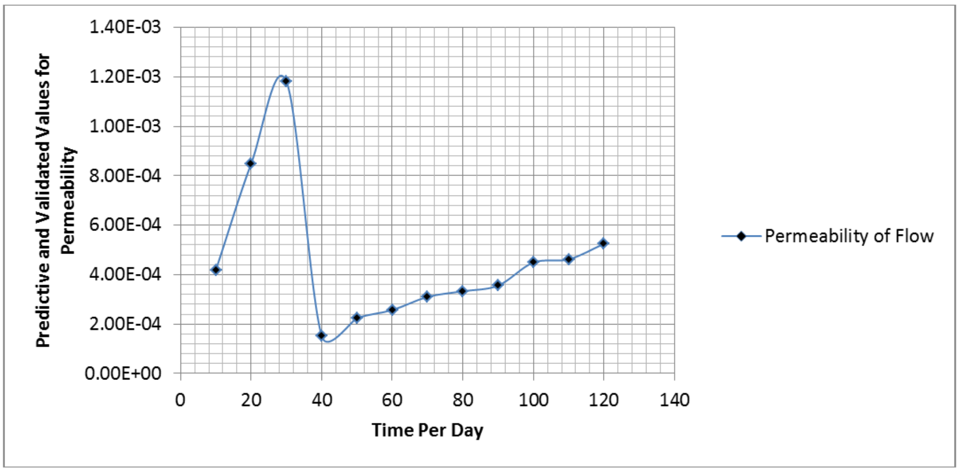

Figure 7. *Permeability of flow at Different Depth.*

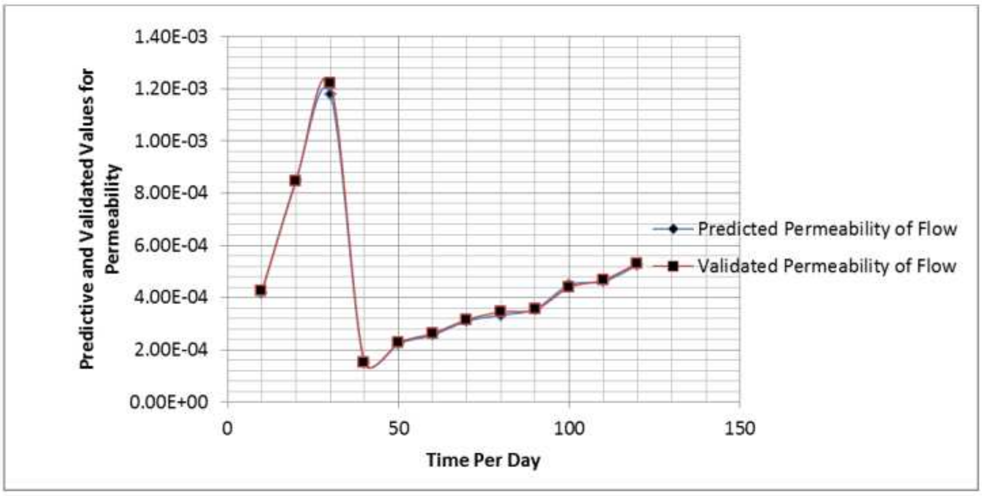

Figure 8. *Predicted and Validate Permeability of Flow at Different Depth.*

Figure one and two shows that the permeability of flow observed slight vacillation in exponential phase where the optimum values of deposition were recorded at thirty nine meter, while the lowest rate of permeability of flow were recorded at three meters, the variation of permeability deposited slight heterogeneous strata base on the increase in depth to the porous formation. The rates of homogeneity of permeability were pressured by the structure of the strata. The developed model were subjected to validation, both parameters developed favorable fits. While figure three and four experiences different phase compared to figure one and two, because vacillation were observed in these figures, vacillation were experienced where an increase were observed between three and nine metres, sudden decrease were observed between twelve metres and fifteen metres with fluctuation decrease to the lowest deposition of permeability in the formation, the predicted and validated parameters generated best fits. Figure five and six experience slight exponential depositions with increase in permeability due to some formation characteristics predominantly depositing slight fluctuations of fine sand formation to Phreatic bed, the structure of the deposited strata pressured the permeability deposition in the formation, the rate of increase in permeability flow are determined on the deposited lithostratification of the formation under the influence of variation from porosity and void in deltaic environment. figure seven and eight experience vacillation, the rate of porosity and velocity predominant in the formation developed influential variation, these were found to pressured the deposition of permeability in the strata, these express the behaviour of the deltaic lithostratification under these two parameters, the rate of permeability expresses an increase between ten to thirty days period from its permeability of flow between the structure of the deposition, sudden development in the formation took places through change in porosity and void ratio under the influenced of unconsolidated structure in the strata, in most case, these can generate fast migration of some mineral in the formations, another dimensions are the rate of disintegration on the grain size structure at different bed, it developed various degrees of macrospores generating variation of intrusion of these mineral producing strong bond consolidating the formations. Variation of permeability and its flow net are influenced by these conditions as it expressed in figure seven and eight, these expression affect minerals depositions, sudden decrease with respect to change in depth and time were observed, slight increase were recorded from forty to hundred and twenty days.

5. Conclusion

Modeling permeability were carried out to determine their rate of flow in the design and construction of ground water systems, these formation characteristic determine yield rate in ground water, thus express the rate of Aquiferous zone. The developed model were able to take these variable into consideration in other to monitor the permeability of flow in heterogeneous formation, the behaviour of the formation were integrated in the system that monitored the yield rate for productive well through the governing equation for the study. such expression were derived base on the conditions the system were subjected, the velocity of flow were simulated to generated predictive values, the behaviour of velocity in heterogeneous formation were thoroughly expressed from the graphical representation at various conditions, the rate of vacillations were found base on the rate of porosity and permeability predominant in deltaic formations, experts in field of ground water engineering will definitely found these developed model useful in design and construction of water wells avoiding abortive well in the study area.

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