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Research article

PREDICTIVE MODEL ON THE EFFECT OF POROSITY ON MICROBIAL MIGRATION TO GROUND WATER AQUIFERS IN DETAIC ENVIRONMENT; EGBEMA IMO STATE OF NIGERIA

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Abstract

The effect of porosity on migration of microbes to ground water aquifer has been studied and predictive models developed, in the study, samples were collected from the study location and were subjected to laboratory experimentation and analysis. Predictive models representing variation of porosity and microbial migration were later developed and compared with results from the study location, which compared faviourably. The predictive models will serve as a tool in assessing microbial migration to ground water aquifers, thus ascertaining ground water free from contaminants.

Keywords: microbial, water, aquifers

1. Introduction

Mobility refers to a biological or chemical contaminant's capability to move within soil or ground water over time. A contaminant might move under the persuade of magnitude as with light or dense non-aqueous phase liquids or under the manipulate of ground water flow as with dissolved constituents. As the contaminant moves through a porous medium, condition within the medium tend to resist the mobility of the contaminant. For instance, molecules (e.g., cat ions and pesticides) tend to adsorb onto particles of the porous medium in proportion to their concentration in ground water. Adsorption also depends on the substantial and chemical distinctiveness of the means such as carbon content and pH. Dissolved contaminants also exhibit the tendency to diffuse within the solute, although diffusivity is a minor instrument of mobility in the case of rapid ground water flow such as with injection wells. In addition to chemical factors affecting adsorption, substantial factors such as ground water hydraulic gradient, hydraulic conductivity, porosity, and bulk density also influence mobility.. Numerous soils are proficient of physically filtering (or straining) parasites (cysts and eggs) and bacteria as the runoff moves through soil pores because of their moderately large size. One of the most significant factors in removal of bacteria is the pore size of the soil matrix, with smaller pores being better able to remove bacteria. Bacteria, which have many dietetic requirements, usually die off once filtered from the runoff because of a lack of nutrients. Cases have been reported of active bacteria (from septic tank effluent) traveling distances of up to 10 metres in sandy aquifers, 70 metres in gravelly Aquifers, and 10metres in limestone rock layer (Kaplan, 1991). Note that this progress is alleged for properly sited, designed, operated, and maintained septic systems. In addition to progress, bacteria may simply persist. For example, enteric bacteria have been observed to survive from 10 to 100 days in soil depending on the moisture content, temperature, organic matter, pH, sunlight, and antagonism from native soil micro flora present in the soil (Canter and Knox, 1985). Generally, bacteria removal is enhanced by low runoff loading and recurrent drying periods between doses. Viruses are less easily filtered. The major means of virus removal is through adsorption onto soil particles. Virus adsorption is greatly affected by the pH of the soil-water system. This effect is due primarily to the amphoteric nature of the protein shell of the virus particles. At low pH values, below 7.4 units, virus adsorption by soils is rapid and effective. In addition, coarser soils with higher pH values were less effective in adsorbing viruses. Higher pH values considerably Decrease the effectiveness of virus adsorption by soils because of enlarged ionization of the carboxyl groups of the virus protein and the increasing negative charge on the soil particles. Virus adsorption also is subjective by other soil characteristics such as clay content, silt content, ion exchange capacity, and particle size. Adsorption also can differ as a function of virus type and strain due to the inconsistency in the arrangement of proteins in the outer capsid of the virus since this will pressure the net charge on the virus (which affects the electrostatic potential between virus and soil) (USEPA, 1984). Dry soils may also inactivate viruses (Kaplan, 1991). One study found virus removal in soils to be three times greater in unsaturated conditions than in saturated conditions (Powelson and Gerba, 1994). The implication of this finding for Class V addition systems (e.g., large-capacity septic systems) is that if ground water mounding underneath these systems were to reach the infiltrative surface, it could result in saturated flow conditions, possibly allowing greater concentrations of viruses to travel to ground water. Ground water mounding reduces the distance from the bottom of the organization to the water table (MN Pollution Control Agency, 1984). This distance is a critical factor in the treatment of sanitary wastes and effluents because the unsaturated soil above the water table filters and absorbs contaminants, including parasites, bacteria, and viruses (Price, 1988).The ambient surroundings is an important factor for efficient virus removal. A study by Scandura and Sobsey, (1997) resolute that the risk of viral contamination is higher in most coarse (sand) soils. When water tables are most shallow (smallest vadose zones or unsaturated soils) and in winter when temperatures are at the lowest. nevertheless, extensive reductions of enteric viruses, bacteria, and nutrients are possible if the site has soils with clay content at or exceeding 15 percent, if the vadose zone is at or exceeds 10 metres, and if the injection well does not inject directly into a saturated zone (or in the case of large-capacity septic systems, the drain field distribution lines do not become submerged). Initial virus removal or inactivation can be reversed by changing environmental conditions. Heavy rainfall can induce saturated soil conditions or significant temperature changes (Yates, 1987) Viral organisms may persist in temperatures as cold as -20 °C, but can be inactivated by high temperatures (exceeding 31°C) (Harris, 1995; Yates, 1987). Viruses have been observed to travel more than 180 metres and survive as long as 170 days (Canter and Knox, 1985). Like bacteria removal, virus removal is improved by low pH and ionic strength (Canter and Knox, 1985). Virus adsorption also depends on the strain of the virus. A different strain of the same virus may adsorb to a different extent and/or at a different rate. According to Yates, (1987), communicable viruses are not normally there in runoff, and are only shed in the feces of infected individuals. However, this would make larger systems more likely than smaller ones to contain such viruses. At the 1998 Ground Water Protection Council annual forum, Mr. Michael Rapacz (MA Department of Environmental Protection) presented evidence that viruses can remain active for up to two-years of ground water transport. His findings are supported by other research, including an article in Ground Water which found that: (1) viruses could travel as fast, or faster than inorganic contaminants; and (2) the combination of the virus sorption processes and long survival times resulted in the presence of viable seed virus for more than nine months, (DeBorde, et al., 1998).

2. Material and Method

Sample where collected from five different locations in the study location, the method applied in the insitu method of sample of collection, the sample where collected based on the soil formation with a distance on five meters depth, using urgar in collecting the sample, the results generated where divided into two covering the study area where one part of the results where applied generating an equations are $y = 0.00x^3+0.004x^2-0.061x+0.302$ $R^2+0.909$, $y = 0.001x^3-0.004x^2+0.278$ $R^2= 0.706$, $y=-0.005x^2+0.031x+0.227$ $R^2= 0.654$, $Y=.0.008X^2+0.0052X+0.117$ $R^2=0.603$, $y = 0.016-0.08x^2+0.306$ with $R^2= 0.772$. This equations where resolved applying excel programs that generated a model prediction values, the theoretical model values where compared with other results gotten from the study location for comparism.

2. Results and Discussion

Table 1: Theoretical and Measured values at different Depth (location 1)

Depth Meter (mm)	Theoretical values of Porosity	Measured value of Porosity
0.2	0.28	0.29
0.6	0.24	0.26

0.8	0.25	0.28
1	0.24	0.25
1.2	0.24	0.24
1.4	0.22	0.23
1.6	0.21	0.21
1.8	0.2	0.2
2	0.19	0.19
2.5	0.17	0.18
3	0.15	0.14
4	0.12	0.12
5	0.1	0.13

Table 2: Theoretical and Measured values at different Depth (location 2)

Depth Meter (mm)	**Theoretical values of Porosity**	**Measured value of Porosity**
0.2	0.27	0.29
0.6	0.25	0.24
0.8	0.24	0.23
1	0.23	0.22
1.2	0.22	0.23
1.4	0.21	0.2
1.6	0.2	0.19
1.8	0.2	0.19
2	0.19	0.18
2.5	0.16	0.15
3	0.14	0.12
4	0.11	0.12
5	0.1	0.11

Table 3: Theoretical and Measured values at different Depth (location 3)

Depth Meter (mm)	**Theoretical values of Porosity**	**Measured value of Porosity**
0.2	0.23	0.22
0.6	0.24	0.24
0.8	0.25	0.25
1	0.25	0.26
1.2	0.26	0.27

1.4	0.26	0.27
1.6	0.26	0.28
1.8	0.26	0.25
2	0.27	0.25
2.5	0.27	0.27
3	0.28	0.26
4	0.27	0.27
5	0.25	0.27

Table 4: Theoretical and Measured values at different Depth (location 4)

Depth Meter (mm)	Theoretical values of Porosity	Measured value of Porosity
0.2	0.17	0.15
0.6	0.15	0.13
0.8	0.15	0.15
1	0.16	0.15
1.2	0.19	0.18
1.4	0.17	0.19
1.6	0.17	0.16
1.8	0.18	0.18
2	0.19	0.18
2.5	0.2	0.18
3	0.2	0.19
4	0.19	0.19
5	0.17	0.19

Table 5: Theoretical and Measured values at different Depth (location 5)

Measured values at different Depth location 5 Depth Meter (mm)	Theoretical values of Porosity	Measured value of Porosity
0.2	0.28	0.28
0.6	0.26	0.25
0.8	0.24	0.26
1	0.23	0.24
1.2	0.22	0.23
1.4	0.22	0.21
1.6	0.2	0.21

1.8	0.2	0.19
2	0.19	0.19
2.5	0.19	0.21
3	0.19	0.19
4	0.21	0.22
5	0.27	0.27

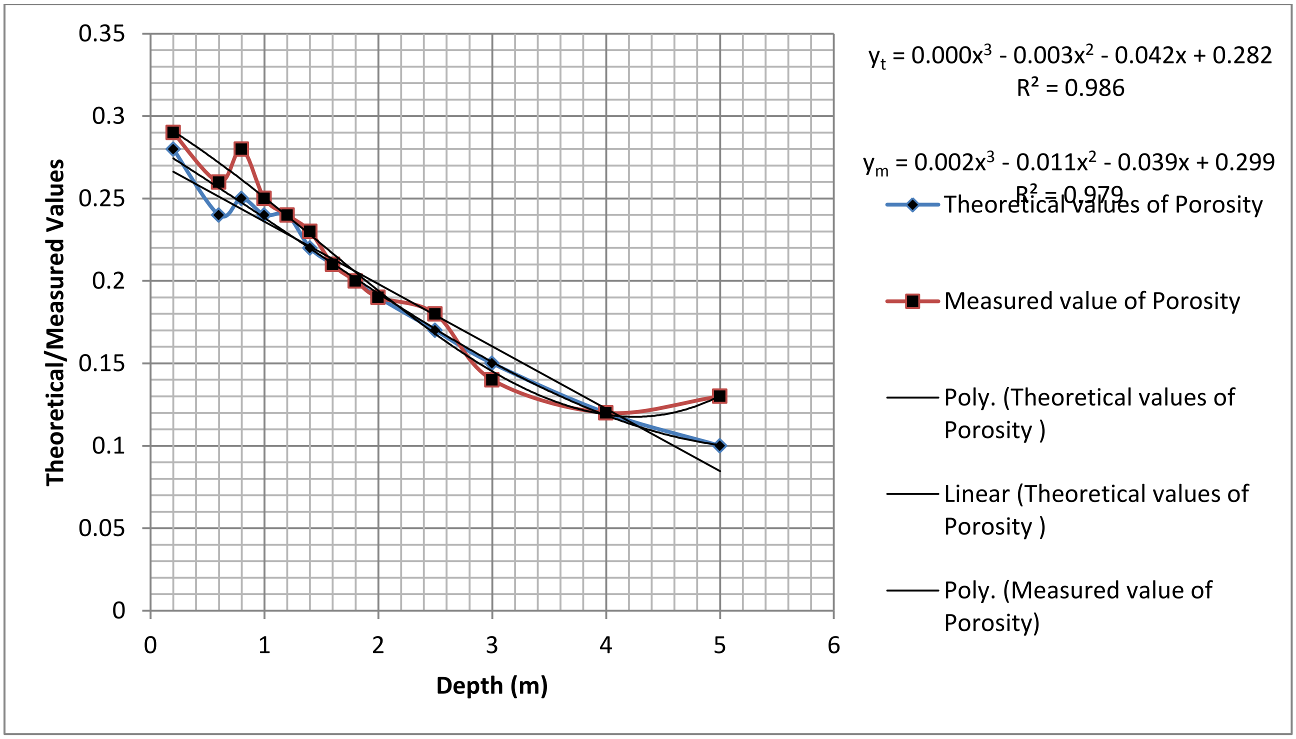

Figure 1: Theoretical and measured values at different Depth

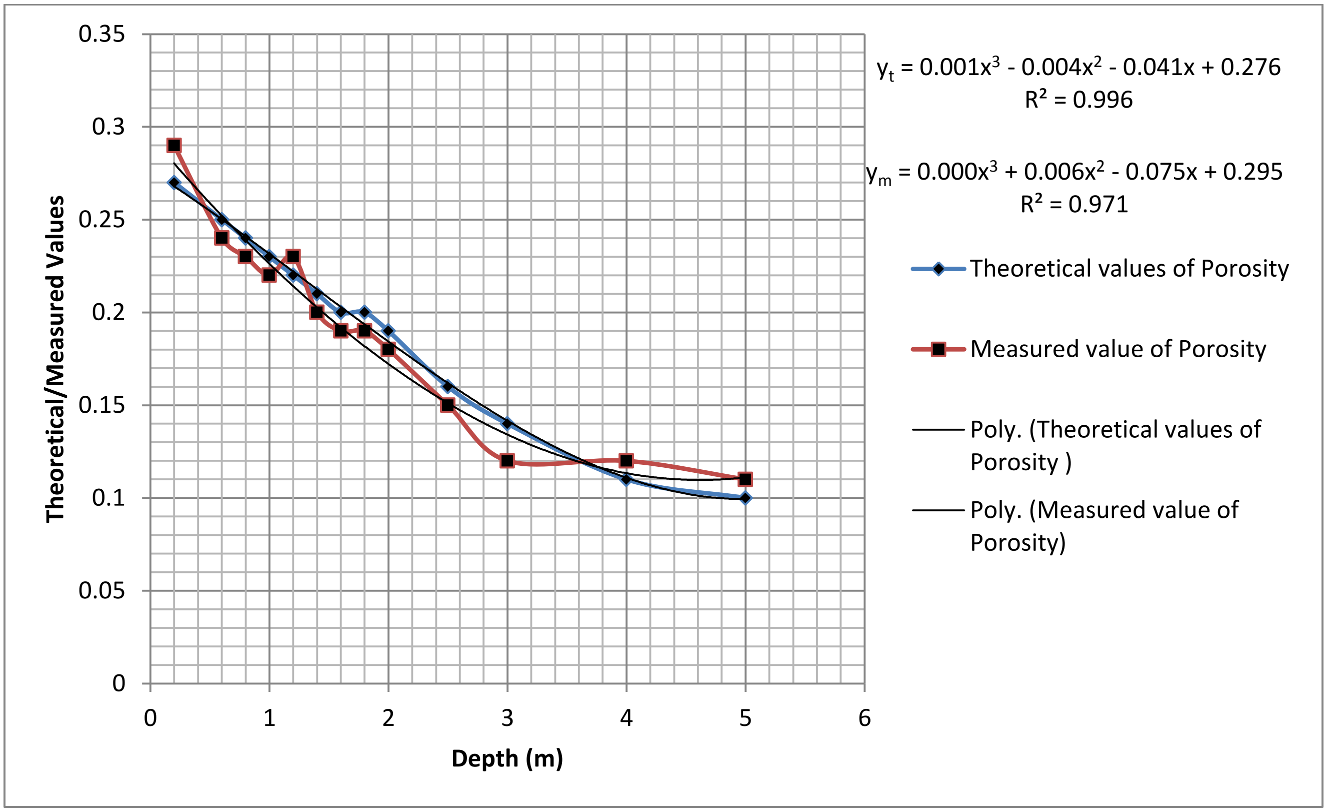

Figure 2: Theoretical and measured values at different Depth

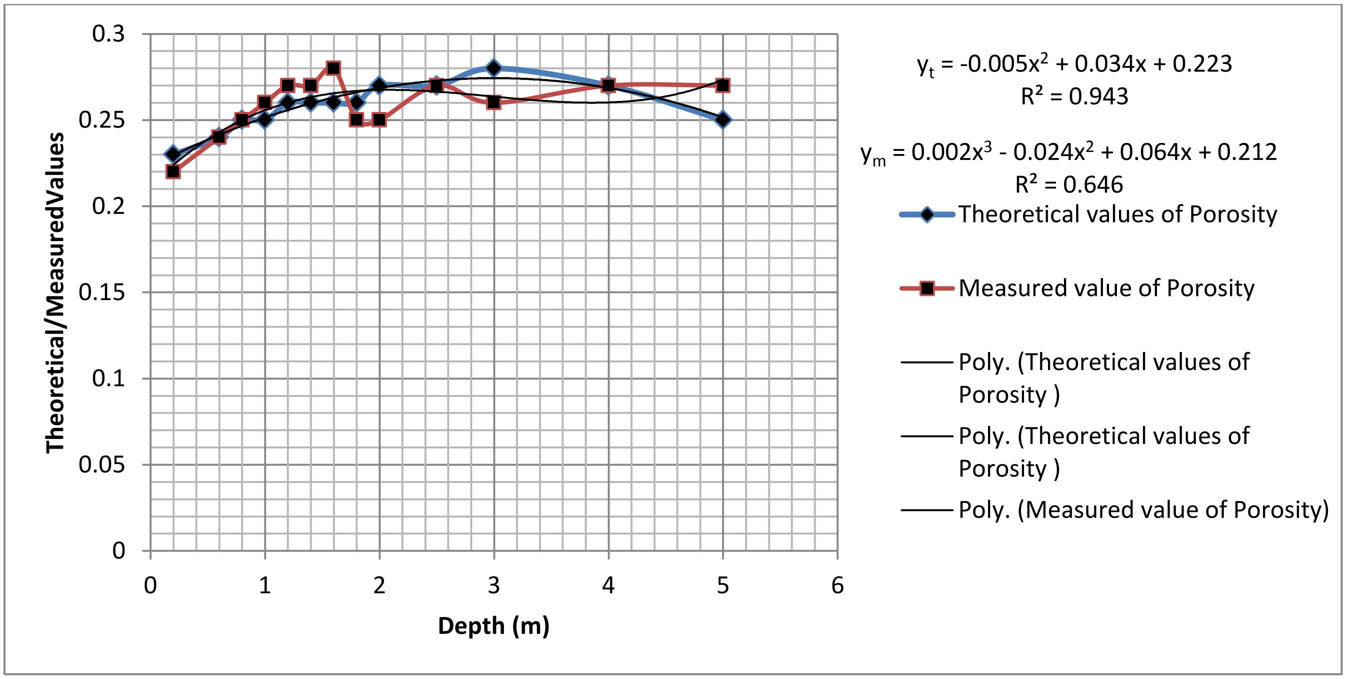

Figure 3: Theoretical and measured values at different Depth

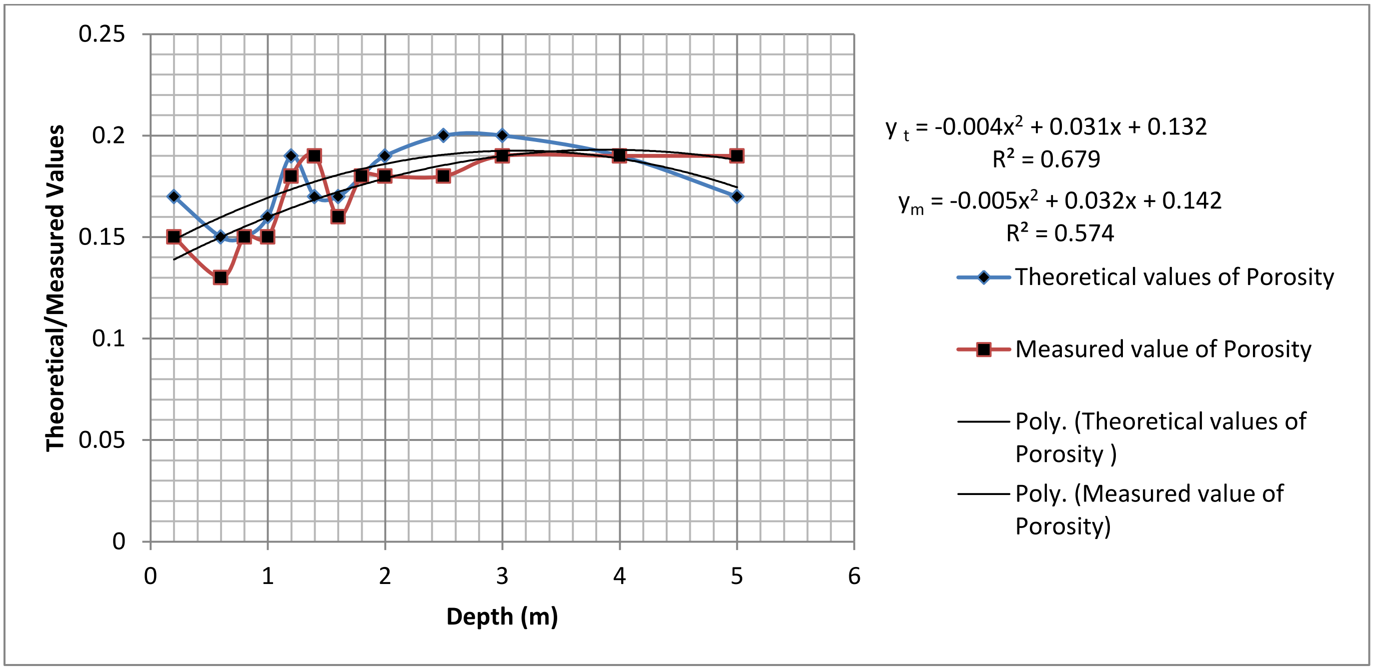

Figure 4: Theoretical and measured values at different Depth

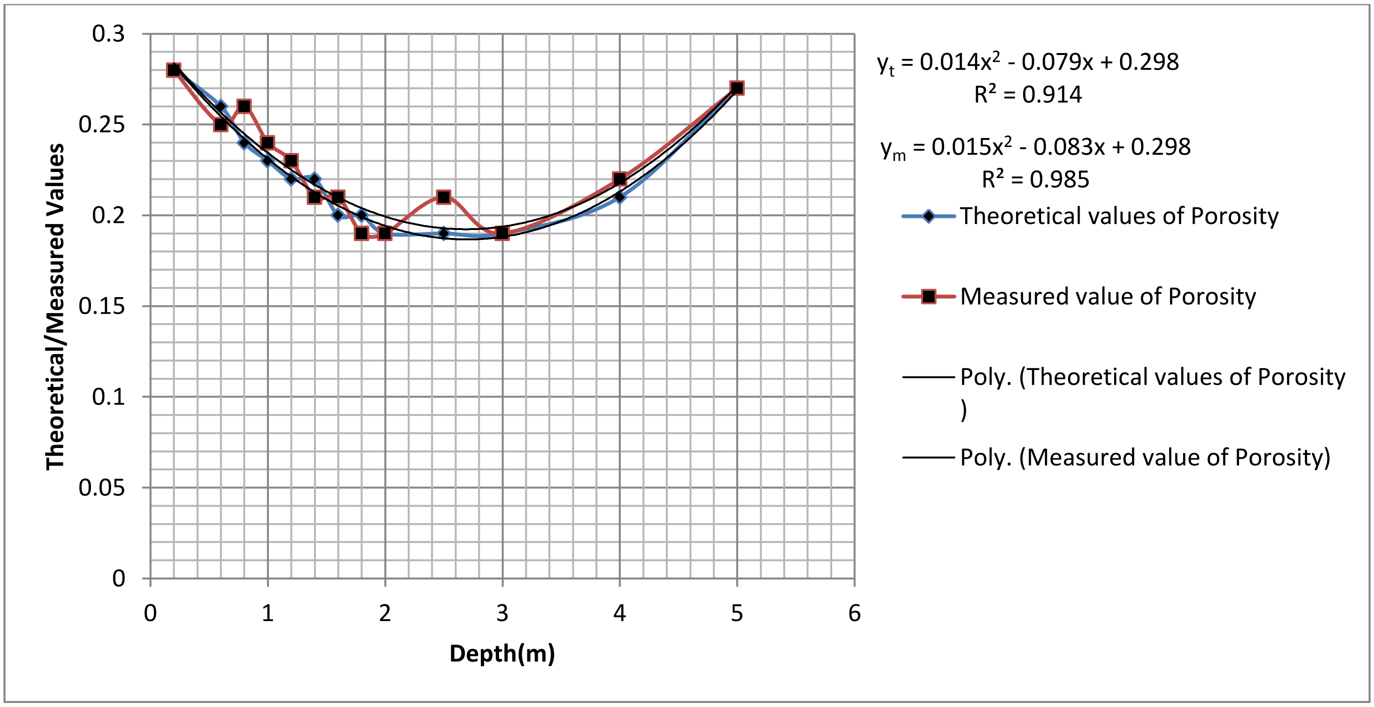

Figure 5: Theoretical and measured values at different Depth

In figure 1and 2 shared a decreasing trend in both theoretical and measured porosity with depth. In trend it's observed that theoretical and measured values porosity values of 0.28 and 0.29 respectively were obtained, but at 5m depth, both theoretical and measured values reduced to 0.1 and 0.13 respectively. The trend in figure 2 showed that at 0.2m depth both theoretical and measured porosity were 0.27 and 0.29 respectively , while 5m depth both porosity values reduces to 0.1 and 0.11 respectively the predicted theoretical and measured porosity for figure 1 and 2 are presented as follows $y_t = 0.003x – 0.003x^2-0.042x+0.282$ R^2 0.986. y_m $0.002x^3-0.011x^2-0.039x+0.299$, $R^2 = 0.979$,and $y_t = 0.01x^3-0.004x^2-0.041x+0.276$,$R^2 = 0.996$. $y_m = 0.000x^3 + 0.006x^2 – 0.075x +0.295$, $R^2 = 0.971$. In figure 3 it is observed that both theoretical and measured porosity shared an increasing trend with depth, while in figure 4 an alternating increase and decrease occurred up to 2m depth. Their respective models following 3 and 4 presented as follows: $y_t = 0.005x^2 – 0.034x + 0.223$, R^2 0.943.$y_m = 0.002x^3 – 0.024x^2 + 0.064x + 0.212$, $R^2 = 0.646$ $y_t = -0.004x^3 + 0.031x^2 + 0.132$, $R^2 =0.679$, $y_m – 0.005x^2 + 0.032x + 0.142$, $R^2 = 0.574$. Both theoretical and measured models of figure 5 shared a decreasing trend up to 2m depth beyond which both models are presented as follows yt = 0.014x2 – 0.079x + 0.298, $R^2 = 0.914$, $y_m = 0.015x^2 – 0.083x + 0.298$ $R^2 = 0.985$.

3. Conclusion

Base on the study the following conclusion can be drawn: 1 both the theoretical and measured porosity models produced agreeable results. 2. The models can be used to examine the rate of migration of microbes to ground water aquifers in the study location. . The drilling of bore holes in the study area should done base on the stipulate standard design, considering the rate of porosity that have affected the migration of microbes to ground water aquifers in the study area, so that good quality drinking from ground water exploration can achieved, in other for the settlers to have access to quality drinking water free that is from every contaminant.

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