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Research article

PREDICTIVE MODELS OF POROSITY TO VALIDATE THE BEHAVIOUR OF E.COLI TRANSPORT TO GROUND WATER AQUIFERS IN PORT HARCOURT: RIVERS STATE OF NIGERIA

Eluozo, S. N[1]Ademiluyi, J. O.[2]

E-mail: solomoneluozo2000@yahoo.com

Department of Civil Engineering, Faculty of Engineering, University of Nigeria Nsukka

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Abstract

Predictive model of porosity to monitor the behaviour of E.coli transport to ground water aquifer has been carried out. This paper addresses the influence from porosity on fast migration of microbes, samples from a borehole site were collected and were subjected to thorough analysis, the results were subjected to a plot that developed equations, the model equations were resolved and it generated theoretical values. The values were compared with other measured values in the study location, both parameters compared faviourably well, this study is imperative because it has produce a baseline for professionals to understand the rate of influence from soil porosity on the migration of E.coli in pheratic aquifers. It has also produce a platform for water engineers and scientist to understand the fundamentals factor of safety to apply in design of groundwater in other to prevent water pollution in deltaic environment.

Keywords: Predictive model, water pollution, environment, analysis

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1. Introduction

The importance of ground water is often overlooked. However, some 97% of all fresh water found on earth is stored under ground (excluding frozen water in glaciers) over 1.5 million people depend on it for their drinking water and many more will in the future if the millennium development Goals are to be met . The resource is naturally fairly resistance to drought, storing up water in times of plenty: and releasing it in times of need: also the quality of the water tends to be good and is much less vulnerable to contamination than surface water. However, the resources is not invulnerable with the quality to pump out huge quantities of water, and the advent of particularly persistence contaminants, the resource need to protected and managed. Ground water is stored within pore space and fracture in rocks; the proportion of void in a rock is the porosity and is generally expressed as percentage. Where the pores and fracture are joined up, water can flow easily and the rocks are said to be permeable. The rocks characteristics determine how much ground water can be stored and how productive an aquifer is. (Alan et al 2005) Alan et al (2005) explain that the ability of an aquifer to transmit ground water described by its hydraulic properties, hydraulic conductivity, thickness, porosity, transmissivity and storage coefficient. Porosity is the total void space within a rock and therefore, usually defines the total amount of ground water stored in an aquifer. About 70% of the Earth is covered with water, 97% of which is part of oceans. Heating of oceans by the Sun keeps the Earth's water in a continuous circulation from the atmosphere to the Earth and back to the atmosphere through condensation, evapotranspiration, and precipitation processes. (Alessandral 2004) The groundwater in the unsaturated or vadose zone of land is usually referred to as soil moisture. The thickness of this zone extends from soil surface to a few metres below the surface in humid regions, and to 300 m or more below surface in arid regions. Although the water hold by soils is a small fraction of the Earth's water budget, soil moisture plays an important role in the water cycle since controls the proportion of rainfall that percolates, runs off, or evaporates from the land, influences plants growth and transpiration, and is related to the precipitation variability within a region (Alessandral 2004) The increasing scarcity of groundwater in semi-arid and arid environments requires better understanding of groundwater recharge to maintain a sustainable supply of water (Scanlon et al. 2006). This is especially true in areas that have growing populations, such as the Lucerne Valley in the western Mojave Desert (figure 1). For several decades beginning in the early 1900s, water levels sharply declined in the Lucerne Valley groundwater basin due to groundwater production for agricultural purposes (Schaefer 1979; Laton et al. 2005). Since adjudication in 1996, pumping records have indicated that water levels have remained relatively constant and, in fact, have begun to rise in some locations (Laton et al. 2005). This rise suggests that modern groundwater recharge must be similar to, or exceed, the volume of groundwater production (Laton et al. 2005). While the primary source of recharge is runoff from the San Bernardino Mountains that is recharges through alluvial fan deposits, changes in precipitation volume have little effect in the water levels within the basin (Schaefer 1979; Laton et al. 2005). However, since little surface water flows into the closed basin, additional recharge into the aquifer must also be accounted for from precipitation that occurs the upper highlands as well as the surrounding desert mountains and return flow from agricultural sources (Laton et al. 2005). Additionally, it has been assumed that infiltration is limited in the Lucerne (dry) Lake due to the impermeable clay layers in the area (Laton et al. 2005).However, Fife et al. (1977; 1980) reported that desiccation fractures have developed in 60% of the Lucerne (dry) Lake. Such fissures have the potential of providing a path for groundwater recharge (Schaefer 1979; Fife et al. 1980; Knott 1992 various studies have been conducted to better understand the complex nature of recharge in semiarid and arid desert environments. Groundwater recharge was modeled for the High Plains Aquifer of Texas and New Mexico, and results indicated that the estimated recharge varied over nearly two orders of magnitude (Wood and Sanford 1995). This variation in magnitude is likely due to the heterogeneity of the soil in the study area, which is commonly the most difficult factor in quantifying groundwater recharge in arid and semiarid environments (Wood and Sanford 1995). While this recharge model demonstrates that approximately 2% of the annual precipitation contributes to recharge, a large percentage of the recharge may actually result from infiltration through the playa lake basin floor and macropore recharge through the sediments surrounding the playa lakes (Wood and Sanford 1995). Similar results were obtained in the Thar Desert of the Middle East, where deep percolation of infiltrated precipitation through a thick unsaturated zone has been found to be the primary source of recharge (Athavale et al. 1998). Soil heterogeneity was found to be the attributing cause of large variations in recharge throughout the study area (Athavale et al. 1998). Athavale et al. (1998) concluded that an average of 12.5% of total annual rainfall in the Thar Desert was recharged into the aquifer. The depth that precipitation can infiltrate is an important consideration, since evapotranspiration can remove soil moisture from shallow depths and prevent deep percolation. In the Amargosa Desert near Beatty, Nevada, surface infiltration was detected to a depth of 2 m, which was significantly deeper than the average 0.2 m infiltration depth observed in Hueco Bolson, Texas in the Chihuahuan Desert (Scanlon 1994). Scanlon (1994) also observed that the infiltration rate was much lower than the determined water potential; this difference was attributed to the upward driving forces of the liquid and isothermal vapor movement. A comparison site in Hanford, Washington in the Eastern Washington Desert was noted to have higher groundwater recharge potential, which Scanlon (1994) attributed to the coarser surficial sediments and winter snowfall. Overall, groundwater recharge in desert environments can be several orders of magnitude less than the amounts of evapotranspiration and precipitation (Wanke et al. 2008). It has been estimated that semiarid and arid regions average recharge rates of 0.1% to 5% of the long-term average annual precipitation and that recharge generally occurs from indirect precipitation into ephemeral streams, dry rivers and lakes (Scanlon et al. 2006; Wanke et al. 2008).

2. Material and Method

Samples were collected from a borehole site at in different locations within the study areas. Insitu methods of sample collection were applied, through ground boring at different strata within the study areas. Soil porosity was evaluated after their bulk unit weight, specific gravity, and void ratio of the soil sample been determined. The results were subjected to plot, the plot from the porosity results generated a model equations. The model equations were resolved; it produced theoretical values, the values from the model equations were compared with other results from different locations.

3. Results and Discussion

Predictive model values of porosity from the study location to validate the behaviour of E.coli transport to ground water aquifers are presented Table and Figures below.

Table 1: comparison of theoretical and measured values of porosity at different

Depth	Theoretical Values	Measured Values

3	0.78	**0.84**
6	0.58	**0.58**
9	0.59	**0.56**
12	0.49	**0.47**
15	0.39	**0.46**
18	0.3	**0.3**
21	0.21	**0.22**
24	0.12	**0.14**
27	0.03	**0.04**
30	0.005	**0.01**

Table 2: comparison of theoretical and measured values of porosity at different

Depth	Theoretical Values	Measured Values
3	0.85	**0.82**
6	0.76	**0.74**
9	0.64	**0.61**
12	0.53	**0.55**
15	0.42	**0.45**
18	0.34	**0.36**
21	0.3	**0.29**
24	0.32	**0.34**
27	0.42	**0.45**
30	0.61	**0.64**

Table 3: comparison of theoretical and measured values of porosity at different

Depth	Theoretical Values	Measured Values
3	0.74	**0.75**
6	0.73	**0.72**
9	0.73	**0.71**
12	0.72	**0.72**
15	0.71	**0.71**
18	0.7	**0.7**
21	0.69	**0.69**

24	0.68	**0.68**
27	0.67	**0.67**
30	0.66	**0.66**

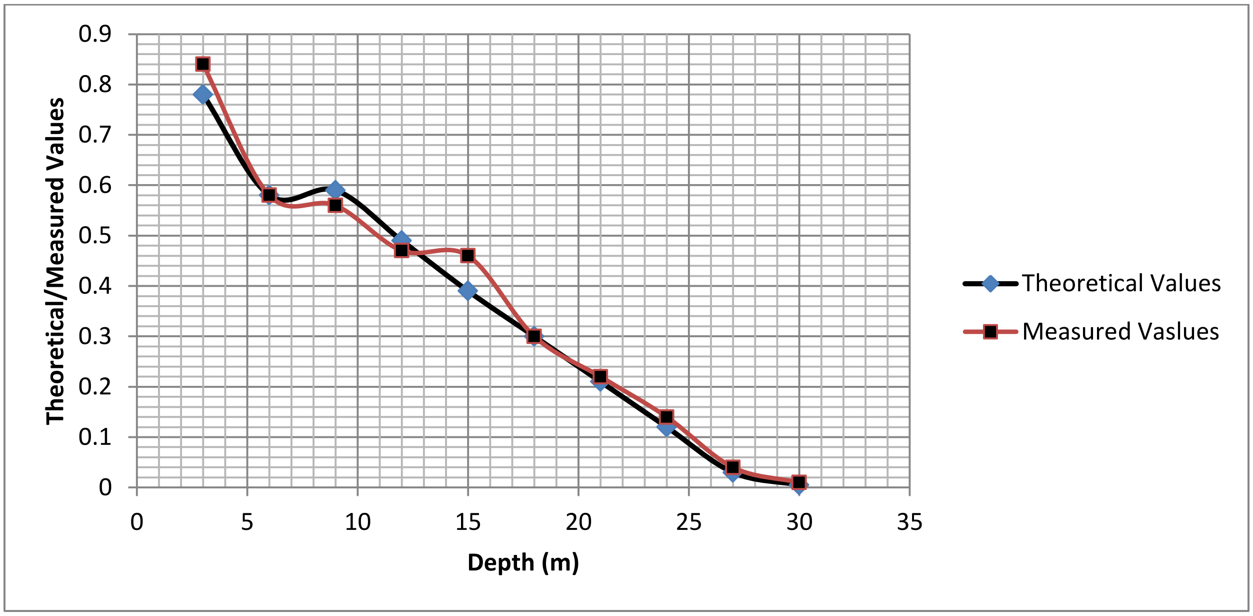

Figure 1: comparison of theoretical and measured values of porosity at different

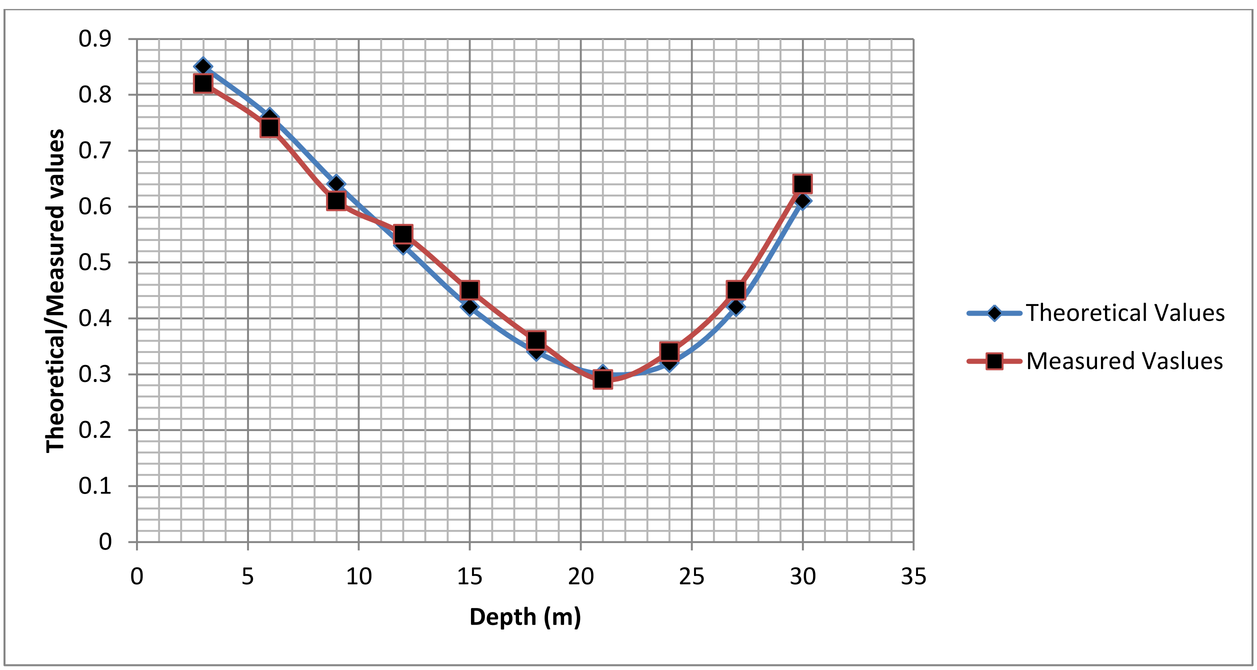

Figure 2: comparison of theoretical and measured values of porosity at different

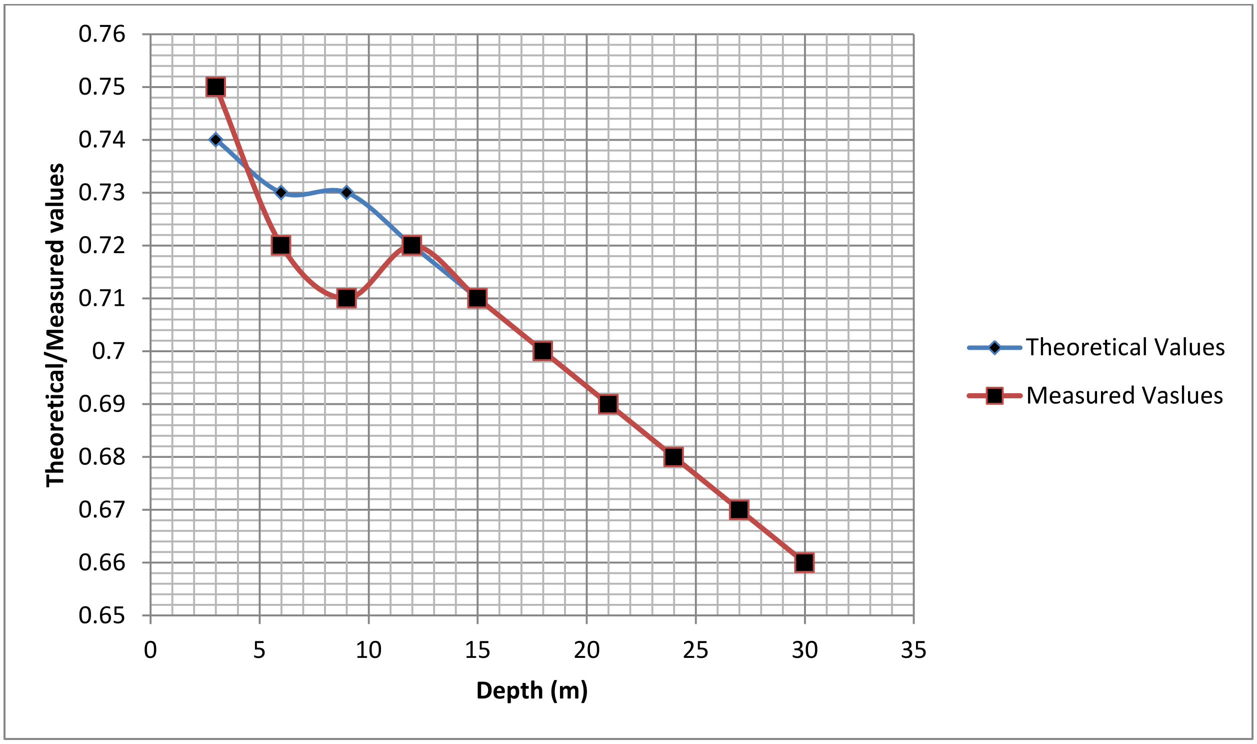

Figure 3: comparison of theoretical and measured values of porosity at different

Figure one shows that the theoretical values obtained its lowest degree of porosity at three metres, suddenly developed a fluctuation, decreasing down to the highest degree of porosity at thirty metres, while the measure values maintained the lowest degree of porosity at three metres and the highest degree at thirty metres respectively, both parameters compared faviourably well, showing that the predictive values can be applied to monitor the rate of porosity influence on the migration of E.coli transport to ground water aquifers. Figure two shows that the theoretical values obtained the lowest degree of porosity at three metres, decreasing gradually to where the highest degree of porosity were recorded at twenty four metres, but suddenly increase from twenty seven metres to thirty metres, while the measured values maintained the same degree, the lowest at twenty four metres, finally experience increase from twenty seven to thirty metres. Both parameters developed a best fitting . Figure three generated its theoretical values to a point were the lowest degree of porosity were deposited at three metres like figure one and two, it suddenly develop a slight oscillation between six and twelve metres to a point where the highest degree of porosity were also recorded at thirty metres, while the measured values maintained the same degree of porosity, the lowest at three metres, with a slight oscillation form and linearly decrease with respect to depth to a point were the highest degree were recorded at the same thirty metres. The rate of migration from one region to another under plug flow law can be monitored through the influence of porosity. The geological formation determine the rate of porosity including its variations as deposited in deltaic environment, its highest level of porosity definitely contribute to shallow aquiferous deposition, and this condition contributes to E.coli fast migration with respect to depth and time. This predictive model is imperative because the rate of E.coli fast migration can be monitored from the developed model in the study location.

4. Conclusion

The predictive model of porosity to monitor the rate of microbial migration (E.coli) has been thoroughly expressed; it has explained the rate of influence on fast migration of E.coli to ground water aquifer. There is no doubt that the influence of high degree of porosity is the fundamentals baseline of microbial migration at a very short time with respect to depth. More so, the study area developed this challenges base on the geological deposition because the formation are deltaic, it develop a shallow aquifers and high porosity, the deltaic nature at the study area generated high rain intensities, it increase the yield of aquifer through the degree of deposited porosity in the formations. This study is imperative because the yield rate of pollution and shallow aquifers depth are influence by the deltaic nature in the study area.

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