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Original article

Calibrating the velocity of solute on *E. coli* transport in Pheratic aquifers in port Harcourt, rivers state of Nigeria.

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ABSTRACT

Calibrating the velocity of solute transport in phreatic aquifers has been assessed, the solute velocity of transport established various rate of velocity at different depth in the study area. The study confirm the influence of the flow paths as one of the causes of variation in solute velocity of flow, few area were examined that confirms the influence of stratification of the soil formation, this has played some role on the rate of velocity flow at different depth, formation characteristics like porosity where also observed to have recorded some influence in the stratification of silty and fine sand where the an optimum level where recorded, the lower rate of velocity are where lateritic soil are predominant, few location experience an average mix of lateritic and silty formation as observed in average velocity of those depths. The study is imperative because it has assessed the rate of velocity of solute flow at different formation, this concept will determine the time of solute migration in the study area.

1. Introduction

Subsurface Stormflow in steep unchanneled soil mantled hillslope is the dominant runoff generation process in many parts of the Pacific Rim. A number of studies have demonstrated specific processes for subsurface Stormflow occurrence, including transmissivity feedback, flow through the fractured bedrock, kinematic wave routing and flow through discrete preferential pathways. Perhaps the most common mechanism for rapid subsurface flow on steep, wet hillslope is lateral preferential flow at the soil-bedrock interface (Mosley, 1979; McDonnell, 1990; Tsuboyama et al., 1994; Weiler et al., 1998; 2003; Sidle et al., 1995; 2000). For this study, we define predominantly vertically oriented preferential pathways with lengths comparable to the soil depths as "micropores and slope parallel preferential flow pathways as "pipes". These pipes can either be formed by soil fauna (mole and mouse burrows) or more frequently in forest soils by dead root channels (sometimes eroded). In this study we do not consider the continuous, large pipe networks that were frequently observed in Britain and in other loess-dominated places of the world (Jones and Connelly, 2002, Markus. 2003).

As urban and industrial development continues to expand around the world's rivers and coastlines, so does the rate of unintentional release of contaminants to subsurface and surface waters and the need for effective assessment of such environments (winter, 2000). Hydrologists have long known that surface waters and groundwater are intrinsically linked systems (e.g. Glover, 1959; Cooper, 1959; Clement et al., 1996; Simpson et al., 2003). Areas around streams, rivers, lakes and coastal environments represent zones of interaction and transition between the two systems where dissolved constituents such as pollutants can be diluted, exchanged, transformed or destroyed. Identifying predominant processes affecting solute exchange across transition zones is therefore, critical in assessing contaminant fluxes to the sediment/water interface, and ultimately in estimating contaminant exposures for the receiving ecosystems. Groundwater/surface water interactions in estuarine environments are influenced by a number of processes forming complex spatially and temporally variable systems. Density contrasts between the typically fresh groundwater and saline to brackish marine and estuarine surface waters leads to mixing and convective circulation at the groundwater discharge boundary so that the system is characterised by the intrusion of saltwater into the adjacent coastal aquifer (Glover, 1959; Cooper, 1959; Reilly and Goodman, 1985; Ataie-Ashtiani et al., 1999; Simpson and Clement, 2004). Tidal activity can often induce a fluctuating water table as well as infiltration of surface water into sediments, forming a surficial mixing zone with groundwater discharging from the adjacent aquifer (Robinson et al., 1998; Ataie-Ashtiani et al., 1999; Boudreau and Jorgensen, 2001; Acworth and Dasey, 2003). Although there is still no single conceptual definition for such a surficial mixing zone, the terms 'hyporheic zone', 'subsurface estuary' and 'groundwater/surface water interface' or 'GSI' are gaining common usage in the scientific literature White (1993) conceptually defined the hyporheic zone as 'the saturated interstitial area beneath the stream bed and into the stream banks that contain some proportion of channel water or that have been altered by channel water infiltration'. This definition may be broadened to include rivers, lakes, estuaries and coastal environments where surface water infiltrates into the underlying sediments and interacts with groundwater. Although numerous studies have addressed groundwater and solute inputs to surface water bodies (e.g. Harvey et al., 1987, Gallagher et al., 1996, Portney et al., 1998, Krabbenhoft et al., 1990, Lorah and Olsen, 1999, winter, 2000; Tobias et al., 2001), few studies to date have examined near-shore groundwater discharge in detail. Studies of note however, include those by Robinson and Gallagher (1999); Smith and Turner (2001); Linderfelt and Turner (2001); Simpson et al. (2003) and the initial study by Westbrook et al. (2000) related to the current work (Westbrook et al 2005).

2. Materials and methods

Column experiments were also performed using soil samples from several borehole locations, the soil samples were collected at intervals of three metres each (3m). An E.coli solute was introduced at the top of the column and effluents from the lower end of the column were collected and analyzed for E.coli, and the effluent at the down of the column were collected at different time, analysis, velocity of the transport were monitored at different time.

3. Results and discussion

Calibrating the velocity of solute on E. Coil transport in pirates aquifers is presented in the table and figures below.

Table 1

Velocity of E. Cali solute transport at different distance.

Distance (m)	Velocity of solute time
3	9.40E-04
6	8.87E-04
9	9.79E-04
12	1.13E-03
15	1.18E-03
18	1.20E-03
21	1.29E-03
24	1.35E-03
27	1.49E-03
30	1.52E-03

Table 2

Velocity of E. Cali solute transport at different distance.

Distance (m)	Velocity of solute (time)
3	9.40E-04
6	8.87E-04
9	9.79E-04
12	1.13E-03
15	1.18E-03
18	1.20E-03
21	1.29E-03
24	1.35E-03
27	1.49E-03
30	1.52E-03

Table 3

Velocity of E. Cali solute transport at different distance.

Distance (m)	Time
3	8.48E-04
6	8.61E-04
9	9.00E-04
12	9.56E-04
15	1.00E-03
18	1.14E-03
21	1.20E-03
24	1.29E-03
27	1.43E-03
30	1.51E-03

Table 4
Velocity of E. Cali solute transport at different distance.

Distance (m)	Velocity of solute (time)
3	1.00E-03
6	1.26E-03
9	1.42E-03
12	1.72E-03
15	2.36E-03
18	3.69E-03
21	4.37E-03
24	4.98E-03
27	6.45E-03
30	1.42E-02

Table 5
Velocity of E. Cali solute transport at different distance.

Distance (m)	Velocity of solute (time)
3	9.00E-04
6	9.47E-04
9	9.90E-04
12	1.89E-03
15	3.22E-03
18	6.00E-03
21	1.35E-02
24	1.29E-02
27	4.30E-03
30	1.23E-02

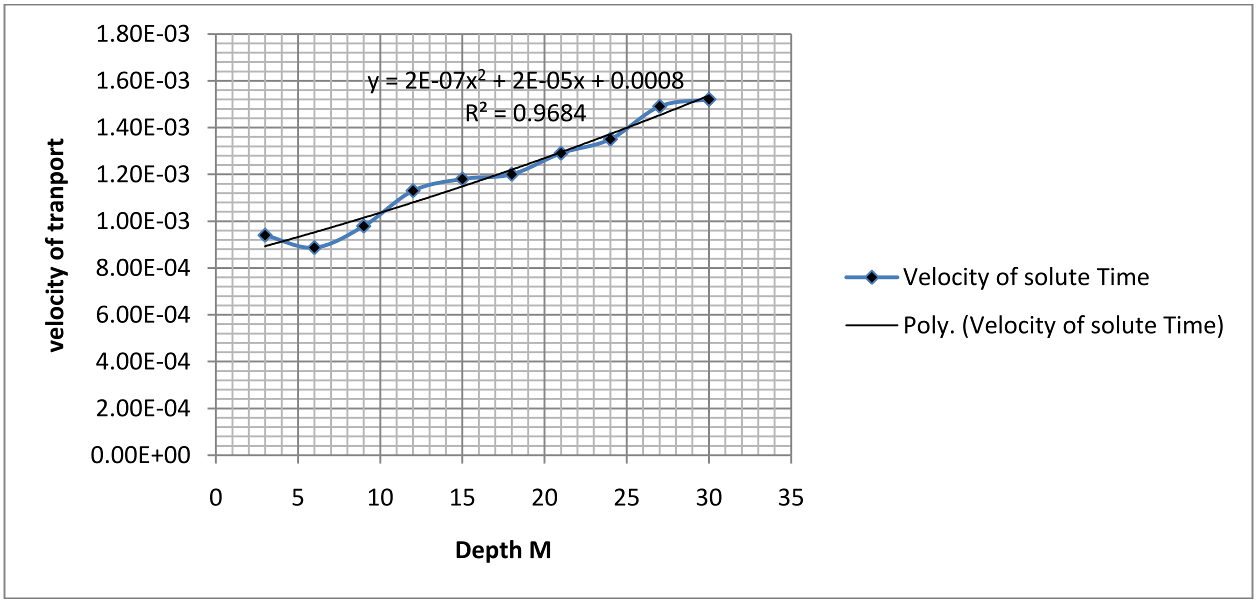

Fig. 1. Velocity of E. Cali solute transport at different distance.

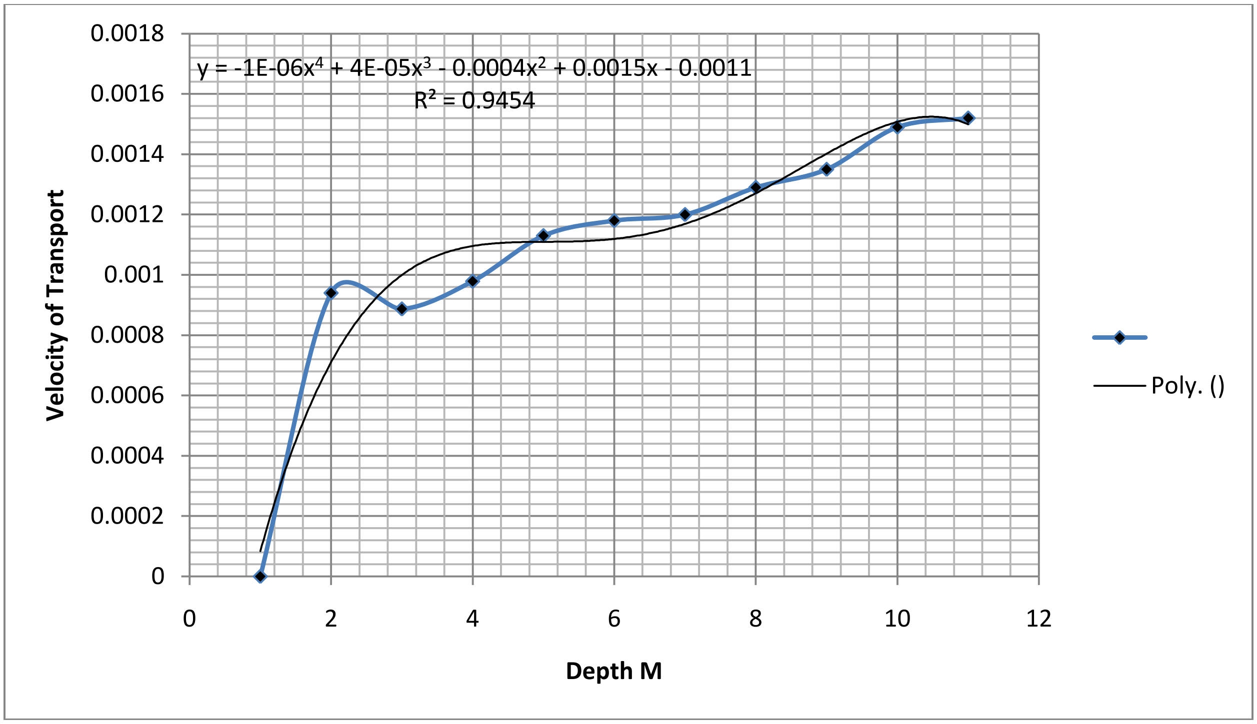

Fig. 2. velocity of E.coli solute transport at different distance.

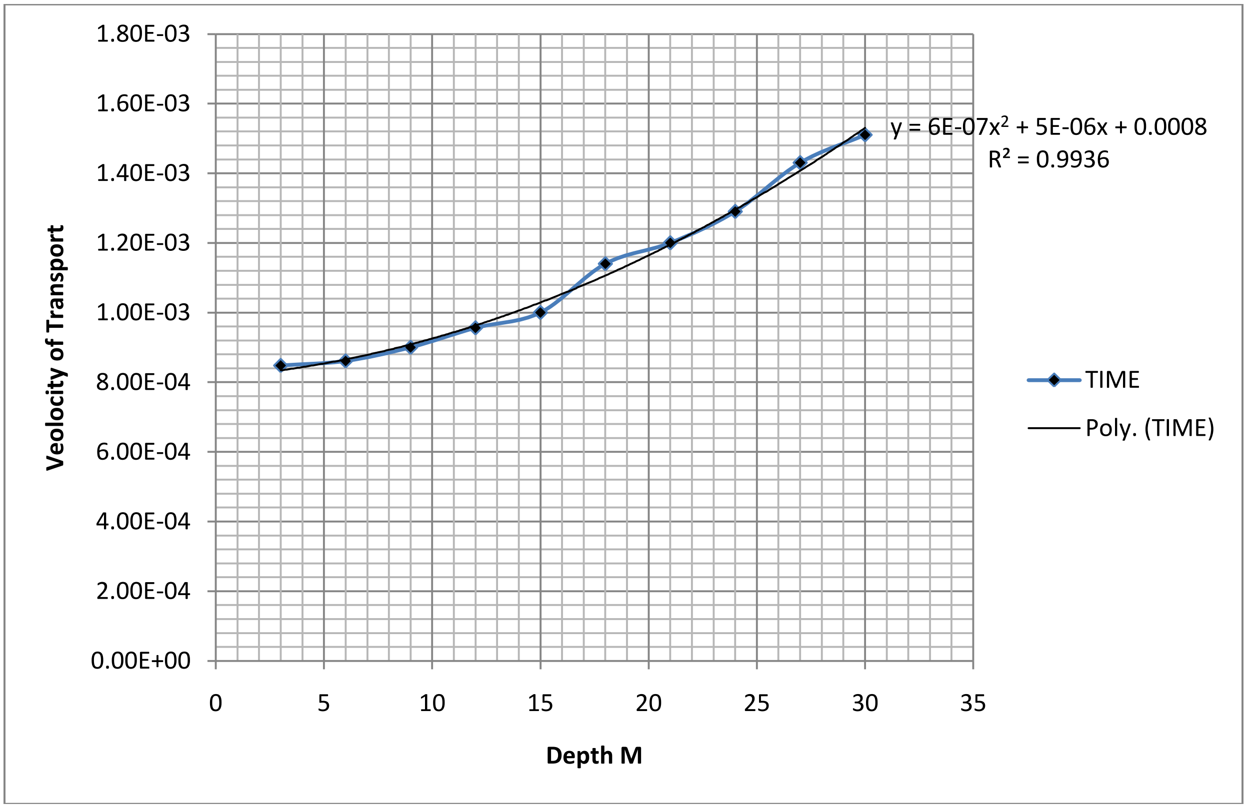

Fig. 3. Velocity of E. Cali solute transport at different distance.

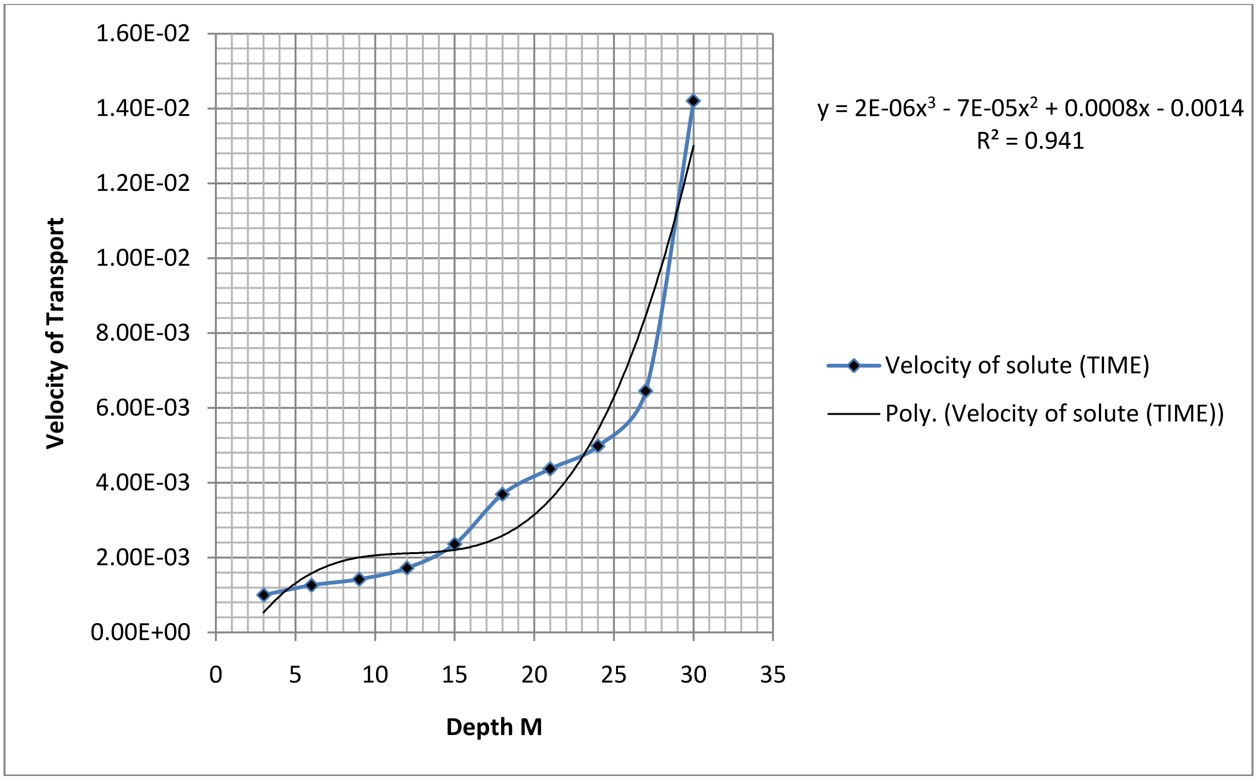

Fig. 4. Velocity of E. Cali solute transport at different distance.

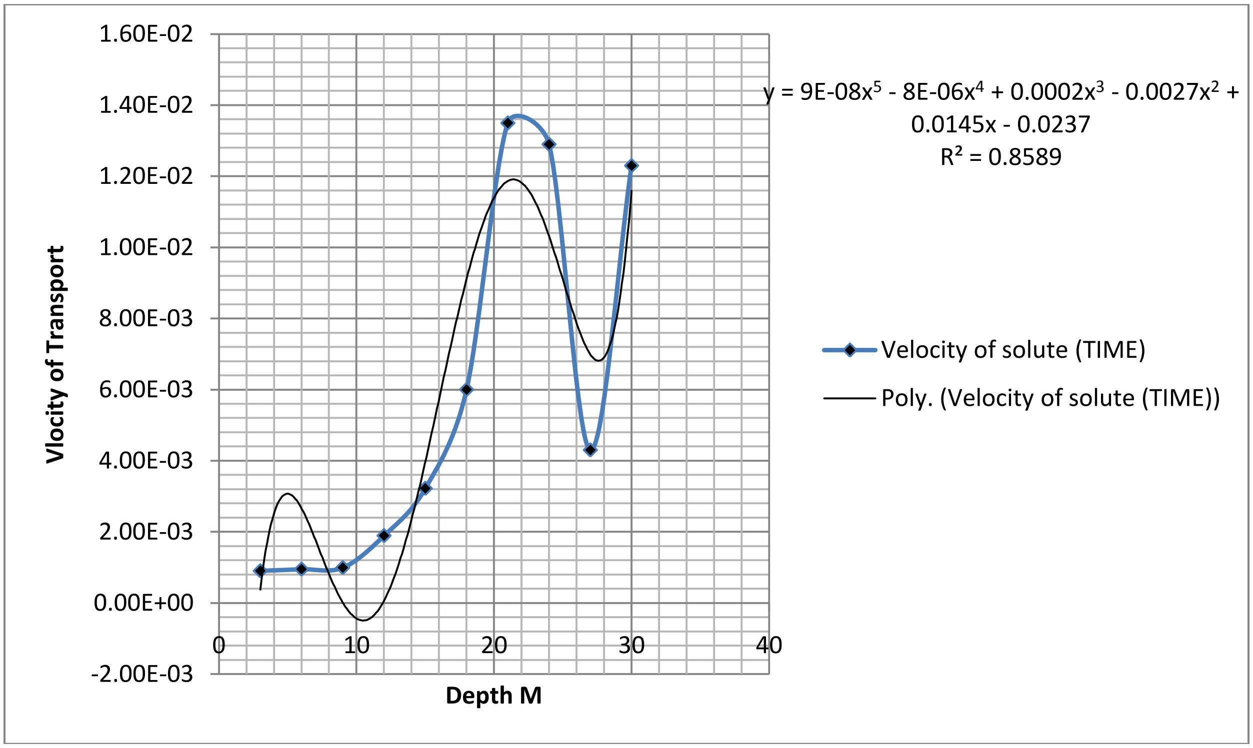

Fig. 5. Velocity of E. Cali solute transport at different distance.

Figure 1 shows that the velocity experienced a gradual increase in a fluctuation form to where the maximum level where recorded at thirty meters where the vacillation where observed are the region where lateritic soil are deposited, the rate of velocity as presented in this figure can be attributed to structural deposition of the formation where the lateritic soil are mixed with silty formation this may definitely influence the velocity of flow at the rate of clay content are an average deposition. Figure 2 experienced a rapid increase between three and six meters and fluctuate from twelve to thirty meters where the optimum level where recorded. This condition of flow shows that the formation of the soil did not deposit predominant lateritic soil, this similar to figure one, the formation deposit greater percentage of silty and fine and that influence the velocity of flow. Figure 3, observed a greater percentage of lateritic with slight clay deposition between three and twelve meters and transit from that region to where it observed homogenous formation of fine sand base on these condition, the velocity of flow gradual increase to the optimum point at thirty meters. Figure 4 experienced low rate of velocity between 3 and 21 meters and suddenly increase from twenty four to thirty meters where the optimum level where recorded this condition shows that the deposition of the formation where predominant deposit lateritic and clay formation, this influence the velocity of flow in these formation. The rate of porosity where very low between 3 and 21 meters compared to 24 to 30 that influences the increase of velocity at various formation. figure 5 experienced a gradual increase in velocity of flow between three and twelve meter and rapidly increase to where the optimum value where recorded at eighteen meter, sudden decrease where observed between twenty-one and twenty-seven, but finally an increase where observed at thirty meters, the formation where found to be heterogonous at this location, the formation experience variation of flow path and this influence the velocity of solute as presented in the figure. Velocity of solute determined the time of transport and distance travel in soil formation, microbes are living organism, there behavior where found to have influence on the variation in velocity of solute through the deposition of the formation. The study area are predominantly with homogenous formation this would have also influence the velocity of flow, but in most could not it has been confirm that the homogenous condition influence the flow paths, in some geological deposition of some area, the flow net and flow path of the formation are heterogonous in deposition, so even when the formation of the soil are found to be homogenous that do not influence much the velocity of flow to be homogenous. Finally, Few location in the study area may experience the influence of stratification deposition as presented in figure five, porosity variation are determine on the soil structural deposition, base on the behavior of the microbes migration, in some case it also influence the velocity of flow.

4. Conclusion

The rate of velocity of solute on E. COLI transport in the study has been thoroughly examined. The velocity of solute of the microbes was founded to experience linear and fluctuate increase base on the deposition of the soil. This where found to influence the migration of solute flow, in most conditions the flow path are more influential, porosity of the soil where found to deposit high between fifteen meters and thirty meters in the study area where deposit homogenous formation where predominant, while few areas are heterogonous, the velocity of flow in the study area where found to be determined by the variation of flow path in the soil structural deposition, the velocity of solute flow calibration is imperative because this condition will determine the time of transport of different formation and predict rate of transport of solute and various formation.

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