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Original article

Dispersion influence from void ratio and porosity on *E. coli* transport in homogeneous soil formation in coastal area of Degema, rivers state of Nigeria

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ABSTRACT

Dispersion of E.coli transport in homogeneous fine and coarse soil in coastal area of degema has been examined. The transport of E.coli where confound to have deposited in coastal formation, through the predominant of alluvium deposition in the study location, shallow aquifers where also confirmed to deposit at the study area, the influence from high degrees of porosity where confirmed to have play a major role in the dispersion of the contaminants in the study location. The study is imperative because these source of transport are through the flow path in the soil resulting to the spread of the contaminants, dispersion where found to occurred through high degree of porosity and void ratio in the study area, this condition where found to increase the concentration of the microbes in some of the region, the degradation of the microbes in these condition can only take place when there is an inhibition that will reduce the concentration to the standard, where the microbial meets world heath organisation standard, these confirms that quality of water can be abstracted those aquiferious zone, voids ratio and porosity variation in there degree of deposition are through the stratification of the soil ,under the influence of geological formation of the study area, the study can be applied as a bench mark to determine the rate .of dispersion ,on the study location.

1. Introduction

To determine if a given water supply is safe, the source needs to be protected and monitored regularly. There are two broad approaches to water quality monitoring for pathogen detection. The first approach is direct detection of the pathogen itself, for example, the protozoan *Cryptosporidium parvum*. While it will be more accurate and precise if specific disease-causing pathogens are detected directly for the determination of water quality, there are several problems with this approach. First, it would be practically impossible to test for each of the wide variety of pathogens that may be present in polluted water. Second, even though most of these pathogens can now be directly detected, the methods are often difficult, relatively expensive, and time-consuming (WHO, 1996). Instead, water monitoring for microbiological quality is primarily based on a second approach, which is to test for .indicator organisms. For a classification table created by the author of typical indicator organisms). The indicator microorganisms should fulfill the following criteria (Stetler, 1994):

The concept which explains the ultimate destination of rainwater is the sea either directly through run off or indirectly be infiltration and subsurface flow. A system of water movement in the atmosphere or rainfall, dews, hailstones or snowfalls over land as run off. Vertical and horizontal movement underground as infiltration or subsurface and continuous movement of all forms of water is the hydrogeology cycle. In the atmosphere, water vapours condense and may give rise to precipitation. However, not all this precipitation will reach the ground surface; some are intercepted by vegetation cover or surface of building and other structures and then evaporate back into the atmosphere. The precipitation that reaches the ground surface may flow in to stream, lake and ocean, where it will either be evaporated or form seepages intruding in to the ground likewise soil moisture and further percolate downward to underline aquifer where it may be held for several years longer. Groundwater in Nigeria is restricted by the fact that more than half of the country is underlain by crystalline basement rock of pre-cambian era. The main rock types in this geological terrain include igneous and metamorphic rock such as migmatites and granite gneisses. Generally in their unaltered form, they are characterized by low porosity and permeability. Porosity in basement rocks is by induction through weathering while secondary permeability induces by tectonic activities which manifest in form of that often act as conduct path facilitating water movement. In other words, aquiferous zones in the basement terrain include fractured/weathered rocks. The yielding capacity of well, drilled within such rock are always very enormous. (Shitta 2007)

Groundwater is the main resource of drinking water in many parts of the world. Contamination resulting from industry, urbanization and agriculture poses a threat to the groundwater quality (Amadi, 2009). The task of balancing groundwater protection and economic activities is challenging. Therefore, understanding the effects of different water management strategies and the role of climate change is essential for the sustainable use of coastal groundwater resources (Prasad and Narayana, 2004). According to Olobaniyi and Owoyemi (2006), the coastal regions of the world are the most densely populated areas in the world. More than one third of the world's populations are living within 100 km of the coastline (Hughes, et al., 1998). At the same time, the coastal regions provide about one third of the world's ecosystem services and natural capital (Aris, et al., 2007). Such growth is accompanied by increasing demand for water supply leading to the over-exploitation of the aquifer system and excessive drainage for land reclamation purposes. Contamination of the groundwater by natural means (seawater intrusion) and through anthropogenic means (human activities) cannot be ruled out in the area. The study is aimed at evaluating the quality of groundwater from the coastal plain-sand aquifer Port-Harcourt area with the view of determining its suitability for domestic, irrigational and industrial purposes. The heavy industrial and human activities in the area lead to the present study. The aquifer system in the area is largely unconfined, highly porous and permeable and the possibility of anthropogenic interference cannot be completely ignored, hence the need for this study.

Port-Harcourt, the 'garden-city and treasure base of the nation' is situated about 60 km from the open sea lies between longitude 6o55'E to 7o10'E of the Greenwich meridian and latitude 4o38'N to 4o54'N (Fig. 1) of the Equator, covering a total distance of about 804 km2 (Akpokodje 2001). In terms of drainage, the area is situated on the top of Bonny River and is entirely lowland with an average elevation of about 15 m above sea level (Nwankwoala, 2005). The topography is under the influence of tides which results in flooding especially during rainy season (Nwankwoala and Mmom, 2007 Nwankwoala, 2005). Climatically, the city is situated within the sub-equatorial region with the tropical monsoon climate characterized by high temperatures, low pressure and high relative humidity all the year round. The mean annual temperature, rainfall and relative humidity are 30oC, 2,300 mm and 90% respectively (Ashton-Jones, 1998). The soil in the area is mainly silty-clay with interaction of sand and gravel while the vegetation is a combination of mangrove swamp forest and rainforest (Teme, 2002). Port-Harcourt falls within the Niger Delta Basin of Southern Nigeria which is defined geologically by three sub-surface sedimentary facies: Akata, Agbada and Benin formations (Whiteman, 1982). The Benin Formation (Oligocene to Recent) is the aquiferous formation in the study area with an average thickness of about 2100 m at the centre of the basin and consists of coarse to medium grained sandstone, gravels and clay with an average thickness of about 2100 m at the centre of the basin and consists of coarse to medium grained sandstone, gravels and clay (Etu-Efeotor and Akpokodje, 1990). The Agbada Formation consists of alternating deltaic (fluvial, coastal, fluviomarine) and shale, while Akata Formation is the basal sedimentary unit of the entire Niger Delta, consisting of low density, high pressure shallow marine to deep water shale (Schield, 1978).

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 days for analysis,

2.1. Permeability test and porosity

Falling-head test method is the method applied. This method is usually employed to determine a coefficient of permeability for fine grain soil. The soil sample is usually undisturbed and very often the u 4 sampling tube can be used as container during the test. A coarse filter screen is placed at the upper and lower ends of the sample tube. The base of the sample tube is connected to the water reservoir, to the top of the sample tube is connected a glass stand pipe of known cross section area. This pipe is filled with water as the water seeps down through the soil sample; observations are taken of time versus height of water in the standpipe above base reservoir level. Series of tests are performed, using different sizes of stand pipe and the average value of the coefficient of permeability is taken. Note must be taken of the unit of weight of the sample’s moisture content.

Furthermore, falling-head permeability test using the standard mild parameter, a substantial head loss can occur through the thick porous stone in the base. The small water entry orifice through the cap may produce a sample cavity from local flow condition. Care is required to produce a water tight system. Use a mater stick to obtain the hydraulic head h1 and h2.

In the falling test, since water flow through the sample as the level of water in the stand pipe drop over a time interval at the rate of flow can determine the value of *k* by plotting in pole against it and finding the gradient.

Notice that in a falling head test, the effective stresses change because the pore pressure change as the level of water in the standpipe falls. Any volume changes that occur as a result of these changes of effective stress have to be neglected.

Value of the coefficient of permeability measured in laboratory permeability test are often highly inaccurate, for a variety of reasons such as autotrophy (i.e. value of *k* is different for horizontal and vertical flow) and small sample being unrepresentative of volume of soil in the ground and in practice value of *k* measure from insitu test are much better. Its sample are collected from bore hole drilling site (i.e. aquifer material) through insitu method of sample collection on a sequence of 3 metres interval in several locations, but notice is taken on the dynamics of the sample based on the type of deposition. Other tests include void ratio and porosity for all the study area.

3. Results and discussion

Results have been shown in Tables 1, 2, 3, 4, 5, 6. Also, figure 1 presented shows that fluctuation where experienced on void ratio, where the optimum value where recorded at nine metres, similar condition where also observed in porosity sudden decrease where observed from nine to twelve metres, and it finally fluctuate to thirty metres, optimum value where recorded at nine metres fluctuating down to thirty metres, this condition can be attributed to the rate of disintegration of sedimentary deposition influenced by alluvium deposition predominant in deltaic region. Figure two produce optimum value at nine metre vacillation from twelve metre experienced to the lowest degree at thirty metres, Similar condition where observed for porosity, while figure three were found to experience rapid increase with dynamic in distance between three and twelve metres, sudden decrease were also observed from fifteen metres in a fluctuation form to the lowest at thirty metres. While void ratio in the same vein maintained the level of deposition where optimum value where recorded at six metres and the lowest from twenty four to thirty metres where recorded. Figure four produced the maximum value at six metres fluctuating down from to the lowest observed from twenty four to thirty metres, while void ratio maintained the same vein by vacillating from three to twenty four metres, and observed it optimum value at twenty seven metres, decrease where finally experience at thirty metres. Figure five experience rapid increase with distance from three to thirty metres to where the optimum value where recorded, while void ratio experience fluctuation between three and nine where the optimum value where recorded, it finally fluctuate from twelve to thirty metres where the lowest degree where recorded, figure six experienced rapid increase between three to nine metres and suddenly experience decrease between twelve metres and fifteen metres, optimum value where observed at twenty one metres, the transport of *E. coli* are influenced by several factors dispersion of microbes are base on the influence on structural deposition of the soil, this condition are predominant by the degree of void ratio and porosity in the study location, the microbes are influence by the degree of porosity base on the micropole of the soil, since microbes are living organism, they flow with the fluid on the soil within the micropoles, so the rate of dispersion will depend on the degree of these two parameters, these type of microbial species migrate on there flow path and on the transport disperses to the hole environment the study has shows that dispersion contribute a very large percentage of the high rate of concentration in the study area.

Table 1
Comparison of porosity and void ration at various distances.

Distance	void Ratio location 1	Porosity (N)
3	0.33	0.66
6	0.22	0.44
9	0.25	0.5
12	0.29	0.58
15	0.98	0.04
18	0.12	0.28
21	0.14	0.7
24	0.35	0.7
27	0.98	0.6
30	0.32	0.06

Table 2
Comparison of porosity and void ration at various distances.

Distance	void Ratio location 2	Porosity (N)
3	0.41	0.82
6	0.31	0.62
9	0.56	1.12
12	0.06	0.12
15	0.07	0.14
18	0.19	0.38
21	0.04	0.08
24	0.06	0.12
27	0.00098	0.0013
30	0.09	0.18

Table 3
Comparison of porosity and void ration at various distances.

Distance	void Ratio location 3	Porosity (N)
3	0.29	0.58
6	0.34	0.68
9	0.33	0.66
12	0.23	0.46
15	0.27	0.54
18	0.14	0.28
21	0.1	0.08
24	0.12	0.12
27	0.11	0.0013
30	0.07	0.18

Table 4
Comparison of porosity and void ration at various distances.

Distance	void Ratio location 4	Porosity (N)
3	0.31	0.62
6	0.41	0.8
9	0.38	0.76
12	0.33	0.72
15	0.16	0.32
18	0.2	0.44
21	0.2	0.4
24	0.02	0.04
27	0.98	0.02
30	0.015	0.02

Table 5
Comparison of porosity and void ration at various distances.

Distance	void Ratio location 5	Porosity (N)
3	0.09	0.14
6	0.1	0.2
9	0.07	0.14
12	0.15	0.08
15	0.13	0.24
18	0.12	0.26
21	0.24	0.3
24	0.36	0.24
27	0.49	0.1
30	0.57	0.012

Table 6
Comparison of porosity and void ration at various distances.

Distance	void Ratio location 6	Porosity (N)
3	0.19	0.38
6	0.25	0.5
9	0.38	0.676
12	0.13	0.12
15	0.11	0.22
18	0.15	0.3
21	0.99	0.18
24	0.44	0.08
27	0.1	0.2
30	0.08	0.16

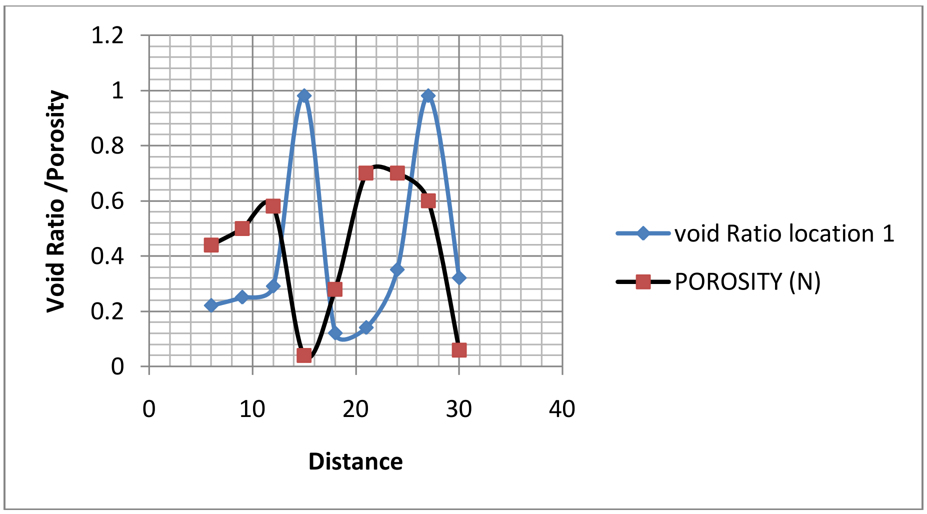

Fig. 1. Comparison of porosity and void ration at various distances.

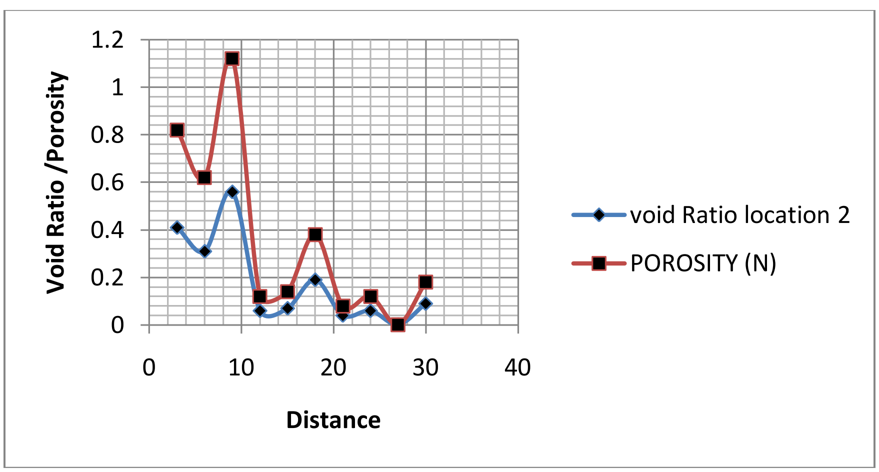

Fig. 2. Comparison of porosity and void ration at various distances.

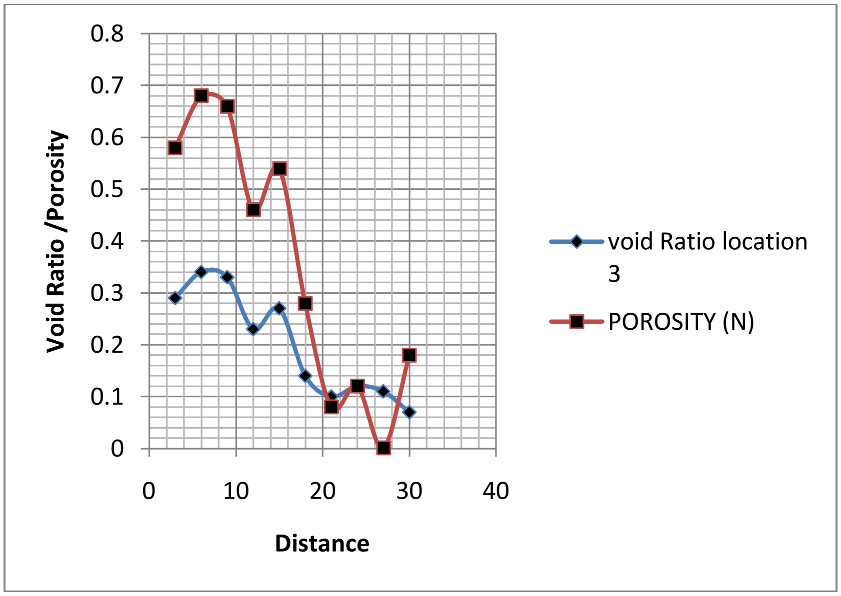

Fig. 3. Comparison of porosity and void ration at various distances.

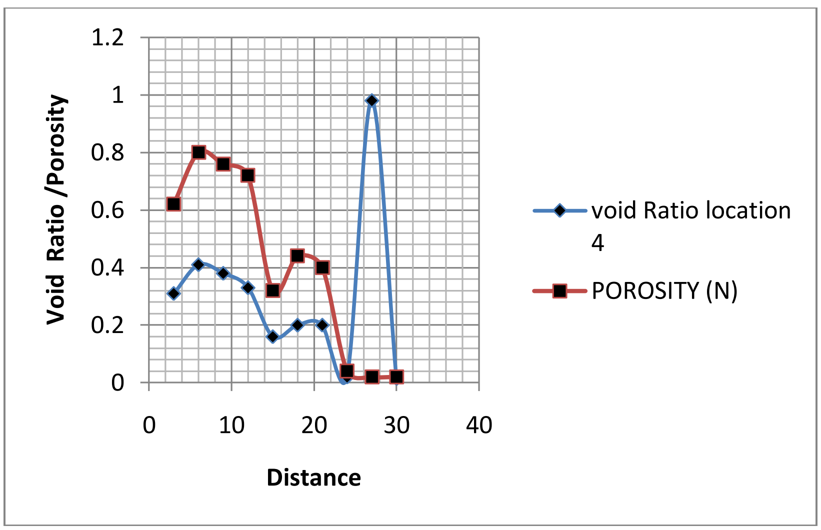

Fig. 4. Comparison of porosity and void ration at various distances.

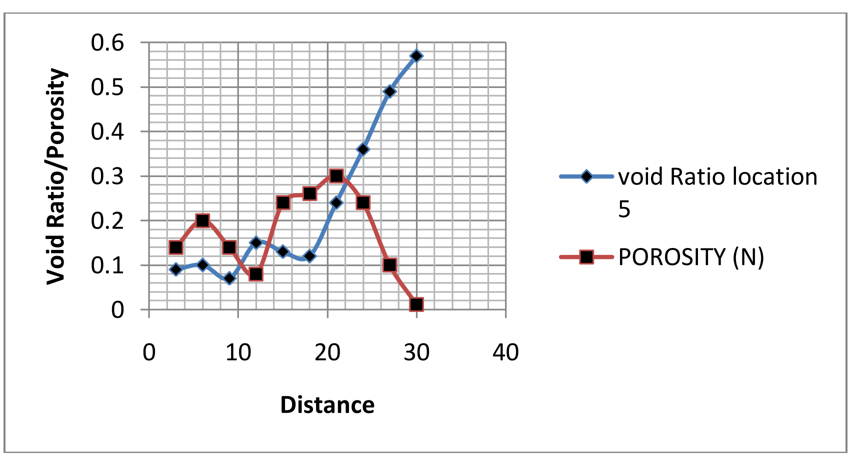

Fig. 5. Comparison of porosity and void ration at various distances.

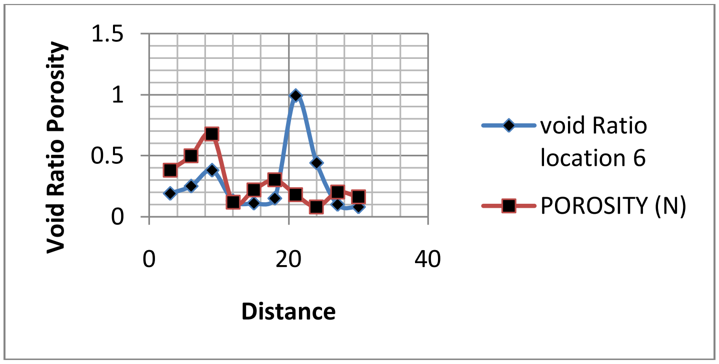

Fig. 6. Comparison of porosity and void ration at various distances.

4. Conclusion

Dispersion on transport process of *E. coli* is one of the variables considered in a system of modeling, the transport of contaminants in soil and water are normally from one region to another under the law of plug flow application. This condition is peculiar on the transport of microbes in soil and water environment because in soil deposition the degree of void ratio and porosity are constantly established, this implies that there is an established relationship between the soil and dispersion of fluid in soil, in these condition it is not out of context that at any point there is transport of *E. coli* transport since there is an established relationship between the both parameters, the tendency of dispersion of the contaminant from the flow path are base on these factors, the rate of dispersion coefficient are determined by the influence of the stratification of the stratum deposition in the study area, transport of *E. coli* in the study area where thoroughly examined through the laboratory analysis, but the rate of dispersion of the contaminants where confound through the analysis done from the contaminated point source, where the concentration where expected to be the control sample, it was confirmed from the trace of the contaminant (E. coli) from the point source. Studies carried out reveals the rate of dispersion. This condition has show other way that migration of *E. coli* contaminates large environments the study is imperative because it has explain the role of dispersion in transport process of *E. coli* in the study area.

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