International Journal of Engineering and Technology, 2 (1) (2013) 17-24
©Science Publishing Corporation
www.sciencepubco.com/index.php/IJET

Establishment of porosity and permeability models correlation to validate E.coli Transport to ground water aquifers: Rivers state of Nigeria

[*]Eluozo, S. N., Ademiluyi, J. O.

Department of Civil Engineering, Faculty of Engineering, University of Nigeria Nsukka
**Corresponding author E-mail: solomoneluozo2000@yahoo.com*

Abstract

The evaluation of porosity and permeability models correlation on the migration of E.coli transport in deltaic environment has been assessed. This is to validate the model generated from the experimental analysis in the study location, these models are generated through the experimental results from both parameters, the theoretical values from both parameters confirm that the models generated is a bench mark that can be applied as a design criteria in preventing the migration of E.coli to ground water aquifer. It has also confirm that it plays a major role in fast transport of e.coli in deltaic environment, the figures displayed shows the level of deposition of geological formation in the study area, the study has also explained the migration of the microbes influenced by porosity and permeability, the results from the experiment generated theoretical values for porosity and permeability, these were evaluated to see their relationship in terms of influence on the behaviour of the microbial transport as a system known as plug flow. The results confirm that without any inhibition from any other deposition, E.coli will be in progressive phase condition; therefore it is advice that the models generated from the study area should be applied in design of bore hole in other to prevent the pollution emanating from e.coli in the study area. Finally, the relationships verified from the study has a fit to the existing geological history of the study area that is predominant of alluvium deposition, this condition ascertain the reality of the experimental results generated from the study area ,it should be applied to avoid water related diseases and threat to life.

Keywords: *porosity and permeability model validate E.coli Transport ground water aquifers.*

1 Introduction

Establishments of porosity and permeability models correlation on E.coli transport in Deltaic environment is a way of determining the influence of microbial transport. The transport of microbes in a rapid state may have been caused by this condition, the study Area have suffered lots of rapid migration of microbial transport influenced by this condition, where most people in the study area have also suffered water related diseases, this can be observed through the most source of quality water which is ground water abstraction, in this condition, since bore hole is a system of plug flow reactor, in most cases it does not happen immediately but in a short period of time. The study from this dimension was observed through the construction of bore hole, they consult inexperienced people that can not consider this condition in the design of ground water development, this has resulted to pollution transport of microbes from this dimension, they suffer this problem that occur immediately and most time in short while, therefore it become imperative that the study of this model evaluation from this dimension should be examine to find deterministic model to be apply during ground water development and design, this is to avoid this threat of human life in the study area. The causes of this rapid transport of microbes is from the influence of porosity and permeability, this include their deposition of Geological formation in the study location, it was observed in variation on their soil depositional structure by evaluating their relationship in deposition, finding out their values through experimental analysis. More so the proportion of void in a rock is the porosity and is generally express as the percentage. Where the pores and fracture are joined up, water can flow easily and the rocks are said to permeable. [5] .Although water is a renewable resource and we use little more than 10% of the total precipitation surplus for public water-supply, irrigation, and industrial processes, its availability is restricted through an uneven distribution, both in time and space. In this respect, there is no essential difference between ancient times and the present day; society has always experienced problems with water: too little, too much, too variable too polluted. Over more than 6000 years mankind has tried to manage these water problems: by intervening in its natural courses through redistribution, storage, and regulation, to accommodate their requirements for irrigation, drainage, flood protection, drinking water, sanitation, and power generation. Management and exploitation resulted in systematic knowledge of behavior of water under more or less controlled conditions. Gradually, from the Renaissance onwards, this empirical knowledge merged with scientific developments into a basic understanding of the hydrological cycle and the mechanics off lowing water. Scientific developments in subsurface hydrology emerged in the early 19th century in Western Europe, particularly in connection with the search for unpolluted drinking water for the growing cities, and in relation to land drainage and dewatering of excavations for building or for mining. The center of progress subsequently shifted to the United States at the beginning of the 20th century, notably because of the importance of groundwater for the development of the semi-arid mid-western areas. The focal point of developments remained with North America, but merged with advances elsewhere from the mid-20th Century, due to the expansion of international communication and dissemination of knowledge. Several parallel, but more or less isolated developments, had taken place in different countries prior to the mid- 20th century [2, 3]. From every point of view, the fundamental interest in a porous medium is ability to hold and transmit water. There are a number of terms that relate to the water-holding potential of a medium. The most important of these is mediums porosity [1, 2] Permeability is a critical parameter for the assessment of how water flows through soil and rocks. The precise meaning of the term ‘permeability’ is sometimes a cause of confusion between engineers and hydro geologists. Civil and geotechnical engineers are interested almost exclusively in the flow of water through soils and rocks and use the term ‘coefficient of permeability’, given the symbol *k*.For convenience *k* is generally referred to simply as ‘permeability’, Therefore, for groundwater lowering purposes permeability, *k*, will be defined as ‘a measure of the ease or otherwise with which groundwater can flow through the pores of a given soil mass’. A slight implication is that the permeability of a porous mass is dependent not only on the nature of the porous media, but also on the properties of the permeating fluid. In other words, the permeability of a soil to water is different from the permeability of the soil to another fluid, such as air or oil. Hydrogeology references highlight this by calling the engineer’s permeability ‘hydraulic conductivity’ to show that it is specific to water. Often, if the term ‘permeability’ appears in hydrogeology references it actually means the permeability of the porous media independent of the permeating fluid, sometimes also known as intrinsic permeability [4 6]. Porosity *n* was defined as the volume *V*P of the pores of a rock or soil sample divided by the total volume *V*t of both pores and solid material so that $n = V\text{p}/V\text{t}$. But porosity at a geometric point cannot be defined since a porous medium is a conglomerate of solid grains and voids. It is then necessary to introduce the concept of representative elementary volume (REV). The REV is sufficiently large to define a *space-averaged* porosity, but it is small enough that the variation from one REV to the next may be approximated by a continuous function on the scale of the measuring instruments. Thus one could take, for example, an REV of 1 cm3 for fine sand, but it could be quite larger for a fractured rock. An alternate approach is to consider the porous medium as a realization of a random process. The porosity at a geometrical point is then an *ensemble average* of an infinite number of realizations [1, 6, 7]. The groundwater level fluctuation is controlled by recharge and draft of groundwater and the Diverse influences on groundwater levels include meteorology, tidal phenomena, urbanization, earthquakes and external loads Stress and strain in water level due to groundwater recharge, discharge and intensity of rainfall are reflected in groundwater level fluctuation with time [8, 9]. The mean annual rainfall over India is about 105 cm and exceeds the global average rainfall of 70 cm. Even then, about 80% of the Indian territories fall under semiarid conditions. This is because of spatial and temporal distribution of rainfall, overall variability’s of monsoon, topographic variations, prevailing semiarid to arid climatic 2006). Moreover, overexploitation, excessive agriculture, untreated effluents and wastes have caused deterioration in groundwater quality. Whereas paucity of clean drinking water can affect the general health and life expectancy of people [6], the use of poor quality water in irrigation can degrade the soils due to contamination [6, 8, 9, 10, 11]. The lowering of groundwater levels has resulted in reduction in individual well yield, growth in well population, failure of bore wells, drying up of dug wells and increase in power consumption [7, 9, 12, 13]. Groundwater is often developed without proper understanding of its occurrence in time and space and is, therefore, threatened by overexploitation and contamination. For that reason, groundwater management is the key to combat the emerging problem of water security. Knowledge of water table depth is a crucial element in many hydrological investigations; many people are surprised to discover that groundwater is widely and heavily used throughout the world. During severe droughts in arid regions of the world, newspapers and television carry dramatic pictures of dry wells in rural communities and people walking long distances for small amounts of household water. However, groundwater usage is important in both humid and arid regions, and it can be a revelation that many cities are dependent on groundwater and use such large volumes of groundwater in their public water supplies. One reason for this general lack of awareness is that groundwater is usually a hidden resource, out of sight and therefore out of mind. It is, nevertheless, as valuable an asset in water supply terms as rivers, lakes and reservoirs, and deserves to be equally protected. As a consequence of this lack of awareness, the main features of groundwater systems are poorly known or even misunderstood. To provide the necessary basic knowledge of hydrogeology for the reader to fully appreciate the rest of the monograph, this chapter aims to rectify the situation by placing place groundwater in its appropriate context within the wider water cycle. It then summarizes the ways in which groundwater occurs and moves, and how it is replenished. The characteristics of the main types of geological settings are described so that the reader is able to see how different hydrogeological environments vary in their response to the pressures of water abstraction and pollution [12, 13].

2 Materials and method

Permeability and porosity Test 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, observation are taken of time versus height of water in the standpipe above base reservoir level. A series of test is 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 of its 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 metre interval in several location, but notice is take on the dynamics of the sample base on the type of deposition. Porosity where also determine applying the standard method of determining porosity where by sample where collected for twenty location in sequence range of three metres each from one to thirty metres and were subjected to thorough analysis. For porosity a standard laboratory experiment were performed to determine the rate of porosity at every location

Table 1: comparison of Theoretical and Measured values of permeability at various Distances

DEPTH	Calculated porosity	verified porosity n
3	0.56	0.55
6	0.6	0.6
9	0.59	0.58
12	0.54	0.52
15	0.46	0.44
18	0.37	0.35
21	0.29	0.27
24	0.24	0.21
27	0.22	0.19
30	0.26	0.23

Table2: comparison of Theoretical and Measured values of permeability at various Distances

DEPTH	calculated k	verified model k
3	8.1	8.1
6	7.34	7.33
9	6.63	6.67
12	5.98	5.99
15	5.38	5.33
18	4.84	4.82
21	4.35	4.33
24	3.92	3.89
27	3.54	3.51
30	3.21	3.18

Table 3: calculated permeability at various Distances

DEPTH	calculated k
3	8.1
6	7.34
9	6.63
12	5.98
15	5.38
18	4.84
21	4.35
24	3.92
27	3.54
30	3.21

Table 4: verified model permeability at various Distances

DEPTH	verified model
3	8.1
6	7.33
9	6.67
12	5.99
15	5.33
18	4.82
21	4.33
24	3.89
27	3.51
30	3.18

Table: 6 calculated porosity at various Distances

DEPTH	Calculated porosity
3	0.56
6	0.6
9	0.59
12	0.54
15	0.46
18	0.37
21	0.29
24	0.24
27	0.22
30	0.26

Table 7 verified porosity at various Distances

DEPTH	verified porosity n
3	0.55
6	0.6
9	0.58
12	0.52
15	0.44
18	0.35
21	0.27
24	0.21
27	0.19
30	0.23

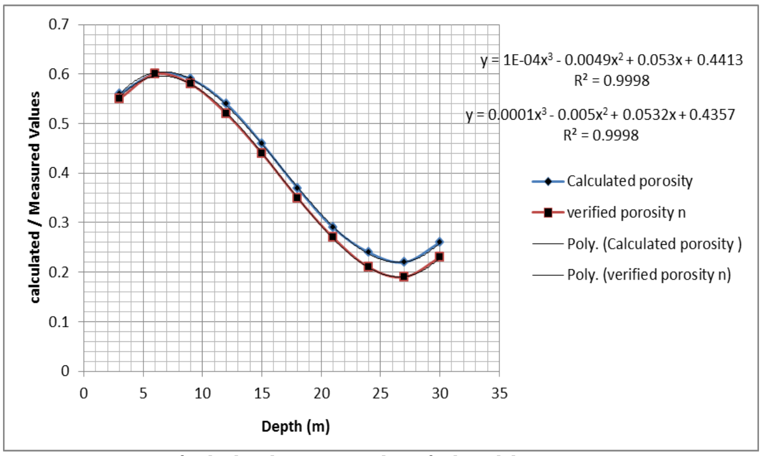

Fig. 1: comparison of calculated porosity and verified model porosity at various Distance

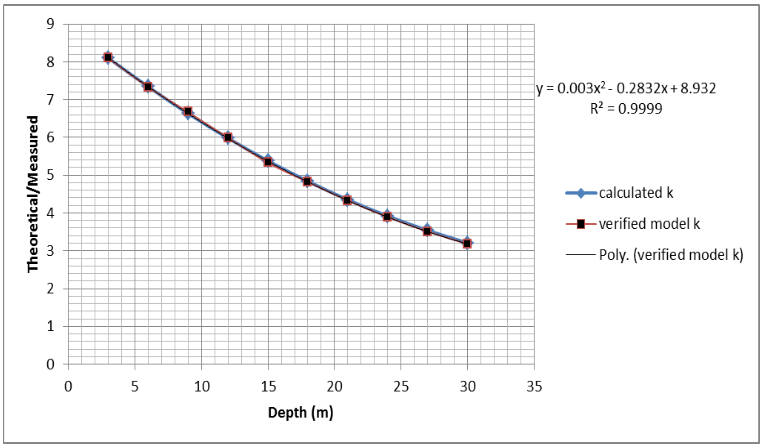

Fig. 2: comparisons of calculated permeability and verified model porosity at various Distance

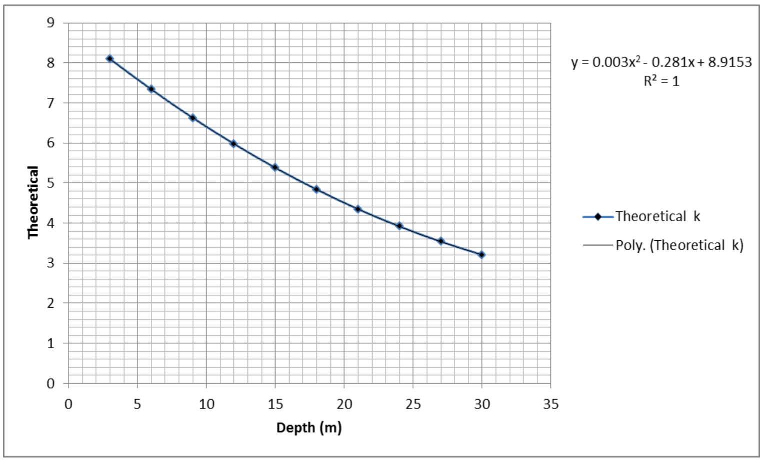

Figure 3 verified permeability at various Distance

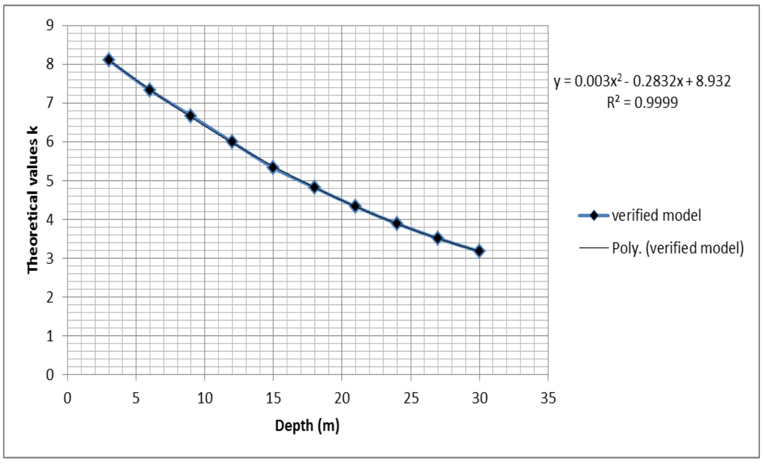

Fig.4: calculated porosity at various Distances

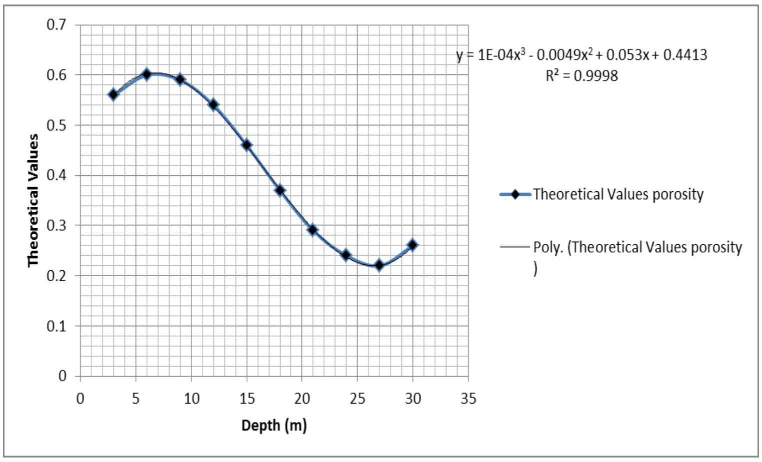

Fig. 5: calculated porosity at various Distances

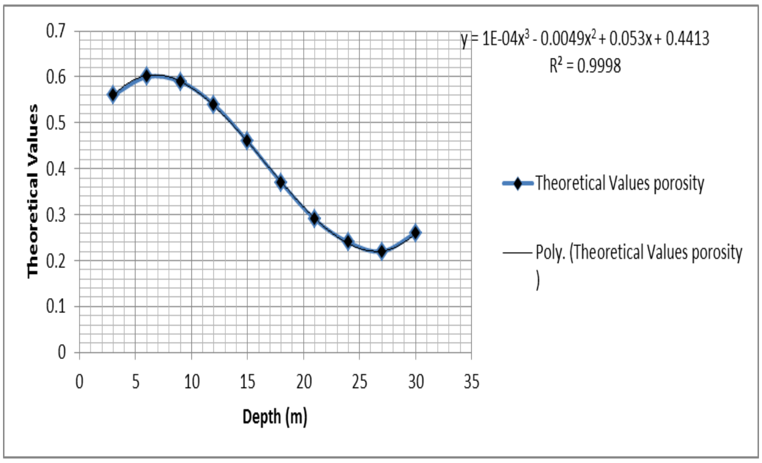

Fig. 6: verified porosity at various Distances

From figure 1 above the calculated porosity generated it lowest degree of porosity at six metres where an optimum value was recorded, declining down gradually to a point also where it recorded its highest level of porosity at thirty metres. Similar to the verified model of porosity it also generated its lowest level of verified model at the same six metres and in the same vein increase permeably with increase in distance to a point were the lowest verified model of the stratum were recorded at thirty metres, both results explain the reality of fast migration of E.coli from one region to the other at different formation of soil. The level of theoretical and measured values are seen to be one of the greatest influence of fast migration of E.coli in deltaic environment especially the study area Rivers State, the model generated from calibration and verification from the study will be a design parameter if it is applied for ground water development in the study location, the comparative study as presented from the figure definitely fit and agree that the both parameter have a relationship, there model generated should be applied in ground water development in preventing transport of E.coli in the study area, both parameter produced the best fit line equation displayed on the graph. Figure 2 shows that permeability developed its lowest level at three metres and gradually increases with distance to a point were the highest level of permeable were recorded at thirty metres. Integrating it to transport of the microbes, one should ascertain the fast migration of E.coli from the silt strata region down to coarse region at homogenous formation on shallow aquifer it implies that those area were water table is high will experience fast transport of E-coli due to this deposition of alluvium deposition in the study location. Figure 3 shows that the theoretical values generate it lowest level of permeability at three metres and gradually increase with increase in distance to a point were the highest level of permeability were recorded at thirty metres, while that of the measured values also maintained the same level of deposition. This can be attributed to the level of geological formation in the study area, in most conditions the predominant of alluvium deposition should be the influence of such level of deposition. this condition also explained the concentration level of microbial transport in some condition, where other influence are adamant, the condition of permeability model verification will assist in model determination of parameter in the design and construction of bore hole considering the pollution of solute transport in the study area. figure 4 shows that the measured values at various distance obtained it lowest degree of permeability at six metres and gradually increase its level of permeability with increase in distance, the highest level of permeability of the stratum were recorded at thirty metres, the verification values will be good in the application of thorough design in most location were high level of microbial concentration and transport are deposited, in such location to achieved a thorough result of ground water abstraction there should be certain consideration in design and construction of water bore holes, by application of the verified model which will be a bench mark for good design and construction of quality water in the study location, the model produce the best fit line equation displayed on the graph. Figure 5 theoretical values recorded the lowest level of porosity and permeability at three metres and gradually increased with distance to a point where it observed the highest level of porous medium, these theoretical values explain that the study locations are homogenous in deposition, it also express the effect it have on microbial transport, whereby the level of porosity generate progressive condition of E.coli behaviour, due to the type of formation deposited, the microbes that find them self in those horizon are influence by the formation, especially where micronutrient are deposited in those formations, the porosity influence the fast migration, including microbial growth and population increase. The parameter generated the best fit line equation displayed on the graph. Figure 6 shows that the lowest level of porosity where recorded at six metres, it gradually increase with distance and recorded the highest level of porosity and permeability at twenty seven and thirty metres the measured values from porosity is a design standard for the location, this can be applied at design stages of ground water development. The verified values from various location explain the deposition of all the formations generated from the experimental result, the effect on the transport of E.coli are through the level of concentration from one region to another as system, looking it as plug flow reactor, the effect and the behaviour are influenced by the soil stratum including other environmental factors.

3 Conclusion

The relationship of porosity and permeability through model validation from the experimental results as been evaluated, the study area has really express the variation in transport base on the deposition of the formation, the result were applied to verified or validate both parameters from the figures it explain the type of deposition in deltaic environment, the study from every point of indication shows the predominant level of alluvium deposition in the deltaic environment, thus the effect on the microbial transport E.coli has also shows the level of alluvium deposition. Finally, it has been generating fast migration of E.coli in progressive phase condition, this implies that the level of concentration without any much influence of inhibition are caused by the level of porosity and permeability depositions, the model verification will definitely assist in design of ground water abstraction, this will serve as bench mark in the study location.

References

[1] Charbeneau R. J: Ground water Hydraulics and pollution transport 2000 pretence Hall upper saddle River pp.
[2] Asawa. G .L : Irrigation and water resources engineering 2008 New age publisher’s pp 121.
[3] Delleur .J. W : The Hand books ground water engineering second edition 2007 CRC Press PP10.

[4] Preene .M. and cashman P.M: ground water lowering in construction: A practical guide spine press Taylor and Francis group London and New York 2002 pp28.

[5] Macdonald et al: Developing ground Water: A guide for rural water supply ITDG Publishing Schumacher centre for technology and development 2005 pp9.

[6] Nash, H. and McCall, G.J.H., Groundwater quality. In 17th Special Report, Chapman and Hall, 1995 London pp1-4.

[7] Rai, S.N. Hydrological Studies, National Geophysical Research Institute, Hyderabad , Hydrological Studies, 2006 pp 17 27.

[8] Gopinath, G and Seralathan, P Studies on Longterm Variability of Groundwater Level in the Hard Rock Crystalline Terrains of a Central Kerala River Basin, IE (I) JournalAGriver. June.2008. Vol.89, pp 4753.

[9] Imtiyaz, M. and Rao, D.J.M., Influence of overexploitation on groundwater 2008 pp1-4.

[10] Briz Kishore, B.H and Bhimasankaram, V.L.S Analysis of Groundwater Hydrographs for Defining a Crystalline Hydrogeological Environment, Journal of Ground Water, SepOct 1981. Vol.19, pp 476481.

[11] Goyal, S.K and Chaudhary, B.S, GIS based study of SpatioTemporal changes in Groundwater depth and quality in Kaithal district of Haryana, India, journal of Indian Geophysics Union, April 2010. Vol.14, No.2, pp 7587.

[12] Sitarama P Kudarvalli, R Prasad k and Udaya B P. (2010), Hydrological Variations of Groundwater in Different Geomorphic Units of Krishna Eastern Delta, Andhra Pradesh, International Journal of Engineering Science and Technology, 2010, Vol.2 (9), pp 40074012.

[13] Sukumar.S , Sankar.K Statistical Study on Pre & Post Monsoon Variation of Groundwater Level in Theni District, Tamil Nadu – India international journal of environmental science 2011 vol 1 No 5.