# Groundwater flow model of unconfined aquifer, South Coimbatore


**Shanthi S**

Department of civil Engineering, Jeppiaar Engineering college,Chennai-73

***Corresponding author: Email: shanthi.cwr@gmail.com**



**ABSTRACT**

An overview study of groundwater flow in South Coimbatore by using Visual MODFLOW 8.1 incorporated with GIS was carried. The study area consist of a discontinuous, unconfined to semi-confined aquifers which was simulated by a simplified model consisting only of two layers based on lithology data.The groundwater recharge was assigned based on GEC -1997.Calibration of a model is the process of changing the aquifer parameters, stresses and boundary conditions using sensitivity analysis approach until conditions of the aquifer flows or hydraulic heads are reproduced with sufficient accuracy.



**Keywords***:* hydrogeology; groundwater flow modeling; groundwater velocity; residual analysis


## INTRODUCTION

Ground water now-a-days has become an emerging source of importance to meet the water requirements of various sectors which includes consumers of water like day today usage, irrigation, urban rural usage, domestic and industrial usage. The sustainable development of ground water resource requires precise quantitative assessment on the level of groundwater table.When the balance between water available and the environmental need is maintained there is no need for groundwater resource management and discussions.The depleting ground water levels have been made an integral part of ground water assessment and modeling.Ground wateris formed when water fully saturates the pores or the cracks in the soil or hard strata rock. Water scarcity and climatic changes are placing demands on groundwater. Ground water is the main source of water in view of the fact that surface water can be availed mainly during monsoons and soon after.Hence it is important to balance between inflow and outflow of groundwater to achieve sustainability and manage groundwater resources to the best of their ability.

## STUDY AREA

Coimbatore is the second largest Metropolitan city and urban agglomeration after Chennai. (State:Tamil Nadu/ Country:India). It is a fastest growing tier-II cities with major textile, Industrial, Commercial, Educational and manufacturing hub of Tamil Nadu. The NoyyalRiver runs through Coimbatore and the city lies amidst Noyyal's basin area and has an extensive tank system fed by the river and rainwater. The study area is bounded on the North by NoyyalRiver. The area is elevated from 234m to 420m above the mean sea level (MSL) and geographical area is 655 km$^2$. The study area receives the rain under the influence of both South West and North East monsoons. The normal annual average rainfall over the district varies from 550 mm to 900mm. During summer season (April to May) the maximum temperature is about 42.6°C, and the mean minimum temperature of about 11.7°C in the plains. Rainfall variation graph of study area from year 2006 to year 2012 is shown in graph.

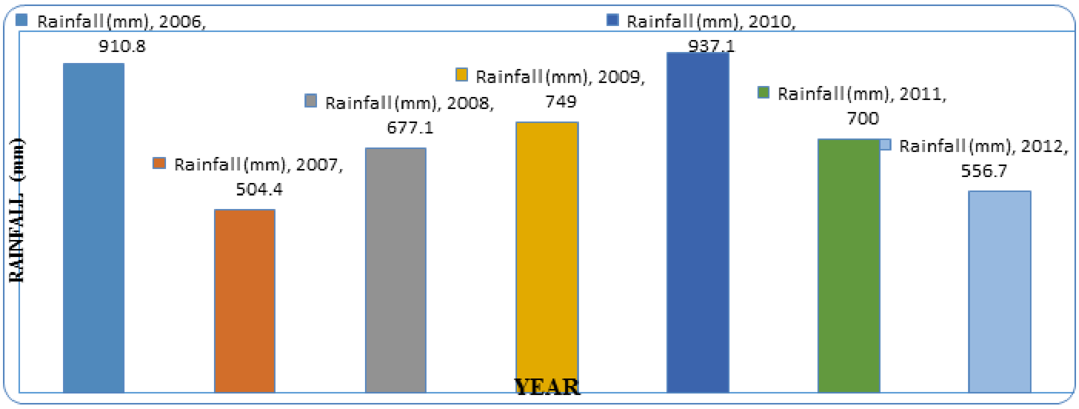



**Figure.1.Rainfall Variation of the Study Area**

## METHODOLOGY

The groundwater assessment was done based on GEC (1997) norms. The groundwater modeling system, MODFLOW 8 (Finite Difference Groundwater Flow) is adopted, to simulate groundwater flow. Two topographic maps 58D/13 and 58F/1 of 1:50,000 scales have been registered (SOI).

Journal of Chemical and Pharmaceutical Sciences ISSN: 0974-2115

**Model Design:** The study area was discretized with grid size of 50 x 50. Thickness of the cells was varied from place to place depending upon the surface topography and thickness of the alluvium. The aquifer system of Coimbatore south comprising discontinuous, unconfined to semi-confined aquifers. The aquifer system of the study area will be simulated by a simplified model consisting only of two layers based on lithology data (Rajamanickam et al., 2010).The top layer for the unconsolidated and semi-confined aquifer elevation was taken from SRTM (Shuttle Radar Topography Machine). The bottom layer for consolidated rocks aquifer was taken lithology data. Groundwater recharge due to rainfall takes place from the top layer. Selection of the cell dimension was a trade-off between the availability of data, accuracy and computer time. Static water levels (non-pumping conditions) were used to evaluate steady-state conditions.

**Input Data of Groundwater Model:** The top elevation of the aquifer was assigned using SOI toposheet and bottom elevation was assigned based on the weathered thickness(Varalakshmi,2010). The discharge from the well was assigned based on secondary data. The groundwater recharge was assigned 10 to 15% of normal rainfall by GEC -1997.Hydraulic conductivity, porosity was assigned based upon field condition (Mamunul,2010) . The water level data 2006 was considered for initial condition and simulation model domain consists of 50 rows and 50 columns. The unconfined aquifer is considered for the study and groundwater flow was assumed to be in a transient state (FouepeTakounjou,2009).

**Boundary Conditions:** The model for the study area was assigned using a combination of physical and hydraulic boundaries. Flow-through boundaries were designed along the west to east boundary of the study area. These were represented by general head boundaries in the model. General head boundaries were used in the model to represent the fluctuations in groundwater elevation over time.The direct recharge from Noyyal river, Kodavadiriver was designated using river boundaries. The values used for river boundaries were based upon secondary data and elevation data.

**Calibration:** Calibration, the most importance phase in the groundwater flow modelling was performed to know the behavior of the aquifer system. Calibration of a model is the process of changing the aquifer parameters, stresses and boundary conditions using sensitivity analysis approach until conditions of the aquifer flows or hydraulic heads are reproduced with sufficient accuracy.

**Validation:** Model validation is the process in which calibrated model used calculated values of hydro-geologic parameters, and boundary conditions to match with historical field conditions. For the flow model validation second year (2009- 2010) data of water level, pumping rates were then upgraded to the model.

## RESULT AND DISCUSSION

**Model calibration:** Calibration is performed with an initial estimate of the parameters A simulation was performed and the output was compared with the observations in the real system. Calibration of the model for study area was accomplished in two steps, steady state calibration and transient state.A total of 7 observation wells were used in the calibration. In order to evaluate model results, the root mean square error (RMSE) of the residuals between observed and calculated water levels used based on the following equation

$$\text{RMSE} = \sqrt[N]{\phantom{x}} \sum(M-S)2/N$$

Where N- number of observations.
M- measured head value in meters.
S- simulated head value in meters.

The smaller the RMSE value, the closer the overall match is between the simulated and observed heads. The calibration method consisted of adjusted were net recharge and hydraulic conductivity.

**Steady State calibration:** An aquifer system is said to be in the steady state conditions (Khurshaidalam, 2006) if the groundwater level, hydraulic gradients and the velocity distribution of groundwater flow do not change with time, although groundwater levels fluctuate seasonally around long term averages.

Journal of Chemical and Pharmaceutical Sciences ISSN: 0974-2115

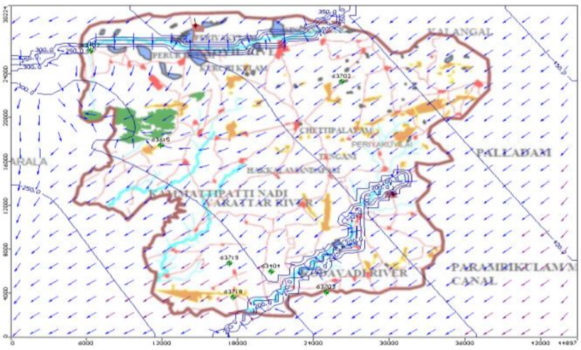


**Figure.2.Velocity Vectors of Flow**

**Transient State Calibration:** The initial hydraulic conductivity values of the steady state model that also used as the values of hydraulic conductivity for transient state model. Model run was executed and results were analyzed. The following changes are done in the calibration process:

i. Varied hydraulic conductivity values.
ii. Changes in recharge values and pumping rate

**i. Varied hydraulic conductivity values:** Initially the entire study area has been designated based on same hydraulic conductivity value. First, that hydraulic conductivity value increased and decreased in the percentage wise and model run was carry out. Since there was no notable change in the calibration graph, the model domain is separated with polygonal areas. The model run was executed and the results were analyzed. The scatter plot and time series graph while changing the hydraulic conductivity is shown in figures.

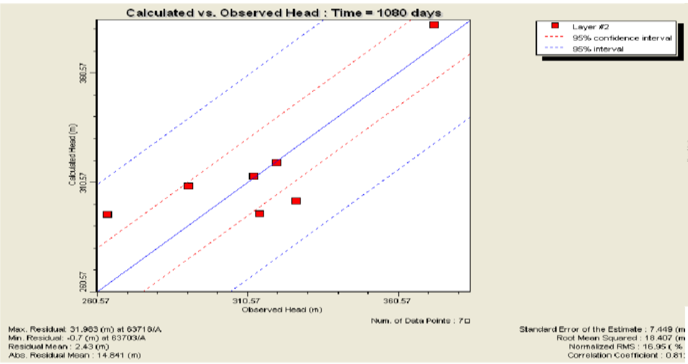



**Figure.3.Calibration Graph for Varied in Hydraulic Conductivity**

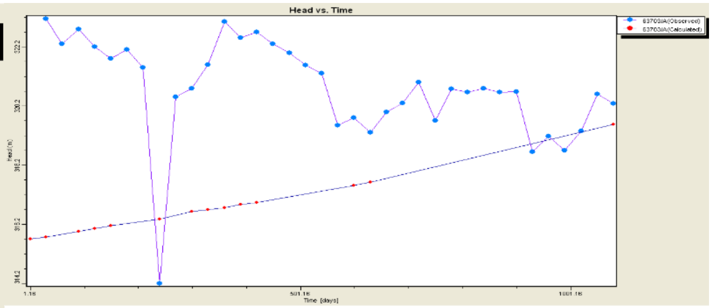



**Figure.4.Time Series Graph for Varied in Hydraulic Conductivity**

**ii.Changes in recharge values and pumping rate:** Recharge of the study area is given a per GEC (1997) norms. Initially it is assigned based upon the secondary values. The calibration and time series graph shown in figure based upon change in recharge value.

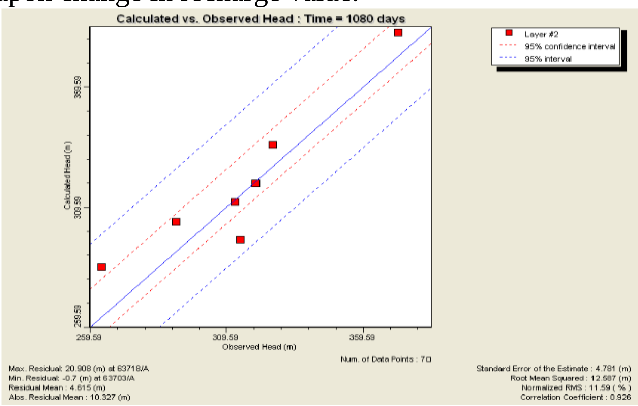



**Figure.5.Calibration Graph for Varied in Recharge Values and Pumping Rate**

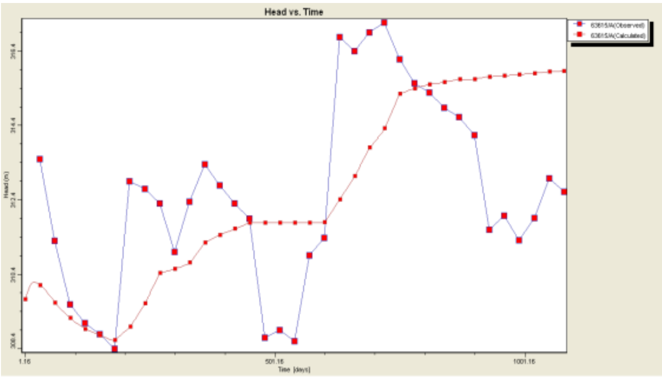


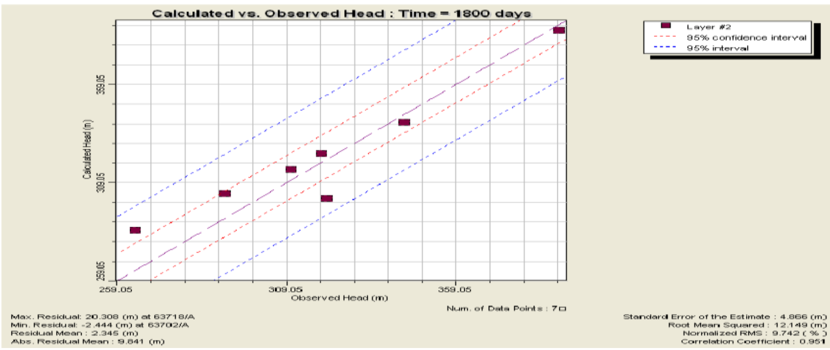

**Figure.6.Time Series Graph for Varied in Recharge and Pumping Rate**

**Table.1.Comparison of results between all calibration changes**

| Calibration parameter | RMSE (m) | Normalized root mean squared (%) | Correlation coefficient |
|---|---|---|---|
| Varied hydraulic conductivity | 12.587 | 11.59 | 0.926 |
| Changes in recharge value | 12.149 | 9.424 | 0.951 |
| Changes in pumping rate | 12.658 | 11.598 | 0.926 |

From above table it could be inferred that the recharge and pumping rates are more sensitive to the model output than any other parameters. By changing the hydraulic conductivity values output results was not that much improved. Then by changing pumping rates and recharge rates, correlation coefficient of up to 0.951 was obtained.

**Model verification:** To establish more confidence in the accuracy and predictive capability of the model, the model was verified against the historic groundwater level data for the period 2009 and 2010 (2 years). The aquifer parameters were kept the same as in the calibration time. Heads calculates by the model for the last stress period of calibration period (December 2008) was used as initial heads. Model runs were made and results were obtained. The scatter plots for the year 2010 is given in figure.




**Scatter Plot of Calculated versus Observed Heads for December, 2010**

## CONCLUSION

A study of groundwater flow in South Coimbatore by using Visual MODFLOW 8.1 incorporated with GIS was carried. The Visual MODFLOW required point data only. The cost of point data is also very low and importing these data is very simple. And also less time required to creating final output. Additional parameters may be used to active better output for different study of south Coimbatore area.

## REFERENCES


FouepeTakounjou A, Groundwater flow Modelling in the upper Anga's river watershed, Yaounde, Cameroon', African Journal of Environmental sciences and Technology, 3, 2009, 341-352.

KhurshaidAlam, Evaluation of aquifer system in Quetta valley through geophysical methods and groundwater flow modelling',Ph.D dissertation, Institute of Geology, University of the Punjab, Lahore-Pakistan, 2009.

Mamunul M.AL., Jahan C.S., Mazumder Q.H., Nawaz S.M.S., Mamud and Adham M.I, Hydrogeological Condition and assessment of groundwater resource using Visual MODFLOW Modelling , Rajshahi city, Bangladesh', Journal Geological Society of India, 79, 2010, 77-84.

Rajamanickam R. and Nagan S, Groundwater Quality Modeling of Amaravathi river basin, Karur District', International Journal of Environmental Sciences, 1, 2010, 91-107.

Varalakshmi V, Rao B, SuriNaidu L and Tejaswini M, Ground water Flow Modelling of aHard Rock Aquifer – a case study, American Society of Civil Engineers, 2010.