Int.J.Curr.Microbiol.App.Sci (2019) *8*(12): 1289-1296

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 8 Number 12 (2019)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2019.812.157

Zone Budgeting of Watershed using Visual Modflow

A. Valliammai[1*] and K. Balathandayutham[2]

[1]SWCE, Tamil Nadu Agricultural University, ARS, Bhavanisagar-638451, India
[2]AED, Dindugal, Tamil Nadu, India

**Corresponding author*

Keywords

Groundwater Flow Model, Visual Modflow, Groundwater, Recharge

Article Info

Accepted:
12 November 2019
Available Online:
10 December 2019

ABSTRACT

Groundwater is an important major natural source of freshwater in the world. Groundwater recharge is an important part of the natural water cycle. Recharge estimates are needed for water balance studies, water supply engineering and water resource purposes. Visual model flow model was employed to simulate the ground water flow and to estimate the recharge for Vadachitur watershed located in Kinathukadavu block of Coimbatore district. Estimation of the hydraulic conductivity, specific yield and specific storage were assigned for each layer of the model based on the hydrological formation and pumping tests. The simulation results show that total inflow into the aquifer is 7.965 Mcum/day and total outflow into the aquifer is 7.954 Mcum/day. The outflow is more than the inflow by an amount of 0.0011 Mcum/day for the period of 365 days. It is recommended to construct suitable recharge structures r to improve the recharge rate for the Vadachitur watershed for sustainable ground water management.

Introduction

The use of groundwater flow models is common in the field of environmental hydrogeology. Models have been applied to investigate a wide variety of hydro-geologic conditions. More recently, groundwater models have been applied to predict the fate and transport of contaminants for risk evaluation purposes. Modeling is a best judgment because it is a powerful tool and can be used for a variety of purposes, including prediction of contaminant transport. Although theoretical analysis is important for solving practical problems; it cannot give prediction results for an individual problem.

Modeling becomes the only way to solve these complex problems related to solute transport by simulating. A three-dimensional finite-difference groundwater flow model was implemented to investigate the variety of hydro geological conditions and to simulate the behaviour of the flow system under different stresses in the aquifer system of PAB basin (Balathandayutham and Mayilswami, 2016). The simulated groundwater flow is subject to a nonlinear moving boundary resulting from periodic recharge and significant vertical hydraulic gradients (Sergio E. Serrano, 2003.) Also the groundwater protection zones can be demarked using Modflow by dividing the total area into a number of grids (Rahman and Shahid, 2004). To estimating groundwater recharge based on water balance component using SWAT-MODFLOW in Minocheon basin found that groundwater recharge rates in the area varied spatially and was dominated by topographical conditions. The method is applicable to humid regions with shallow water table (Mondal and Singh, 2004). The behavior of ground water flow systems and regional wise water budgeting in Vadachitur watershed located in Kinathukadavu block of Coimbatore district was simulated by using VISUAL MODFLOW (version 4.1) for sustainable groundwater management.

Materials and Methods

Study area

The Vadachitur watershed comprises of total geographical area of 257.50 sqkm which is located in the Parambikulam-Aliyar-Palar basin. There is good network of streams in the study area comprising first order, second order and third order streams. All the streams are east flowing and drained into the river Koraiyar. The study area is located between 77^0 4’ 14” E to 77^0 4’ 33” E longitude and 10^0 48’ 51” N to 10^0 52’ 32” N latitude. It is in the over exploited groundwater extraction category (>100%) and located in Granite (Anamalai) terrain. The texture of the soils are varies from clay loam to sandy clay loam (Fig. 1–3).

The hydro-geological boundary condition was characterized by using borehole lithology and preparation of various thematic maps. The aquifer properties were assigned for flow and transport model to simulate the groundwater flow direction and estimate the groundwater potential. The result obtained from the simulation model and map digitization such as water table depth and geological features were used to assign the ranks and weights for overlay process in Geomedia environment. The higher rank and weight indicates more sensitivity to vulnerability. The higher index values obtained from the overlay process indicates the sensitivity zone influencing recharge to the aquifer and was demarcated as groundwater protection zones.

Observation wells

The monitoring of water levels is of prime importance in scheme of artificial recharge of Groundwater. In Vadachitur, 15 wells are identified. Periodically water level is monitoring in the observation wells.

Data

Data on Aquifer characteristics were collected from CGWB and time series data such as rainfall and water level data for the period 1991 to 2010 were obtained from PWD. Base map of the study area was prepared and digitized. The following data were used in this study: (i) Remote Sensing Data such as IRS I-C, LISS-III data of scale 1:50,000 were collected and used to study the soil type, geology and land use of the block (ii) Daily rainfall data for the was used in the analysis of hydrologic characteristic of the study area and to find the annual recharge and (iii) About fifteen wells in the study area were considered for the study and the information of these wells such as groundwater level, well location in terms of latitude, longitude and mean sea level were collected

Input to model

The details pertaining to wells, rivers, other inflow and outflow features for cells were specified for model run. The boundary of the study area in projected coordinate systems was imported into the model and the map. The total study area has been discretized into an orthogonal grid of 40 rows, 40 columns and 2 vertical layers. For the finite difference solution, a grid of 36 x 28 was used furthermore, such a grid spacing, given the step chosen for the solution, meets the requirements for numerical stability, even in areas with intense pumping activity. This spatial discretization has been found to be adequate in view of the available data and the computational time. Aquifer parameters including hydraulic conductivity, specific yield and specific storage were assigned for the each layer of the model based on the hydrological formation and pumping tests conducted by the CGWB, (2003), Chennai. Model was carried out by assuming horizontal isotropy (K_x = K_y) and the value of vertical conductivity was taken as 0.1 times of K_x.

Results and Discussion

Spatial and temporal analysis of annual rainfall of the study area

There are four rain gauge stations viz. Sultanpet, Podanur, Negamam, Krishnapuram in the study area. The average annual season wise rainfalls (1971-2016) of the study area was studied and analyzed (Fig. 4–7).

Model simulation

Water level in observation wells

The shallow observation wells were screened in the depth interval between 3.2- 30.0 m A decline in water levels in the shallow unconfined aquifer-monitoring network was observed from March 2015 to December 2016 and the pumping data was given as input in the model. Specific yield values assumed for all three layers were 0.0001, 0.00001 and 0.000001 respectively. The hydrologic properties like hydraulic conductivity based on lithology were imported for each layer (Fig. 8).

Fig.1 Vadachitur watershed base map

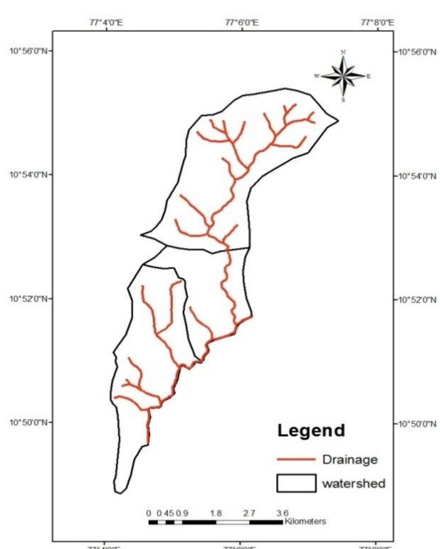


Fig.2 Location of observation wells

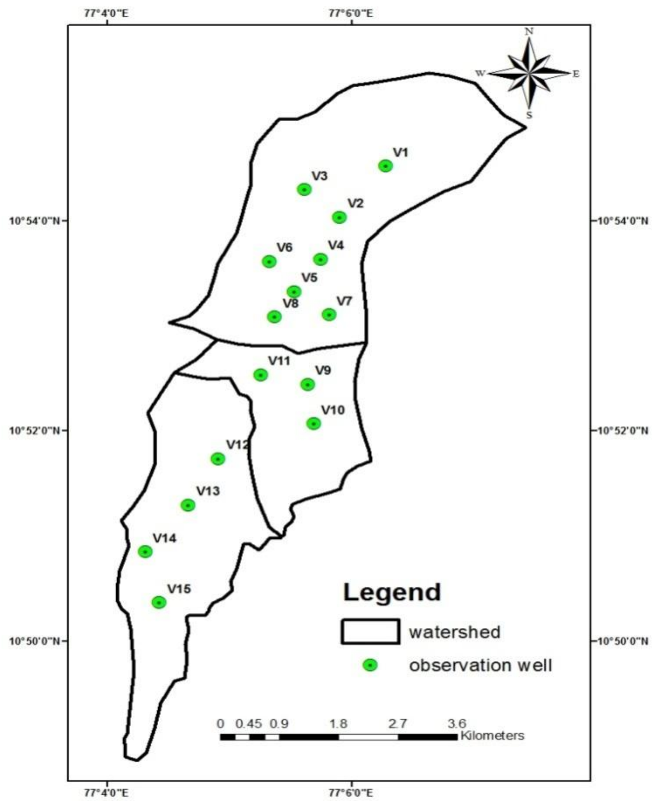


Fig.3 Model grid of the Vadachitur watershed

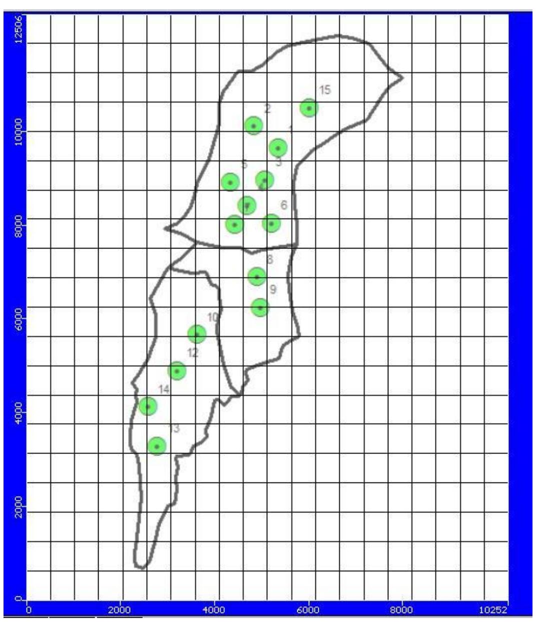


Fig.4 Average rainfall of north east monsoon

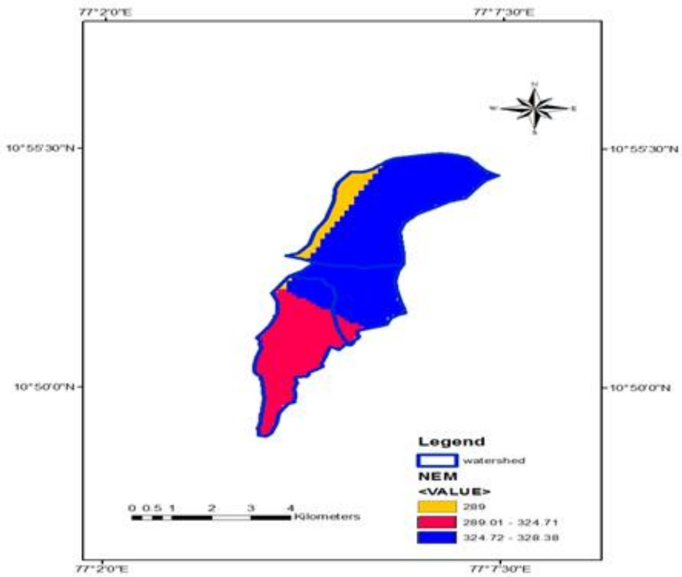


Fig.5 Average rainfall of south west monsoon

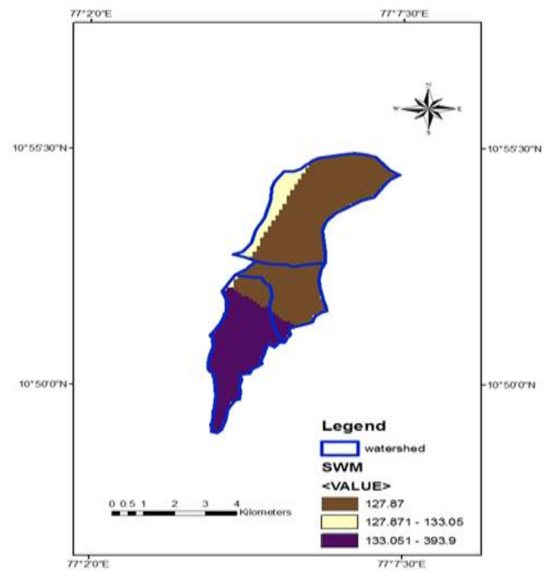


Fig.6 Average rainfall of summer

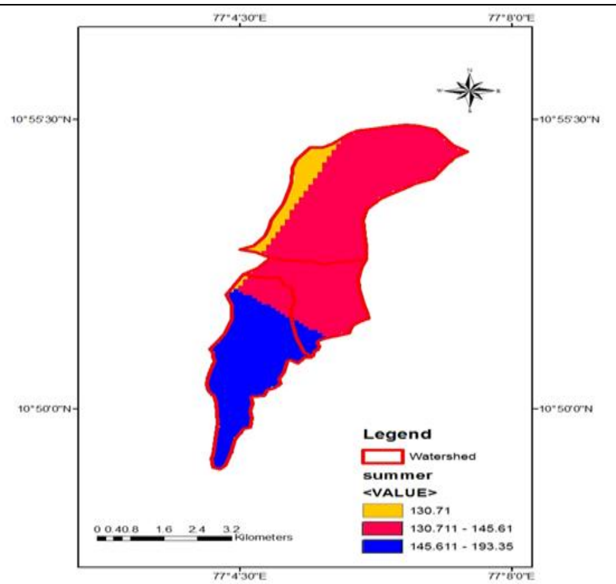


Fig.7 Average rainfall of winter

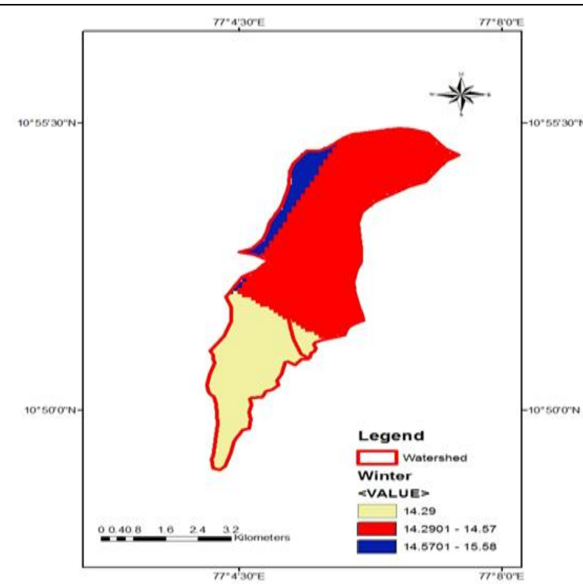


Fig.8 Hydraulic conductivity interpolation map of the Vadachitur watershed

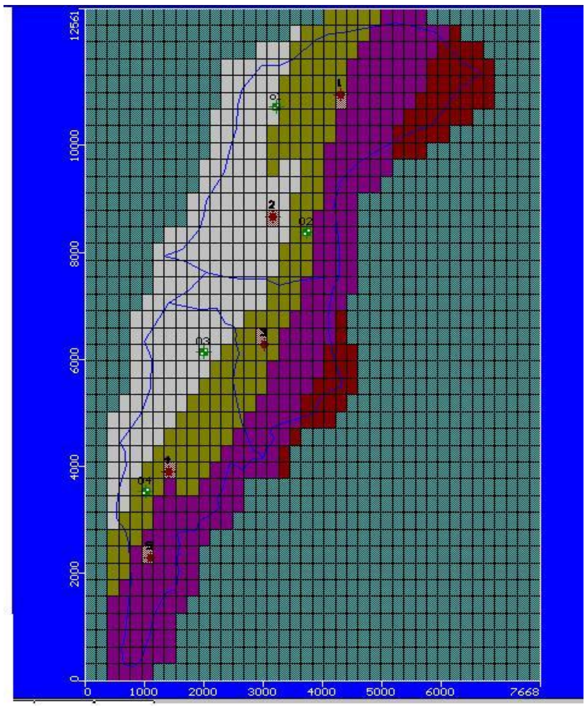


Fig.9 Boundary condition of the Vadachitur watershed

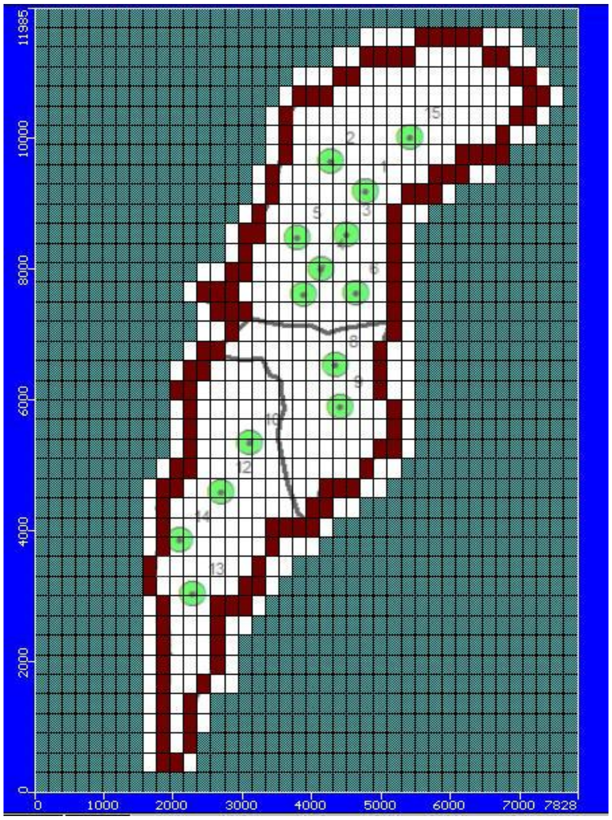
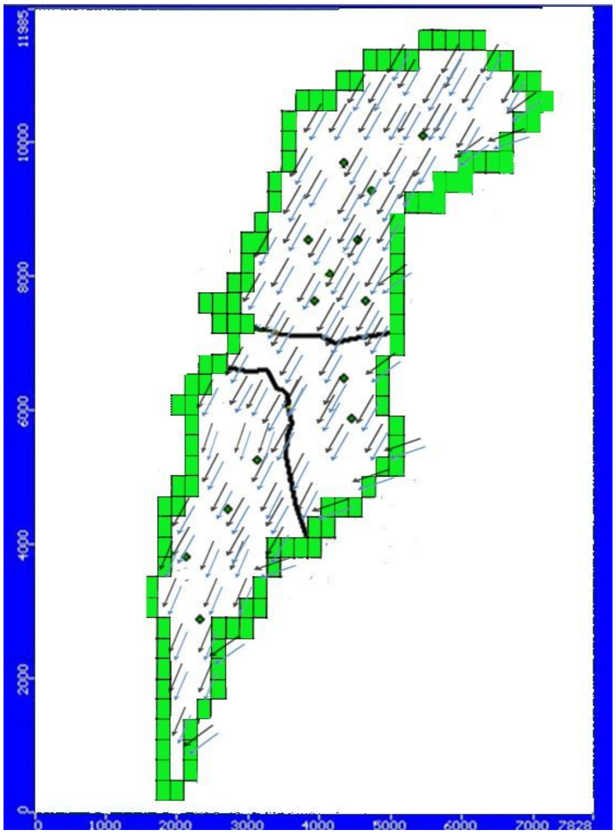


Fig.10 Flow direction in the Vadachitur watershed



The boundary condition in the study area is General Head boundary and the recharge boundaries (recharge from rainfall and recharge from tanks calculated from GEC norms) were assigned. Groundwater recharge was implemented on the top layer (Fig. 9). Heads were assigned to the General Head Boundary with the help of historical water level data.

Groundwater flow

The groundwater flow pattern is toward north east to south west direction in the surrounding areas of the drainage networks. It tends toward the northern end and southern end on either extreme. The area between the drainage as seen from the direction and magnitude of the flow indicates that all the wells fall within this region.

Simulated model was calibrated by trial and error adjustment of parameters or by using an automated parameter estimation code. The calibration was made using 15 observation wells monitored during 2015-2016. By trial and error calibration, the conductivity values were increased during many sequential runs until the match between the observed and calculated water level values were obtained The computed water level accuracy was judged by comparing the mean error, mean absolute and root mean squared error calculated. The absolute residual mean is 0.936 m (Fig. 10).

Zone budget

Zone Budget calculates sub-regional water budgets using results from steady-state MODFLOW simulations. Zone Budget calculates budgets by tabulating the budget data that MODFLOW produces using the cell-by-cell flow option. At a period of 365 days, storage in to the aquifer is 1.62 Mcum/day and flow out of the aquifer from storage is 4.82 Mcum/day. The water pumping out from the wells is 2.1 Mcum/day. Recharge into the aquifer is 5.99 Mcum/day. The total inflow into the aquifer is 7.965 Mcum/day and total outflow into the aquifer is 7.954 Mcum/day. At the period of 365 days, the outflow is more than the inflow by an amount of 0.0011 Mcum/day.

The Vadachitur watershed aquifer was investigated using the MODFLOW package to simulate three-dimensional groundwater flow under steady state conditions. The results of the model calibration show reasonable agreement between observed and calculated water levels for the observation wells. The calibrated model was used to predict the fluctuations of hydraulic heads for the period from 2010 to 2012. The outflow is more than the inflow by an amount of 0.0011 Mcum/day. Hence suitable recharge structures have to be constructed in order to improve the recharge rate for the Vadachitur watershed.

References

Balathandayutham, K and Mayilswami, C. 2016. Modelling Groundwater Flow for Walayar Watershed in Parambikulam Aliyar Palar Basin. Environment & Ecology 34 (1A): 207—211,

Mondal, N. C and Singh, V.S. 2004. A new approach to delineate the groundwater recharge zone in hard rock terrain. Curr Sci 87: 658—662.

Phukon P, S. Phukan, P. Das and Sarma B. 2006 Multicriteria evaluation in GIS environment for groundwater resource mapping in Guwahati city areas, Assam, http://www.gisdevelopment.htm (accessed on 3 Sep 2006).

Rahman, MM and Shahid S. 2004 Modeling groundwater flow for the delineation of wellhead protection area around a water-well at Nachole of Bangladesh. J Spatial Hydrol 4: 213.

Sergio E Serrano. 2003. Modeling groundwater flow under transient nonlinear free surface. J Hydrol Engg 8: 123—132.

How to cite this article:

Valliammai, A. and Balathandayutham, K. 2019. Zone Budgeting of Watershed using Visual Modflow. *Int.J.Curr.Microbiol.App.Sci.* 8(12): 1289-1296.
doi: https://doi.org/10.20546/ijcmas.2019.812.157