Eco. Env. & Cons. 29 (1) : 2023; pp. (81-85)
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ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2023.v29i01.011

Simulation of Groundwater levels in River basin using MODFLOW

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(Received 16 July, 2022; Accepted 25 September, 2022)

ABSTRACT

MODFLOW is a groundwater modelling program. It can be compiled according to the practical applications. Groundwater flow models are used to calculate the rate and direction of movement of groundwater through aquifers. The outputs from model simulation are the groundwater flow and hydraulic heads which are in equilibrium with the specified hydrogeological conditions (i.e. hydrologic boundaries, hydrogeological framework, initial and transient conditions, hydraulic properties and sources) demarcated for the modelled area. Groundwater models perform an important role in the management and development of groundwater resources. This paper presents the results of a mathematical groundwater model developed for the Banda districts which is part of Yamuna River basin. For this purpose, groundwater modelling software (GMS) MODFLOW was used. The model results display that the computed values are in good-fitness of the measure data, which indicate the model is reliable.

Key words: *MODFLOW, Hydro geological conditions, Management, Simulation, Developmen*

Introduction

River basins is used for development planning and management since 1930s. Various forms of river basin development planning and management have been applied in many countries.Most of the worlds land surface is dividable into river basins (Dasmann *et al.*, 1973; Saha and Barrow, 1981; Laconate and Haimes, 1992; Doornkamp, 1985; Lundqvist *et al.*, 1985) Groundwater is important component of River basin Groundwater is almost all over the place below the earth's surface. It is an important source of Irrigation, drinking water supply and for cattle. More than 90% of the world's entire supply of drinkable water is groundwater. The use of groundwater models is common in the field of water resource engineering. Usually, models are conceptual descriptions or approximation that explain physical systems using mathematical equations; they are not exact explanation of physical systems or process. Groundwater models describe the groundwater flow and transport processes using mathematical equations based on certain simplified assumptions. These assumptions typically involve the direction of flow, geometry of the aquifer, anisotropy of sediments or bedrock inside the aquifer, contaminant transport mechanisms and chemical reactions. Because of the simplify assumptions embedded in the mathematical equations and the many doubts in the values of data required by the model, a model must be views as an approximation and not an accurate duplication of field conditions. Groundwater models, however even as approximations are a useful research.

Groundwater lies almost all over below the earth's surface. It is an important source of drinking

(Research Scholar[1], Professor[2])

water supply, irrigation and others. More than 90% of the world's total supply of drinkable water is groundwater. The use of groundwater models is predominant in the field of Hydrology. In general, models are conceptual descriptions or calculations that describe physical systems using mathematical equations;. Groundwater models describe the groundwater flow and transport processes using mathematical equations based on certain simplifying assumptions. A model must be viewed as an approximation and not an exact duplication of field conditions. Groundwater models, however even as approximations, are a useful investigation

Groundwater is the most precious and widely circulated natural water resource, which institutes the largest available source for Irrigation and Water supply in semi-arid regions. The total water resource existing in the world is estimated as 1.37x108 million ha-m. Only 2.8% of this water is available as fresh water at any time on the earth. This 2.8 % includes 2.2% of surface water and 0.6% of ground water, which is existing beneath the earth's surface. Out of the 0.6 %, only the water available within 800 m depth be economically extracted using the present drilling technology. This accounts to 0.3% (41.1×10^4 million ha-m) of the over-all ground water. So, groundwater can be referred as the largest fresh water source on earth other than the polar ice caps and glaciers. It was accounted that amount of ground water within 800 m from the ground surface is over 30 times the amount in all fresh water lakes and reservoirs, and about 3000 times the amount in the stream channels. More than 90% of our rural population is primarily dependent on groundwater (Chandrasekhar *et al.,* 1999).

So, it is important to analyze and predict the future trends in groundwater flow. Moreover, the contaminations in groundwater should also be assessed for the groundwater flow models are used to calculate the rate and direction of movement of ground-

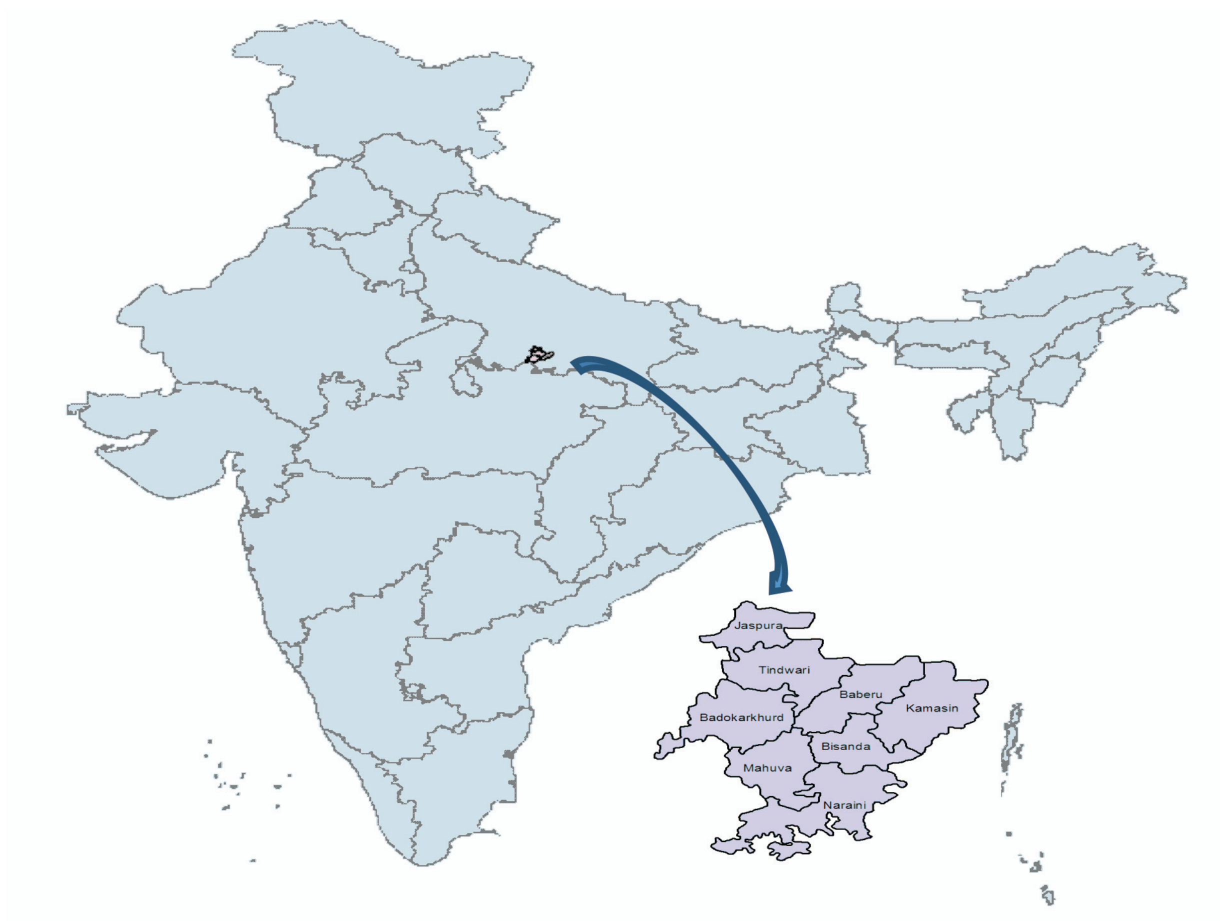

Fig. 1.

water through aquifers (Khadri and Chaitanya, 2016). In present study, Visual MODFLOW. Package is used for the assessment and prediction of groundwater in the study area.

Study Area

Bundelkhand regions comprises of seven districts of Uttar Pradesh Jhansi, Jalaun Lalitpur, Hamirpur, Mahoba, Banda, Chitrakoot and six districts in Madhya Pradesh- Datia, Tikamgrah. Chattrapur, Damoh, Sagar and Panna. The district Banda is a part of Bundelkhand Region. The study area Banda district lies between Latitude 24º53' North to 25º 55' North and Longitude 80º 07' east to 81º 34' east. It is bounded in the north by district of Fatehpur, in the east by the district of Allahabad, in the west by the district of Hamirpur and the south by Rewa, Satna, Panna, and Chhatrapur the district of Madhya Pradesh.

Methodology

In this study, the groundwater flow direction has been done for Banda District of U.P. The methodology adopted in this study consists of the different phases as shown in Figure 2. Data regarding aquifer characteristics such as soil type, water levels of wells, hydraulic conductivity, porosity and storability are generated based on borehole lithological data are collected from Central Groundwater Board (CGWB) and State Groundwater Board

MODFLOW model has been accessible to assess and modeling of groundwater flow in three dimensions by USGS institute. This model was produced by McDonald Herburg using programming language of Fortran 77. Programming structure of this software is modular which cause to regulate data entry and exit to the program and data exchange connecting its various parts. Also, modular structure makes it possible to develop the software significantly so that, since 1998 to date, this program has been evolving constantly. The general equation applied in this software is as equation

$$\partial/\partial x(K_{xx}\,\partial h/\partial x)+\partial/\partial y(K_{yy}\,\partial h/\partial y)+\partial/\partial z(K_{zz}\,\partial h/\partial z) + q_s=S_s\,\partial h/\partial t \qquad ..\ 1$$

which in fact is Richards's equation: (1) Where, Kxx, Kyy and Kzz are hydraulic conductivity values in the directions of X, Y, Z. h is groundwater head, W is flow volumetric flux per unit volume (indicates the flow source and sink), Ss is aquifer specific storage and t is the time. Equation above along with appropriate initial and boundary conditions form an equation system by which resolving, h value is achieved in different times and places. Fig 2 Describes the steps involve in MODFLOW

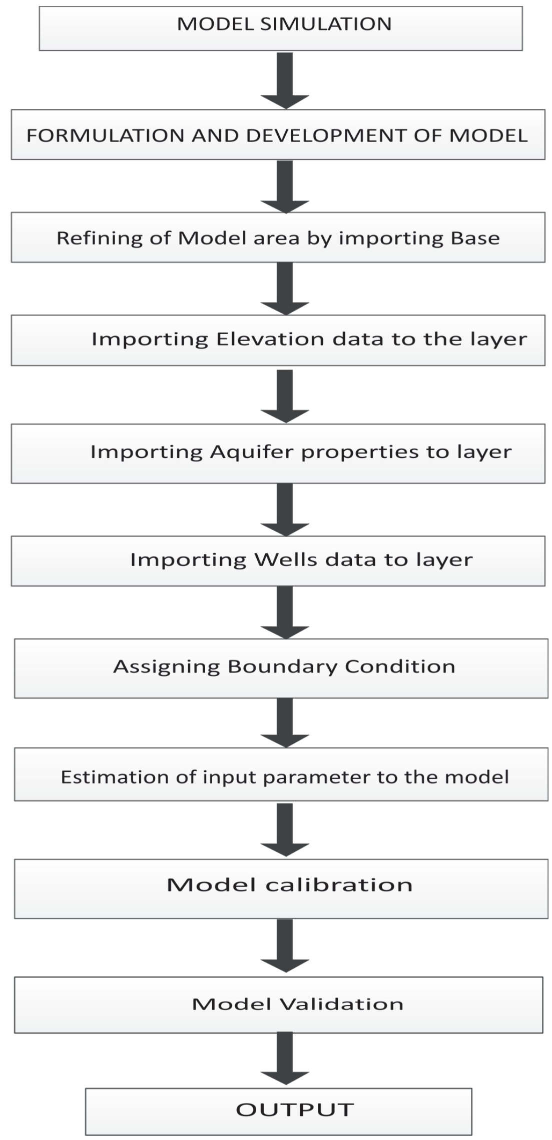

Fig. 2.

Results and Conclusion

From the available data, the Hydraulic conductivity of different zones are imputed in Model Zones as below:

Groundwater model now a days used by water resource engineer to perform various task..The rapid increase of calculation power of computers

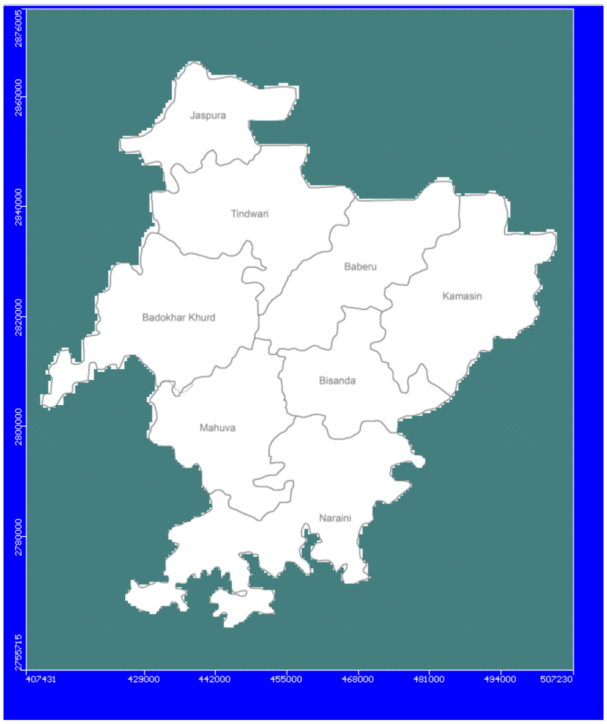

Fig. 3. Model area with block boundaries (without Grid, White part active area and coloured part inactive area)

and availability of user friendly modeling systems has made it possible to model large scale regional groundwater systems. The current modeling study is very preliminary and subject to many norms and assumed hydraulic parameters. Groundwater models are tools which are frequently used in studying

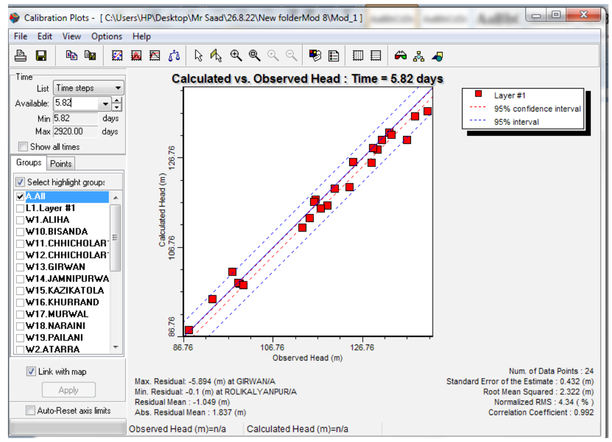

Fig. 4. Model Calculated vs Observed at 5.82 days

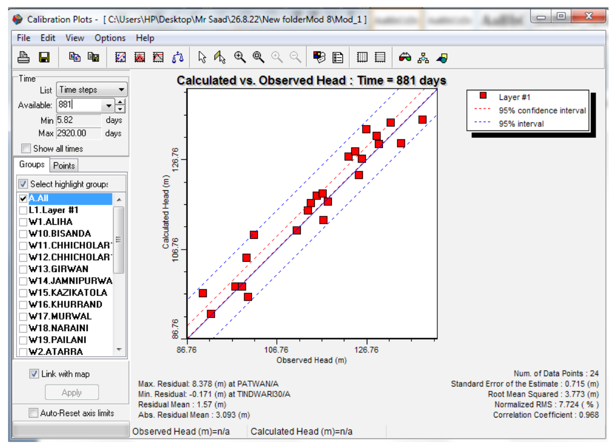

Fig. 5. Model Calculated vs Observed at 881 days

Table 1. Similarly for Storage Parameters similar zones have been considered and assigned to suitable values in the model.

Zone	Type of deposits/rocks	K_x (m/d)	K_y (m/d)	K_z(m/d)
Zone I	Bundelkhand gneissic complex	1	1	0.1
Zone II	Older alluvium deposits	3	3	0.3
Zone III	Recent alluvium deposits	4	4	0.4
Zone IV	River Channel alluvium deposits	6	6	0.6

Table 2.

Zone	Type of deposits/rocks	S_s	S_y	Effective porosity	Total porosity
Zone I	Bundelkhand gneissic complex	0.00002	0.01	0.02	0.04
Zone II	Older alluvium deposits	0.00002	0.1	0.06	0.12
Zone III	Recent alluvium deposits	0.00003	0.12	0.08	0.16
Zone IV	River Channel alluvium deposits	0.00005	0.15	0.10	0.2

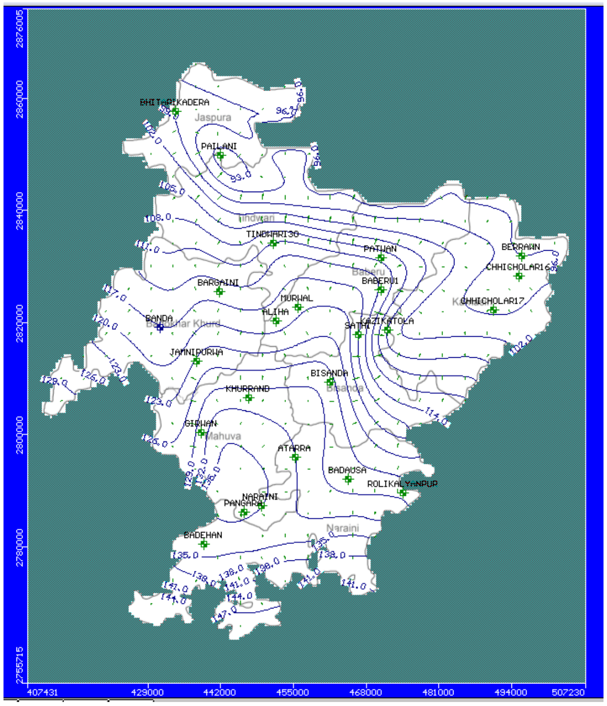

Fig 6. Water Table contour at 881 days

groundwater flow systemsIn the present study, a MODFLOW model is developed to estimate head calibration of Banda District of U P with the known boundary conditions and field observations. The model calibration has been performed based on the available data. The model results display that the computed values are in good-fitness of the measure data, which indicates that the model is reliable.

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