Review on Scope of Groundwater Modeling

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Abstract — We all know that the earth contains 70% of water and of 30% Land surface. But from that 70% of water 97% is saline water and we cannot use that water in our day to day life. Now a day the only source of pure water comes from the sub-surface. So that we need to improve the technique to bring out as maximum pure water as possible from the sub-surface. For that groundwater modeling is required. For this purpose many software are available which gives the idea about the lithology and movement of groundwater flow direction. In this paper we are giving the literature review on the groundwater modeling which gives brief idea about groundwater study. Groundwater is the most important source of drinking water in India. Especially it plays a vital role in the development and public health of the population in arid and semi-arid zones. Unfortunately due to injudicious and unplanned urbanization and Industrialization for the past few decades in few parts of the country, the resource is either being depleted or degraded in quality.

I. INTRODUCTION

Ground water is a distinguished component of the hydrologic cycle. Surface water storage and ground water withdrawal are traditional engineering approaches which will continue to be followed in future. The uncertainty about the occurrence, distribution and quality aspect of the ground water and the energy requirement for its withdrawal impose restriction on exploitation of ground water. In spite of its uncertainty, ground water has some obvious advantages.

Groundwater modeling is an important tool to provide guidance for management of groundwater particularly in the areas where the hydrological cycles are predicted to be accelerated due to climate change (Mall et al., 2006). Groundwater modeling becomes even more important because of rapidly falling groundwater levels due to overexploitation, particularly in the state of Rajasthan which is among the four states/union territories where severe groundwater depletion is occurring as a result of human consumption rather than natural variability (Rodell et al., 2009).

Groundwater model development of any natural system is preceded by development of a conceptual model which is then converted into a numerical model. The conceptual model is based on the subjective judgment of the analyst. One can expect the conceptual model to be continuously updated as new information is acquired (Bredehoeft, 2005). Once the concepts are formulated, they can be translated into a mathematical frame work resulting into equations that describe the process (Marcer and Faust, 1980). A numerical model so framed provides a tool by which to test the appropriateness of the prevailing concept. In the generic sense, a conceptual model is a simplified representation of the site to be modeled including the model domain, boundary conditions, sources, sinks and material zones. The purpose of building conceptual model is to simplify the field problem and organize the associated data so that the system can be analyzed more readily (Anderson and Woessner, 1992). The simplifying assumptions are required partly because a complete reconstruction of field system is not feasible and partly because there is rarely sufficient data to completely describe the system in full details. The conceptual model should therefore be kept as simple as possible while retaining sufficient capacity to adequately represent the physical elements of the hydrological behavior. However, the model should not be configured or constrained such that it artificially produces a restrained range of prediction outcomes. Problem with approximating reality are magnified while carrying out transport modeling because besides simplifying flow, the solute transport processes are also reduced to a few transport mechanisms which are considered dominant (Spitz and Moreno, 1996).Time and again errors in prediction revolve around a poor choice of the conceptual model. Development of conceptual model normally involves preparation of water budgeting for estimating ground- water recharge. Water budget preparation is a complex exercise which involves collection of data related to rainfall for number of years, identification of groundwater extraction sources and estimation of gross extraction from each source. Once the data is collected, recharge is estimated by applying water balance equation. However, this method is quite empirical as several assumptions are required to be made while estimating the groundwater recharge. Further, estimated recharge is typically in lump sum form representing the average recharge of a zone in the study area. In the present study, a methodology has been presented in which spatially distributed values of groundwater recharge estimated by using spatial varied data for rainfall, groundwater table variations, hydro- geological zones and several Geographical Information System (GIS) tools has been used for development of conceptual groundwater flow model instead of lump sum value of average recharge for the study area normally used.

II. LITERATURE

The groundwater models can be used as predictive tools with the objective of determination of future conditions or the impact of a proposed action on existing conditions of the subsurface groundwater regime. They may also be used as generic or screening tools in regulatory mode for the purpose of developing management standards and guideline

(Bedient et al., 1994). Some of the groundwater modeling studies undertaken by various researchers in India are the flow and contamination transport model for the groundwater regime in upper Palar basin, Dindigul town, Tamil Nadu due to groundwater pollution by tanneries (Gurunadha and Thangarajan, 1999; Mondal and Singh, 2005), the flow and mass transport model to assess the migration of the contaminated plume for the Patancheru Industrial Development Area (Gurunadha et al., 2001) and the mass transport modeling to assess the migration of the contaminated plume for Treatment, Storage and Disposal Facility (TSDF) constructed for disposal of hazardous waste generated by industries in and around Hyderabad city (Gurunadha et al., 2004).

Internationally, extensive research work has been undertaken by a large number of researchers where groundwater modeling has been carried out. Craner (2006) developed a steady-state numerical groundwater flow model using MODFLOW with MODPATH to understand direction of groundwater flow, groundwater age, and nitrate transport pathways of the Southern Willamette Valley, Oregon, USA. The study suggests it may take 10's of years to see measurable declines of groundwater nitrate in some locations.

Almasri and Kaluarachchi (2007) also developed a soil nitrogen dynamic model to estimate nitrate leaching to groundwater. These estimates were used in developing a groundwater nitrate fate and transport model. The framework considers both point and non-point sources of nitrogen across different land use classes. The methodology was applied for the Sumas–Blaine aquifer of Washington State, US, where heavy dairy industry and berry plantations are concentrated. Simulations were carried out using the developed framework to evaluate the overall impacts of current land use practices and the efficiency of proposed protection alternatives on nitrate pollution in the aquifer.

GIS is an important tool in development of conceptual model for any groundwater flow and contaminate transport problem. GIS offers data management and spatial analysis capabilities that can be useful in groundwater modeling. It provides automatic data collection, systematic model parameter assignment, spatial statistics generation, and the visual display of model results, all of which can improve and facilitate modeling (Watkins et al., 1996).

Gogu et al. (2001) designed a GIS database that offers facilities for groundwater vulnerability analysis and hydrogeological modeling for the Walloon region in Belgium. A "loose-coupling" tool was created between the spatial-database scheme and the groundwater numerical model interface GMS (Groundwater Modeling System). Following time and spatial queries, the hydrogeological data stored in the database can be easily used within different groundwater numerical models.

Remote sensing is another useful tool in the acquisition of spatially distributed data for groundwater modeling. Airborne geophysical surveys allow for the identification of faults and dikes, changes in lithology and the depth of magnetic features (Doll et al., 2000; Danielsen et al., 2003; Jorgensen et al., 2003).

This information is helpful in constructing realistic conceptual models of aquifers. For a phreatic aquifer, where the surface of the terrain is also the upper boundary of the aquifer, surface elevations can be determined by various remote-sensing techniques such as airborne platforms (for example light detection and ranging LIDAR, interpretation of stereo orthophotos or satellite platforms using radar interferometry). Several preprocessed Digital Elevation Models (DEMs) such as Shuttle Radar Topography Mission (SRTM) and ASTER Global Digital Elevation Model (GDEM) are freely available on internet for obtaining groundwater elevation data.

A. DEVELOPMENT OF CONCEPTUAL GROUNDWATER FLOW MODEL FOR PALI AREA, INDIA DECEMBER 2011

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In this paper, a methodology for development of conceptual groundwater flow model has been presented in which spatially distributed values for groundwater recharge has been utilized instead of lump sum average values of recharge normally obtained by water budgeting method. The study also extensively uses GIS for preprocessing of hydrological, hydrogeological and geological data. In my view, the methodology presented in this paper provides better tools for building a conceptual model for tackling groundwater modeling problems.

B. LABORATORY VALIDATION OF AN INTEGRATED SURFACE WATER— GROUNDWATER MODEL 20 JANUARY 2013

T. D. Sparks, B. N. Bockelmann-Evans, R. A. Falconer

The hydrodynamic surface water model DIVAST has been extended to include horizontally adjacent groundwater flows. This extended model is known as DIVAST-SG (Depth Integrated Velocities and Solute Transport with Surface Water and Groundwater). After development and analytical verification the model was tested against a novel laboratory set-up using open cell foam (60 pores per inch—ppi) as an idealised porous media representing a riverbank. The Hyder Hy- draulics Laboratory at Cardiff University has a large tidal basin that was adapted to simulate surface water—ground- water scenario using this foam, and used to validate the DIVAST-SG model. The properties of the laboratory set-up were measured and values were determined for hydraulic conductivity (permeability) and porosity, evaluated as 0.002 m/s and 75% respectively. Lessons learnt in this initial experimentation were used to modify the flume construction and improve the experimental procedure, with further experimentation being undertaken of both water level variations and tracer movement. Valuable data have been obtained from the laboratory experiments, allowing the validity of the nu- merical model to be assessed.

Modifications to the input file to include representations of the joints between the foam blocks allowed a good fit between the observed and modelled water levels. Encouraging correlation was observed in tracer experiments using Rhodamine-WT dye between the observed exit points of the tracer from the foam, and the modelled exit points with time.

C. ESTIMATING GROUNDWATER RECHARGE INTO A SHALLOW UNCONFINED AQUIFER IN BANGLADESH. 18 OCTOBER 2012

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This paper presents a data conservative approach, in which quantitative groundwater recharge estimation in a shallow unconfined aquifer is interpreted in details by the analysis of observed precipitation and water level fluctuations records. Kushtia district in Bangladesh has been taken as a case study area based on the observed data and information. In the adopted state-of-the-art methodology used for this study, well-known water table fluctuation technique has been modified so that groundwater recharge in shallow aquifer can be estimated by using the least available data and information. Observed time series of precipitation and groundwater levels records at a few monitoring wells in the study area are the only data required to carry out the study. The approach illustrated in this paper can be useful in any initial level of assessment in groundwater studies. In addition, results can be applied as input data for developing numerical groundwater model for any groundwater resource investigation in the study area or similar drainage basins in Bangladesh.

D. EXPLORING GROUNDWATER OCCURRENCE IN TANDAVA RIVER BASIN JUNE 2013 G. ASHENAFI TOLESSA & P. JAGADEESWARA RAO

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The researchers aspire to identifying groundwater occurrences in the river basin. In order to reach, geology, geomorphology and lineament map are applied in order to undertake groundwater investigation. In the study area alluvial, quaternary, gondawana Archedians and migmatite lithological groups are found and lineament intersection observed in the upper catchment. The result shows alluvial plain, beach ridge and intermountain valley has good groundwater potential zones; pediment inselberg complex has poor groundwater potential whereas structural hill with lineament intersection and pediplain weathered has moderate groundwater potential zone. Therefore, such result will help as a water resource pillar for water deficient area in the river basin.

E. THE ENERGY BALANCE OF GROUNDWATER FLOW, 1996

R.J. Oosterbaan(International Institute for Land Reclamation and Improvement
(ILRI), Wageningen, The Netherlands), J. Boonstra1 and K.V.G.K. Rao(Central Soil Salinity Research Institute (CSSRI), Karnal-132001, Haryana, India)

In this paper, an energy balance of groundwater flow is introduced. It is based on equating the change of hydraulic energy flux over a horizontal distance to the conversion rate of hydraulic energy into to friction of flow over that distance. The energy flux is calculated on the basis of a multiplication of the hydraulic potential with the flow velocity, and is integrated over the total flow depth. The conversion rate is determined in analogy to the heat loss equation of an electric current. The hydraulic energy balance is applied to the steady-state flow of water in a phreatic aquifer recharged by downward percolation stemming from rainfall or irrigation, and a quantitative example is given using a numerical solution. It is shown that the gradient of the water table is smaller than that calculated with the current methods, which do not take into account the energy associated with the incoming percolation water.

F. THE ENERGY OF GROUNDWATER FLOW APPLIED TO SUBSURFACE DRAINAGE IN ANISOTROPIC SOILS BY PIPES OR DITCHES WITH ENTRANCE RESISTANCE, 1996.

R.J. Oosterbaan

The energy balance of groundwater flow developed by Oosterbaan, Boonstra and Rao (1994), and used for the groundwater flow in unconfined aquifers, is applied to subsurface drainage by pipes or ditches with the possibility to introduce entrance resistance and/or (layered) soils with anisotropic hydraulic conductivities. Owing to the energy associated with the recharge by downward percolating water. It is found that use of the energy balance leads to lower water table elevations than when it is ignored. The energy balance cannot be solved analytically and a computerized numerical method is needed. An advantage of the numerical method is that the shape of the water table can be described, which was possible with the traditional methods only in particular situations, like drains without entrance resistance, resting on an impermeable layer in isotropic soils.

G. SPATIAL AND SEASONAL VARIATION IN GROUNDWATER LEVEL AND URANIUM, May 13-15 2010

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Groundwater caters the needs of most of the rural and urban population in developing countries like India. Being an integral part of the hydrological cycle, its availability depends on the rainfall and recharge conditions. This study was carried out with the objective of understanding the spatial and temporal variation in groundwater level and uranium concentration in a uraniummineralized zone in Peddagattu and Seripalli areas of Nalgonda district, Andhra Pradesh, India.

Groundwater samples were collected from forty five wells during March 2008 to January 2010 and they were analyzed for their uranium concentration using laser fluorimeter. Groundwater level in wells was recorded with the help of a water level indicator. The uranium concentration in the groundwater of this region ranges from 0.2 ppb to 118.4 ppb. About 20.61% of the groundwater samples had uranium concentration about the standards set by USEPA (30 ppb). The comparison between groundwater level and uranium concentration in groundwater shows that the uranium concentration increases with raise in groundwater table.

III. CONCLUSION

From the work we conclude that from the so many groundwater software, MODFLOW is the only one software which uses both the conceptual and numerical modeling and give the most accurate result among all. We can also be used MODFLOW with so many other software data or can develop our own by MODFLOW itself.

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