GROUNDWATER MANAGEMENT: ROLE OF MODELLING – A CASE STUDY

With the invention of high speed computers and advancement in mathematical techniques, groundwater models have become the most sophisticated tool for the decision makers in planning and management of groundwater. Under the systems analytical approach the groundwater models can be formulated and solved in two frameworks viz. Simulation and Optimization, which are well tested in solving real world problems. We can use groundwater simulation models to study the consequences of a proposed action, for predictions and/or management of ground-water, we can even have the quantitative aspects of groundwater flow, changes in hydraulic head with respect to time and space, river/canal interactions and impact of various stresses on the groundwater regime. But simulation models cannot provide the optimal management strategy. However, an optimization model identifies an optimal management strategy from a set of feasible alternative strategies. Because of mathematical complexities involving the non-linearity the present approach in groundwater domain is to have separate optimization model, and testing the optimal strategy through simulation models.

The combined use of simulation and optimization techniques has been demonstrated to be most powerful and useful method in determining and planning management strategies for optimal development and operation of groundwater system. This approach adopted in solving a real life problem is discussed in the case study.

In the National Capital Territory (NCT) of Delhi drinking water crisis is felt during pre-monsoon months when surface water flow through the streams is lean and depth to groundwater level reaches its lowest value of the year. The available groundwater in the dynamic zone is already overexploited in major part of the Delhi area. However, the flood plain aquifer of River Yamuna offers a good prospect of groundwater development.

The aquifer underlying the active flood plain of River Yamuna in NCT, Delhi occupies an area of 97 sq km and stretches about 35 km along River Yamuna. Out of the total area of active flood plain including the river bed, about 16.5 sq km is under water and the remaining 80.5 sq km is water logged or has very shallow water table. Aquifer system of this Newer alluvium has a very good potentiality which can sustain the tubewells with yields ranging from 1400 lpm to 2800 lpm. Transmissivity of the aquifer system of Newer alluvium varies between 730 m^2/day to 2100 m^2/day with hydraulic conductivity varying between 13 m/day to 60 m/day. The quality of groundwater is fresh down to 30 m to 65 m in different parts, below which the water is brackish to saline.

The development of fresh groundwater resources in active flood plain of River Yamuna located in the Palla sector of NCT Delhi provides sustainable solution for managing the pre-monsoon drinking water crisis. It has been envisaged to put a battery of tubewells in active flood plain of River Yamuna and pump them to their maximum capacity during lean pre-monsoon season. The tubewells being at close distance will produce interference in cone of depressions thereby producing a regional decline in the water level of the area. This regional decline in water level has been assumed to be in the range of 4 meters. During post-monsoon times when River Yamuna spills over and spreads in well field area, the de-saturated zone in aquifer produced on account of regional lowering of water levels is recharged and the water levels recoups to its original.

The Palla area is having considerable freshwater thickness in the range of 25 to more than 65 m. The subsurface geology reveals occurrence of four aquifer zones characterized by medium to coarse and fine grained Yamuna sand with gravels. The Yamuna River in this stretch of study area has no visible major drains joining it as such it is pollution free. The active flood plain in the area is totally agricultural land and gets flooded during post-monsoon inundation by River Yamuna. Thus, it is also the only place in Delhi where natural recharge to subsurface aquifers can take place by surface spreading methods during peak post-monsoon floods.

The groundwater pumping in the Pall well field offers a complex situation as the area is underlain by saline groundwater. The amount of pumping in this case is mostly guided by water quality considerations rather than water quantity. Because of underlying saline water, any over withdrawal or excess pumping may result in upconing of saline water leading to deterioration of water quality especially for drinking water needs. This may further complicate the overall saline–fresh water interface down below and hence cautious development of such aquifers is recommended.

Keeping this in view, an attempt has been made to develop an operational groundwater management model so that optimal groundwater development plan along with withdrawal schedule in space and time may be recommended to the user agency. The work has been taken up jointly by CGWB and NIH. The nonlinear, non-convex problem involving discrete (pumping locations) and continuous decision variables (pumpage) has been solved within the Simulation– Optimization (S/O) framework. S/O approach provides an accurate representation of the aquifer responses, but involves high computational burden. Therefore in the present study Artificial Neural Network (ANN) is used as virtual simulator of a variable density driven numerical flow model for aquifer simulation. Simulated Annealing (SA) – a non-gradient based algorithm, is used as an optimizer in this study.

On the basis of Simulation Optimization model developed during the study it was concluded that nearly 30 MGD of water can be safely drawn from these tube wells during monsoon and non-monsoon seasons to augment the water supply to meet the ever increasing drinking water requirements of the National Capital Territory, Delhi. The Palla well field is situated in the Yamuna river bank and during simulation, the River Yamuna has been considered as constant

Gist of K.R. Karanth Endowment Lecture delivered on 29th December, 2008 at the Geological Society of India, Bangalore head boundary. After calibration of the model, the volumetric budget indicates that out of the total groundwater withdrawal a part is flood water (rejected recharge) diverted to augment sub-surface storage during monsoon. This provides the scope for induced recharge from the River Yamuna. Hence, the storage space created during the non monsoon pumpage gets replenished during the flood season and hence the over all ground water regime situation remains under control and provides sustainability.

The experience of Yamuna flood plains in Delhi has shown the scope of enhancing groundwater recharge by pumping to lower the water table ahead of the rainy season and thus creating more space for the flood water to percolate. The concept can be implemented in similar situations in different parts of the country after carrying out detailed study on the hydrodynamics of the flood plain zones involving stream-aquifer interaction.

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