INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 15, No. 2, p. 340-347, 2019

RESEARCH PAPER OPEN ACCESS

Using the numerical model to analyze the groundwater sustainability of Indus river sub basin aquifer

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Key words: Numerical Model, Analyze the Groundwater Sustainability, Indus River Sub Basin Aquifer.

http://dx.doi.org/10.12692/ijb/15.2.340-347 Article published on August 24, 2019

Abstract

In the present study groundwater sustainability of Indus river sub basin aquifer were analyzed using the numerical model. The water table is declined from 106-137ft in the years of 2012-2016. The increasing demand of water is causing the cone of depression to decline which may the dissolved contaminants in it or the intrusion of groundwater with surface water. The effect on groundwater regime by the continuous increasing abstraction of groundwater according to existing pattern of groundwater development was analyzed by estimating discharges and recharging of the aquifer. A discharge to a safe yield must be applied to attain the sustainability of the groundwater. For modeling of the groundwater for sustainability management, Micro FEM is used because it can explain all parts of the aquifer in deep study i.e. by drawing contours, flow lines, transient modeling. Wells data along with its coordinates, elevation, heads, discharge capacity and daily working hours is required. The decline in the water table shows the excess of discharge rate than the recharge rate. The flow lines show that the direction are towards the wells of the nearby area and which has more working hours and exactly there the cone of depression is deepened.

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Introduction

Water is the fundamental compound of social and economic structure and is important for healthy civilization and maintainable development. Due to quick rise in density of population, quick urbanization, industrialization and farming, use the mandate of water is rising day by day. As a result surface and ground water level is depleting; contamination and amplified demand have completed virtuous quality water rarer and extra expensive. Ground water is the preferred different is opposite threats due to anthropogenic actions in India, which has chief due to decline in ground water superiority. The probability of ground water pollution is due to the fraternization up of poisonous elements, manures, waste willing and manufacturing sites. Hence nursing of ground water superiority has become crucial (Subramani *et al*., 2012).

The human needs on the global accessible freshwater distributions go on increasing as the universal development rate improving. In effort to accomplish the water to meet the human requirements, the supplies of freshwater species and natural organizations have to an excessive amount been excited, and the ecological consequences have been awful. Sound freshwater biological collections give prosperity of stock and activities for culture, yet our delivery of freshwater streams must be well accomplished in case we mean to help these facts of attention and freshwater bio variability. We suggestion a construction for working up an naturally tolerable water group program, in which human supplies for water are met by securing and escapist water in a way that can restore the common dependability of wedged channel situations (Richter *et al.,* 2003). Water administration is the essential of today, hence the accessibility of water and additional for upcoming generation is chief goal and the sustainability is also preserved. By using the water paths pointers the sustainability can be retrieved in river. The water footmark is a temperately pioneering marker that procedures the collective volume of freshwater that is used as a creation feature. Its caring is steadily emerging in the calculation of water use underway events. The calculation of the water footmark comprises water assets (blue), rainfall put gone in the grime (green) and pollution (dark). It gives a far attainment assessment of the normal maintainability of water use in a river bowl. The philosophy focus on the rebuilding of the anthropised cycle of water, which is run by joining a hydrological validate and a special expressively supportive system. The method certificates the assessment of the environmental manageability of water management at numerous levels, as well as exist examination of how the selections made in water spacing process effect supportability (Pellicer-Martenez and Martinez-Paz, 2016). The current study was aimed to investigate the using the numerical model to analyze the groundwater sustainability of Indus river Sub basin aquifer.

Materials and methods

Study area

In Indus river sub basin Aquifer Sahiwal is selected which is the area of hot climate. The average temperature recorded there was 24˚C. Average annual rainfall is 200mm. The area is highly populated which caused the land subsidence and Peizometric levels recession. The intrusion of surface to groundwater was causing the exploitation of fresh water. The city has expanded quite fast in the past and still showing the same trend. The abstraction of groundwater of 20 m^3/s in 1999 has increased to 45 m^3/s in 2016 as computed from TMA (Town Municipal Administration) of Sahiwal wells data. The further increase in future will be 84.4 m^3/s by the year 2030 due to increasing demands for domestic and industrial use.

Data collection

The water table depth data of last decade, the month of September is selected for analysis(monsoon); tube wells locations, actual discharge capacity, daily pumping hours, elevation of T/W etc. are collected from WASA Sahiwal. The aquifer parameter values are taken out from preceding reports on Sahiwal. Hydraulic conductivity and transmissivity is taken from reports on Sahiwal modeling.

Groundwater modeling

A groundwater model might be a scale display or an electric model of a groundwater circumstance. These models are utilized to speak to the regular groundwater stream in nature. Some of these models incorporate (concoction) quality parts of the groundwater. Such groundwater these models attempt to foresee the destiny and development of the substance in regular, urban or theoretical situation. Groundwater models might be utilized to anticipate the impacts of hydrological changes (like groundwater reflection or water system advancements) on the conduct of the aquifer and are regularly named groundwater reproduction models. Additionally these days the groundwater models are utilized as a part of different water administration gets ready for urban territories.

Hydrological and dynamic inputs

The essential link amongst groundwater and hydrological contributions is the unsaturated zone or vadose zone. The dirt demonstrations to parcel hydrological data sources, for example, precipitation or snowmelt into surface spillover, soil dampness, evapo-transpiration and phreatic water revive. Moves through the vadose zone that couple superficial water to soil dampness and phreatic water can be ascendant or descending, contingent on the angle of pressure driven head in the dirt, can be demonstrated utilizing the numerical arrangement of Richards' condition incomplete variance condition, or the customary variance condition. The dynamic sources of info disquiet human obstructions with the water administration like water system waste, pumping from wells, water table control, and the operation of maintenance or penetration bowls, which are regularly of a hydrological nature. These data sources may likewise fluctuate in time and space.

Micro FEM

Micro FEM gives the whole processing of groundwater modeling from making of a finite element grid leading processing, calculation, graphical explanation and plotting confined, un-confined, phreatic, stratified and leaky multi aquifer system can be simulated. In finite element modeling triangular shapes are used and these are very useful in aquifer systems as compare to regular shapes taken which are used in finite difference model. In irregular nodes no. of nodes required is less and faster and modest calculations are obtained.

Results and discussions

In the area the number of the aquifer are assign either the area is influenced by one or more aquifers. The type of the aquifer is taken unconfined that it doesn't have any layer which resists flowing the water.

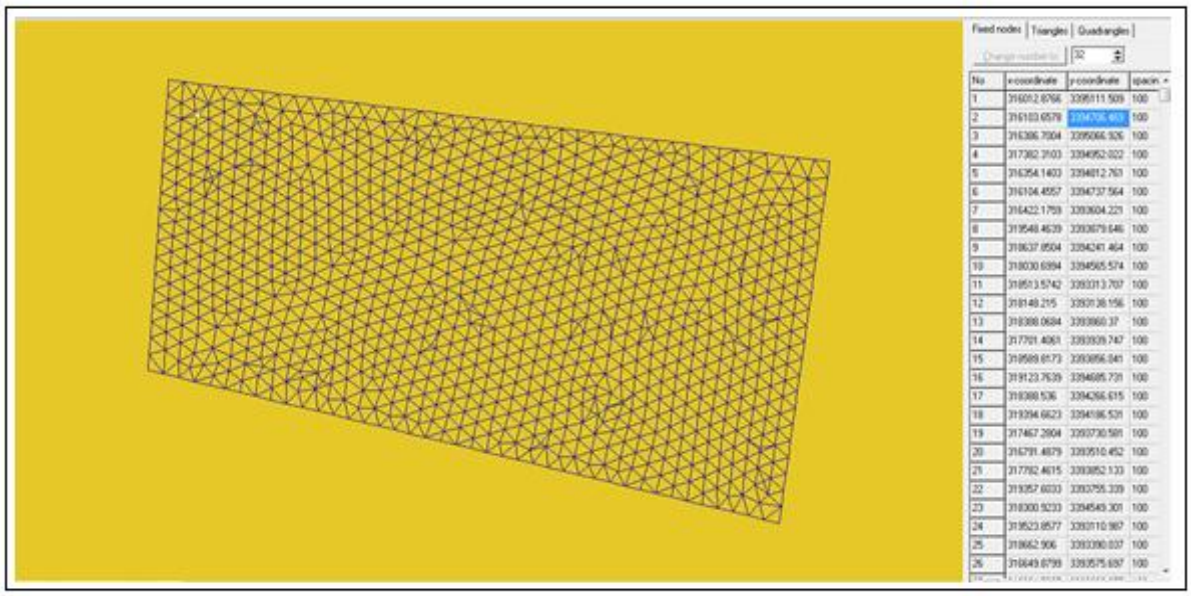

Fig. 1. Creating Fem MESH.

The permeability is taken 0.25 which tells that some of the particle can be permitted through soil. The hydraulic conductivity is 0.003m/s showing that the slope is gentle. The transmissivity of the tube wells is taken 0.15m²/s which is taken from Punjab Irrigation Department. The model is run to see the cone of depression of the tube wells. The 3D view shows the different angles of the cone of depression (Figs 1, 2 & 3).

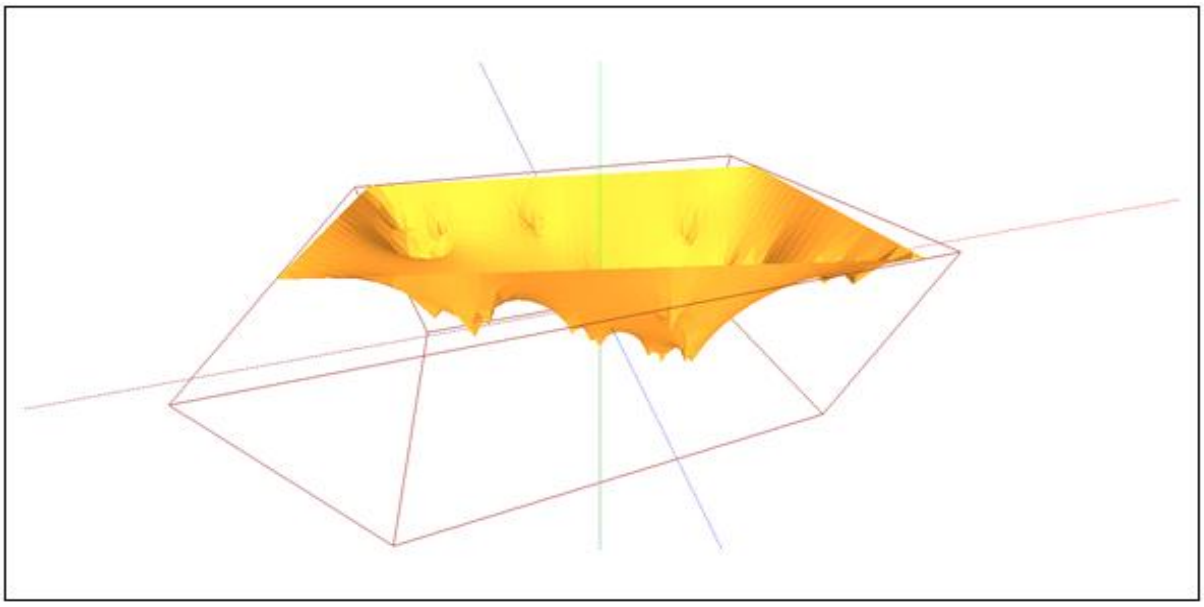

Fig. 2. View of the Cone of Depression (COD).

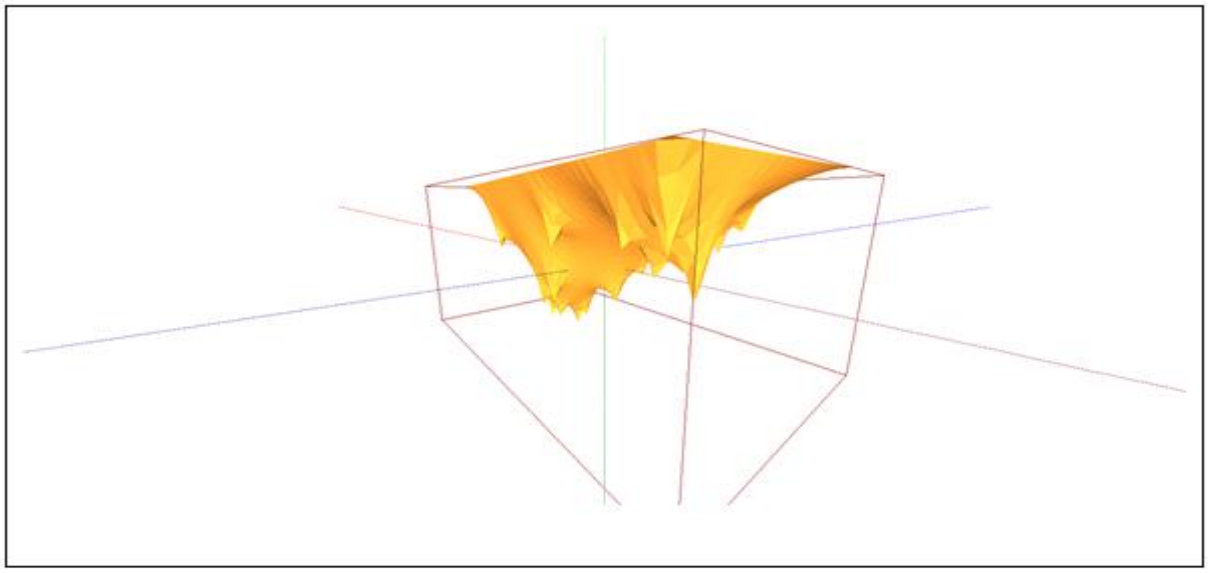

Fig. 3. Another view of COD.

On the basis of the minimum and maximum head values the interval of the contours are selected. The contours showing the influence of the tube wells of the study area. The contours showing the influence of the tube wells of the study area (Figs 4, 5 & 6). In this step contours are drawn with mesh and small intervals and hence it is easy to calculate the each mesh and giving the very precise reading. One of the Tube wells is taken to observe the water balance.

The inflow is 521.46 and out flow are 521.46 in lateral flow which show that in and out difference zero. Total flow is also 521.46. The profile showing the decline of the head when the pumping is started (Figs 7, 8 & 9).

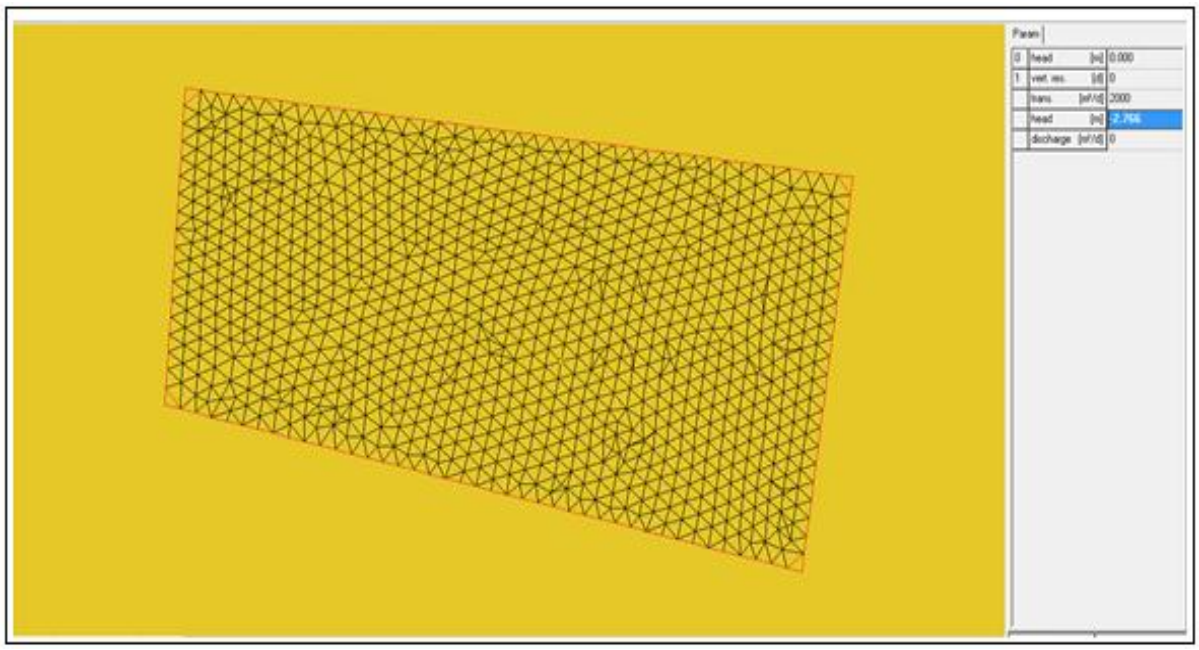

Fig. 4. Boundary condition.

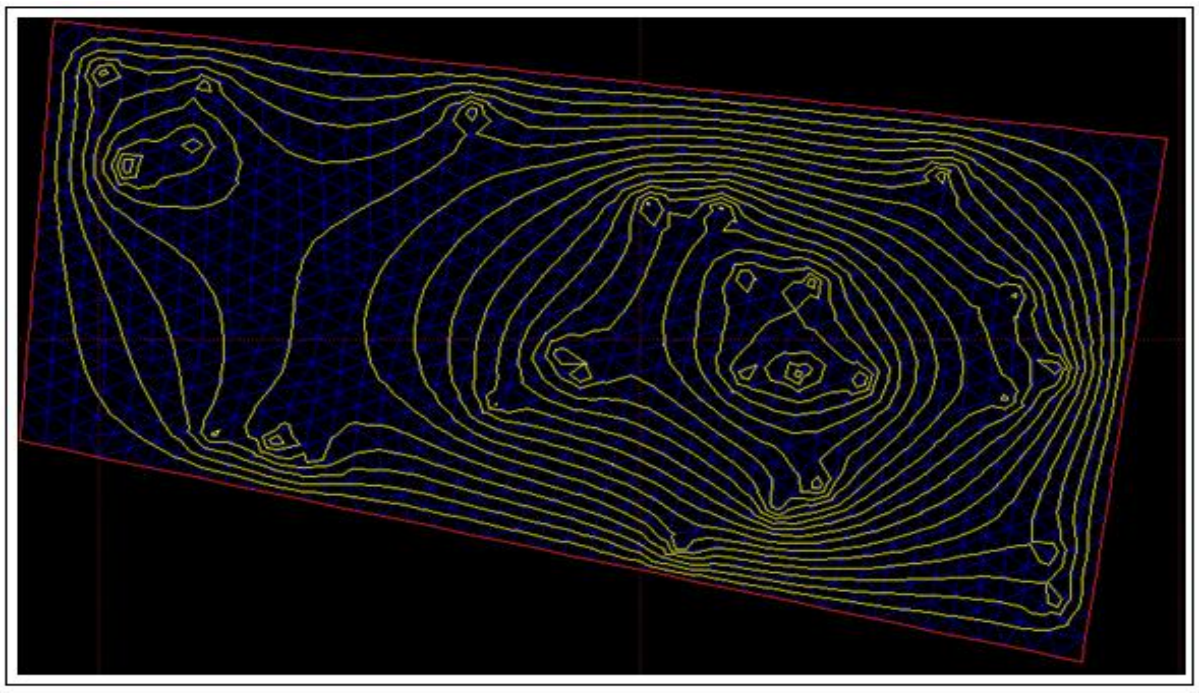

Fig. 5. Drawing contours.

A study was conducted by Mohsin *et al.*, 2013 in Bahawalpur City Pakistan. Three samples were taken from Satellite town, Shahdrah and Islamic colony respectively. Data gathering created on the questionnaire and laboratory examination of water samples. Definite physical and chemical limitations like total dissolved solids (TDS), electrical conductivity (EC), pH, hardness, alkalinity etc. was scrutinized to detect the excellence of ground water. Results expose that groundwater quality in Bahawalpur is destroying. Condition was much poorer in Islamic colony where 48%, 55% and 41% residents have diluted, brackish and water with minor smell respectively. The sustainable management of aquifers is controlling the issue in numerous nations. New scientific instruments can aid its answer, both in the investigation of whether the present administration is maintainable and in the meaning of

procedures and measures to accomplish sustainability. Models will dependably assume a part in this assignment. Another model era can utilize new information sources, for example, ecological tracers, remote sensing data and geophysical information. It should however reproduce a normal deterministic circumstance as well as break down the vulnerability of its expectations by a stochastic approach keeping in mind the end goal to stay sound. At last, the characteristic and building sciences need to interface a great deal more with financial matters and governmental issues to be of genuine functional utilize. An important stage in generation of a model is the calibration, in which the model behavior is compared with the field survey records of previous periods.

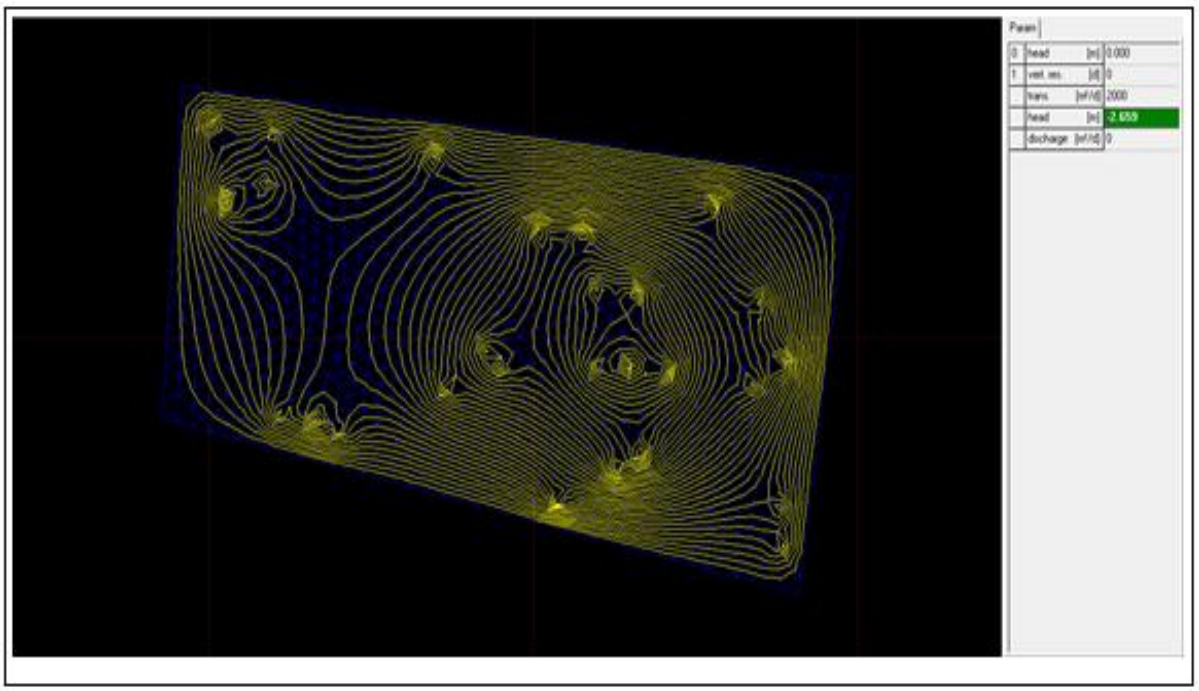

Fig. 6. Contours with mesh gridding.

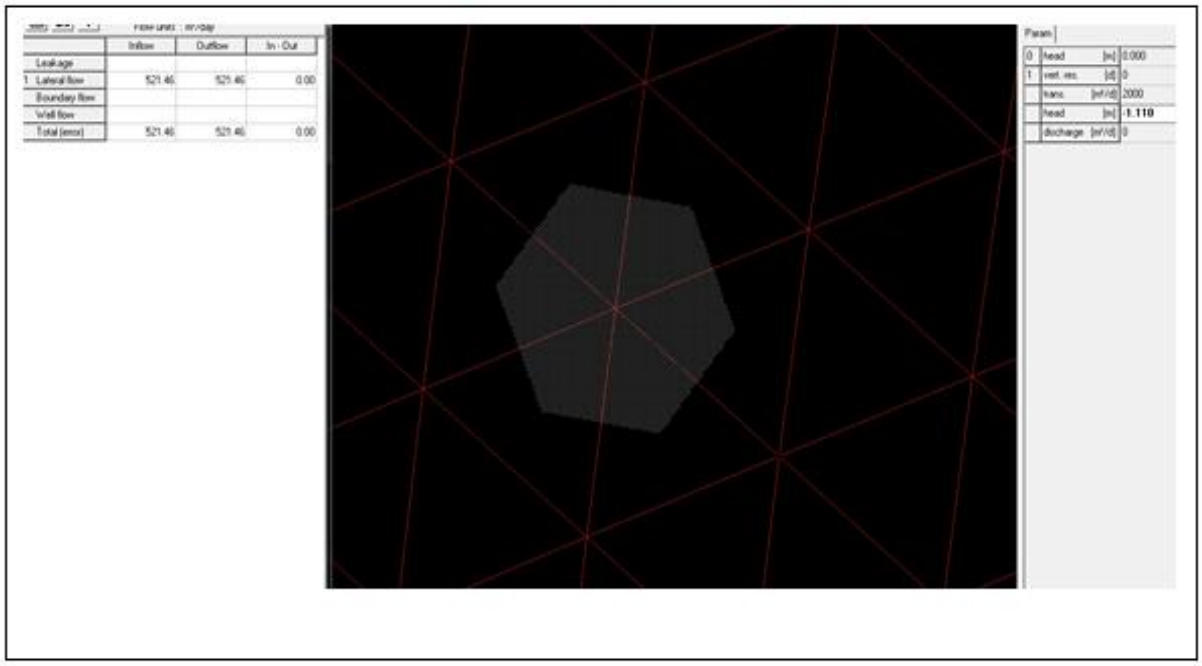

Fig. 7. Checking water balance.

In the calibration the values of the aquifer parameter are altered by sensitivity analysis until sufficiently accurate results of hydraulic heads are obtained. The sensitivity analysis is used in the calibration of the model. Calibration is divide into two stages steady state and current, the hydraulic conductivity and thickness of the aquifer is seen in the steady state and specific yield, areal discharge and discharge through wells are seen in current state.

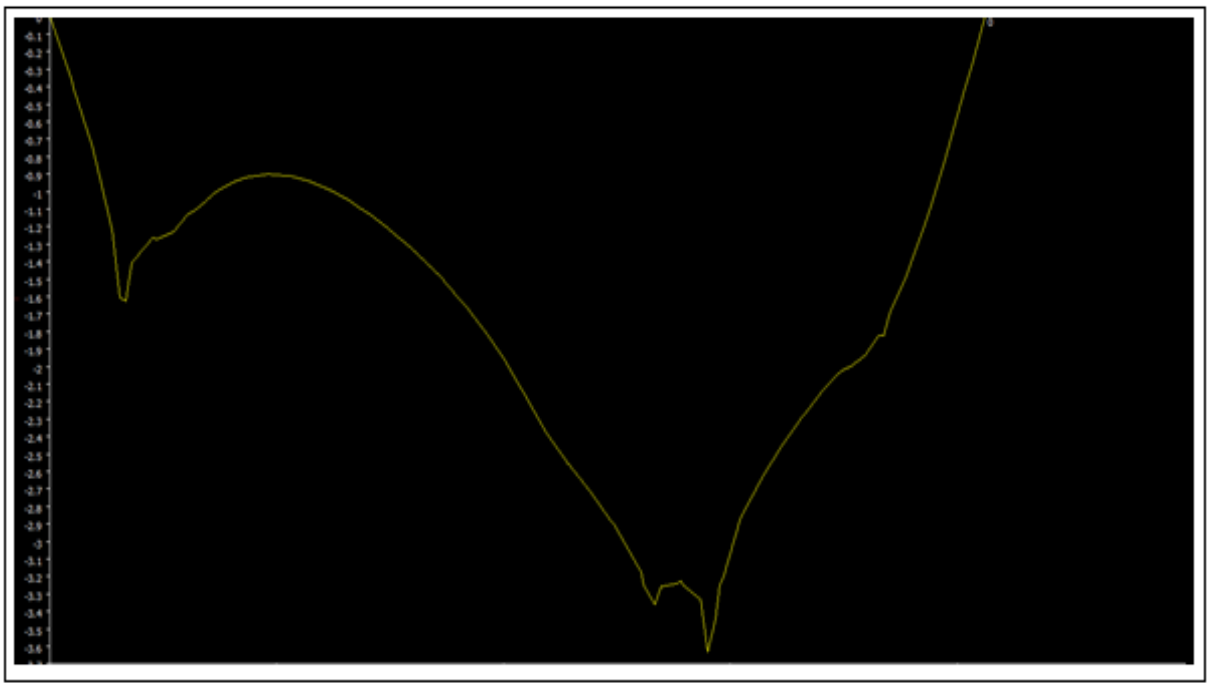

Fig. 8. Water table profile of tube wells.

It is observed during the calibration that hydraulic conductivity was varied in the range 25m/day to 105m/day in the study area. Thickness was varied from 300 to 600 meters by adjusting bottom of the aquifer. It is proved that the model is sensitive to hydraulic heads of aquifer not the aquifer thickness.

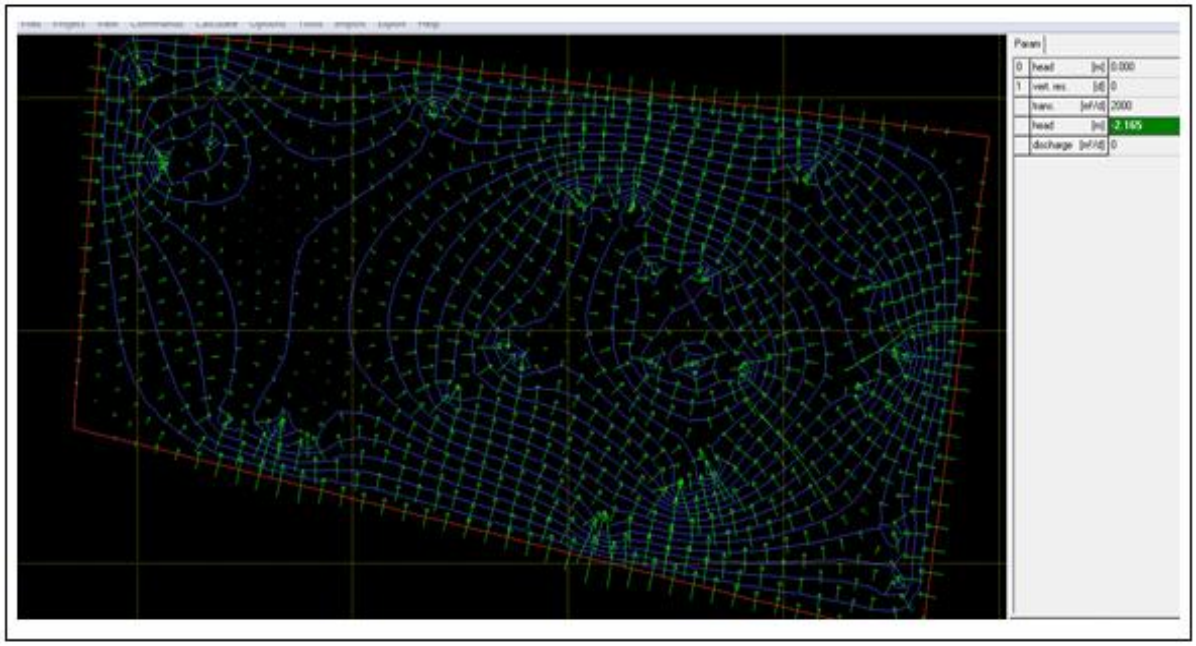

Fig. 9. Flow Direction with gridding.

Conclusion

The decline in the water table shows the excess of discharge rate than the recharge rate. The flow lines show that the direction are towards the wells of the nearby area and which has more working hours and exactly there the cone of depression is deepened. The nearby area of the groundwater is also manipulating. Hence the entire aquifer zone is influenced and causing adverse impact on environment.

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