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Numerical Simulations of Transient Groundwater Flow to Ditch Drains in Homogeneous Anisotropic Soil using MODFLOW

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Abstract— A numerical simulation was carried out to study transient groundwater seepage into equally spaced ditch drains receiving water from a ponded field of homogeneous anisotropic soil. The simulation was carried out using MODFLOW, a three-dimensional finite-difference model developed by McDonald and Harbaugh (1988). The solution to the ditch drainage problem was first obtained by considering equla water levels in the adjacent ditches with iunform ponding depth and other problem was was solved by assuming the unequal water levels in the adjacent ditches with uniform ponding depth. The problems were formulated with the usual Neumann and Dirichlet conditions associated with the boundary value problem. The accuracy of MODLFOW developed models and their simulation results were checked by comparing them with other analytical models for same flow situation and soil parameters. The effects of water level in ditch drains, directional conductivities, specific storage & nature of subsurface soil on distribution of hydraulic head. The studies were also carried out to see the times taken by a transient ditch drainage system to go to steady state for different flow situations and soil parameters.

Index Terms— Transient, Salnity, Isotroic, Anisotropic, Ditch drains, Seepage, Numerical, Simulation, MODFLOW.

1 Introduction

In many part of the world, irrigation drainage is essentially used for increasing agricultural productivity, solving water logging problems and reclamation of salt affected soil. In order to achieve full potential of the irrigated lands in arid and semi-arid regions of the world, the introduction of irrigation generally brings in its wake the problems of water logging and salinity, which must be tackled efficiently for better agricultural productivity. Mostly in India, it has been reported that there is considerable increase in areas pertaining to water logging and salinity (Manjunath, et al., 2004; Chahar and Vadodaria, 2011). Agricultural drainage frequently used in many parts of the world for controlling water logging problems by removing surplus water from the surface of the soil, the root zones of agricultural fields and also helps in preventing increase salinity of irrigated soils. Agricultural drainage are used in rice fields for preservation and restoration of flooded water areas for a desired time period to maintain water balance for increasing productivity (Van Hoorn et al., 1994) and it is also used to provide an optimal groundwater environments for suitable wildlife habitats (Youngs, 1994). The reclamation of salt affected soil is nowadays a major problem for agricultural and environmental problems in the world. The procedure of reclamation of a salt affected soil generally involves impounding the surface of the soil with water up to a desirable ponding depth to build the necessary head that can initiate force movement of water though the soil by dissolving the salts to be carried away or seeped away from the soil doamin and ultimately collecting the disposable salt laden water by a network of parallely placed ditch drains installed for the purpose (Dielman, 1973; Martinez Beltran, 1978). This methods of leaching harmful salts from a soil profile by artificially flooding the soil surface to discharge the leached water through subsurface drains requires good quality irrigation water [electrical conductivity < 0.7 deci-Siemens per metre (Rhodes et al., 1992)]. Several numerical and analytical mathematical models have been developed in the past for various flow situations to understand underlying hydraulics of flow to ditch drainages for a steady state flow situations to a homogeneous and isotropic soil (Kirkham and Van Bavel, 1948; Kirkham, 1950, Fukuda, 1957; Youngs, 1994, Barua and Tiwari, 1995). Several analytical studies on the ponded drainage problem have been solved to shoe the streamlines at the soil surface are more concentrated within the immediate vicinity of the drains and there is a rapid fall of steady surface flux, as one moves away from the centre ditch (Chahar and Vadodaria, 2008a, 2008b, 2011; Kirkham, 1950; Fukuda, 1957; Warrick and Kirkham, 1969; Barua and Tiwari, 1995; Rao and Leeds-Harrison, 1991; Youngs and Leeds-Harrison, 2000, Barua and Alam, 2013).These trend was found to be similar for both situations with negligible ponding depth or a uniform ponding depth. So, ditch drainage used for leaching down of harmful salts from a salt affected area with uniformly ponding depth of water by dissolving or washing away of salts will depend on the types of soil, amount of water level in ditches, anisotropy of soil, specific storages of soil as well as the ponding depth of water at the surface of soil. This will further help in cleaning of soil profile with most optimize way to prevent unnecessary wastage of water, effort and time. In his view, an effort is being made to study transient groundwater flow to a ditch drains in a homogeneous soil using MODFLOW.

2. Statements of the Problems and Mathematical Formulation

To work out numerical simulation for the hydraulic head function the stream function and the discharge rate for

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groundwater seeping into an array of equally spaced ditch drains in a homogeneous and anisotropic soil receiving water from a ponded field a general solution to the three-dimensional continuity equation of transient groundwater flow in a compressible, homogeneous and anisotropic soil medium is considered (Kirkham and Powers, 1972). For such a situation, the concerned equation can be expressed as

$$K_x \frac{\partial^2 \phi}{\partial x^2} + K_y \frac{\partial^2 \phi}{\partial y^2} + K_z \frac{\partial^2 \phi}{\partial z^2} = S_s\left(\frac{\partial \phi}{\partial t}\right), \qquad (1)$$

where ϕ is the hydraulic head, S_S is the specific storage, K_x, K_y and K_z hydraulic conductivities in spatial dimensions x, y and z respectively and t is the time variable. To work out numerical simulation for the hydraulic head function, the stream function and the discharge rate for groundwater seeping into an array of equally spaced ditch drains in a homogeneous and anisotropic soil receiving water from a ponded field using MODFLOW following cases were considered:

(i) the levels of water in the adjacent ditches are equal and the ponding field over the soil surface is uniform,
(ii) the levels of water in the adjacent ditches are unequal and the ponding field over the soil surface is uniform

2.1. Case 1: *Numerical Simulation model for predicting flow into an array of equally spaced ditch drains with equal water level heights in between adjacent drains and receiving water from a ponded field subjected to uniform depth of ponding*

The geometry problem considered for the study of numerical simulation of flow into ditch drains in a homogeneous and anisotropic water saturated soil of infinite areal extent underlain by an impervious barrier is shown by the Fig. 1. Only two are shown here in the figure out of series of parallel equally spaced such ditch drains. The depth of the soil up to the impervious layer is considered as h. The directional hydraulic conductivities K_x & K_y of the soil is considered in horizontal and vertical directions respectively. In this case, ditches are assumed to have the same water level depth of H_1, as measured from the origin O and $S_{a(1)}$ and $S_{h(1)}$ are taken as and the spacing and semi-spacing distances between the adjacent ditches respectively. For our simulation study the ditches are assumed to penetrate all the way up to the impervious base and heights of water in the ditches are as a result of an instantaneous lowering of water in the ditches, otherwise the water being previously assumed to be standing in the ditches up to the soil surface. For the assumed problem, it is further considered an imposed constant depth of ponding δ_0, instantaneously over the surface of the soil with the help of side bunds of width ε_a each running parallely to the drains (Rao et al., 1991; Youngs and Leeds-Harrison, 2000). The soil system has been previously water saturated flush up to the surface of the soil. Constant ponded water is maintained at the surface of the soil between the bunds by continuous irrigated water, which will otherwise go on decreasing with time and eventually deplete all surface ponded water leading to development of unsaturated flow conditions in the soil profile. Since, these conditions have not been considered for the present study, a constant depth is maintained for the simulation. We consider only half of the flow domain of soil profile of *OABFGO* of Fig. 1 for

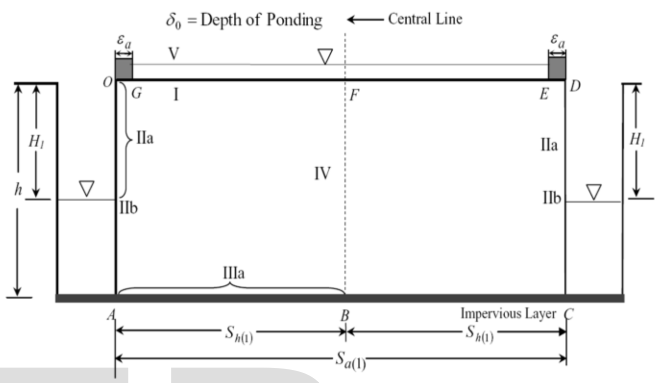

Fig. 1. Geometry of a fully penetrating ditch drainage system with equal water level heights in between adjacent drains and subjected to a uniform depth of ponding at the surface of the soil.

analysis because of the symmetry of the flow domain. The hydraulic head function of the flow domain of soil is designated as $\phi_{(1)}$, that is measured w.r.t the origin *O*. Further the *x*-axis considered to be positive towards the right and the *y*-axis to be positively vertically downward from the origin *O*, for ease of solving the problem. For the sub-domain *OABFGO* of Fig.1, the following initial and boundary conditions for the two-dimensional transient seepage into ditch drainage can be expressed with the above nomenclature and time variable as t, :

$$\phi_{(1)}(x, y, t=0) = 0, \quad 0 < x < S_{h(1)}, \quad 0 < y < h, \qquad \text{(I)}$$

$$\phi_{(1)}(x, y, t>0) = -y, \quad x = 0, \quad 0 < y < H_1, \qquad \text{(IIa)}$$

$$\phi_{(1)}(x, y, t>0) = -H_1, \quad x = 0, \quad H_1 \le y < h, \qquad \text{(IIb)}$$

$$\frac{\partial \phi_{(1)}(x, y, t>0)}{\partial y} = 0, \quad y = h, \quad 0 < x < S_{h(1)}, \qquad \text{(III)}$$

$$\frac{\partial \phi_{(1)}(x, y, t>0)}{\partial x} = 0, \quad x = S_{h(1)}, \quad 0 < y < h, \qquad \text{(IV)}$$

$$\phi_{(1)}(x, y, t>0) = \delta_0, \quad y = 0, \quad 0 < x < S_{h(1)}. \qquad \text{(V)}$$

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2.2. Case 2: A numerical simulation model for predicting flow into an array of equally spaced ditch drains with unequal water level heights in between adjacent drains and receiving water from a ponded field subjected to uniform depth of ponding

The geometry of the ponded ditch drainage problem considered for the simulation study in this case is shown in Fig. 2. In this case, unlike the previous problem, the water level heights in between the adjacent drains are now not equal. As a result, the flows to ditch drains are not symmetrical and the whole flow domain of the soil profile *OABCDEFGO* is considered for simulation study. In this case the spacing between the adjacent drains is considered as $S_{a(2)}$ and the depth of water level from the surface (origin *O*) of the right ditch is considered as H_3. The initial and boundary conditions for the flow problem can expressed as

$$\phi_{(2)}(x,y,t=0)=0, \quad 0<x<S_{a(2)}, \quad 0<y<h, \qquad \text{(I)}$$

$$\phi_{(2)}(x,y,t>0)=-y, \quad x=0, \quad 0<y<H_1, \qquad \text{(IIa)}$$

$$\phi_{(2)}(x,y,t>0)=-H_1, \quad x=0, \quad H_1\le y<h, \qquad \text{(IIb)}$$

$$\frac{\partial\phi_{(2)}(x,y,t>0)}{\partial y}=0, \quad y=h, \quad 0<x<S_{a(2)}, \qquad \text{(III)}$$

$$\phi_{(2)}(x,y,t>0)=-y, \quad x=S_{a(2)}, \quad 0<y<H_3, \qquad \text{(IVa)}$$

$$\phi_{(2)}(x,y,t>0)=-H_3, \quad x=S_{a(2)}, \quad H_3\le y<h, \qquad \text{(IVb)}$$

$$\phi_{(2)}(x,y,t>0)=\delta_0, \quad y=0, \quad 0<x<S_{a(2)}, \qquad \text{(V)}$$

where $\phi_{(2)}$ is considered as hydraulic head and $S_{a(2)}$ is considered as spacing symbols for the current problem in order to differentiate them from the corresponding values in the previous problem and the symbols for the common parameters for both the problems are kept the same as before, as can be seen in Figs. 1 and 2, respectively.

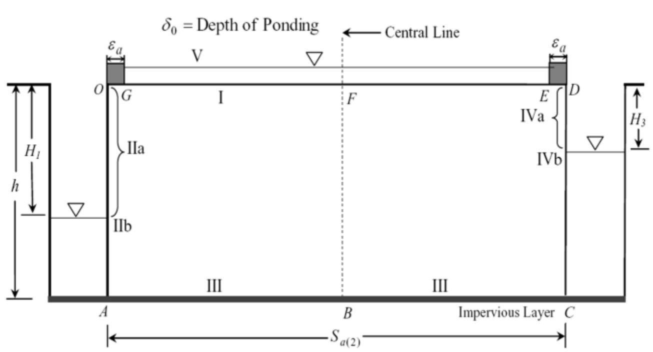

Fig. 2. Geometry of a fully penetrating ditch drainage system with unequal water level heights in between adjacent drains and subjected to a uniform depth of ponding at the surface of the soil

MODFLOW problem formulations were carried out as per the given initial and boundary condition (IC & BCs) as described for the above cases (Case 2.1 & 2.2). Consiering these cases different simulation were carried out to examine the transient flow to a ditch drains using numerical modeling Processing MODFLOW (Chiang and Kinzelbach, 2001) for the particular flow configurations of the problems. An imaginary ponded soil column of different surface area (for particular study and comparison with Kirkhams's and Barua & Alam solution), 15 m by 10 m and thickness of 0.1 m up to the top of a pervious layer is considered. Incase of no ponding depth, the layer is considered to be of zero ponding depth by a constant zero value. The soil column on its right and left faces being flanked by two ditch drains extending all the way up to the impervious barrier was simulated by drawing a grid network of 150 rows, 102 columns and 22 layers. Thus, the size of each grid network used for modeling was 0.1 m × 0.1 m and the thickness of each grid cell 0.05 m, where it should be noted that two columns were kept aside to represent the left and the right ditches and two layers were also kept reserved to simulate the top soil surface and the bottom impervious layer, respectively in order to consider the constant boundary condition for the roblem. To mimic the ditch banks, the cells of the 2nd and 101th columns in the 1st layer were made inactive in the model for all the rows to represnts a Dirichlet boundary condition of no flow situation. Excluding the cells related to the ditch banks, the top layer were assigned a constant cell value of 0.2 m to simulate a uniform ponding depth or constant head of 0.2 m over the surface of the soil for the purpose of transiet simulation. The 22nd layer of the prosed modele was assigned as impervious bottom layer impervious, by making all the cells of model as ineffective layer. For simulation of different depth of water in theTo simulate a half-filled and one fourth filled ditch having a water level of 0.5 m and 0.25 m, constant valued cells were utilized in the first column of the grid network and assigned a value of -0.05 m in the 2nd layer, -0.1 m in the 3rd layer and so on up to the 6th and 11th layer respectively. A constant value of -0.25 m (for one fourth filled ditch) and -0.5 m (half filled ditch) was assigned to all the cells up to the 21st layer. In the same way, the right ditch having a water level height of 0.25 m and 0.50 m was also modeled. The cells belonging to the first and the last rows in all the layers starting from the 2nd and up to the 21st were given a constant value of 0.2 m to simulate the Northern and Southern faces of the model. With the above model structures in place and taking specific storage $(S_s)=0.001\text{m}^{-1}$ and 0.0001m^{-1}, transient MODFLOW simulations were carried out for different flow situation for isotropic and anisotropic soil of hydraulic conductivity values. The numerically predicted hydraulic heads at a few time steps compared with already existing transient analytical results Barua and Alam, 2013 and steady state solution of Kirkham, 1965. Also different simulation studies were carried out for different

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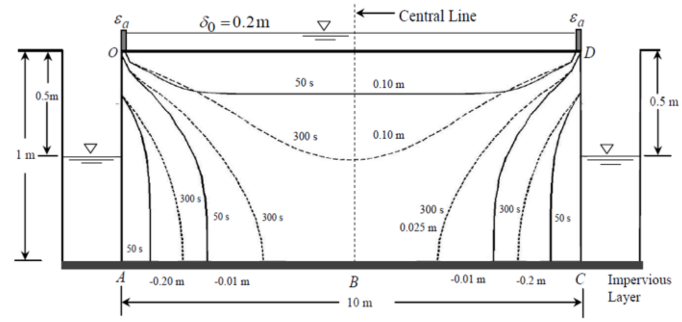
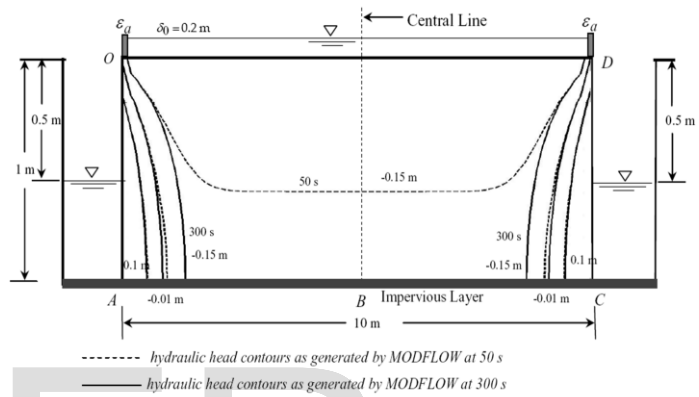
flow scenarios. It should be noted that all the numerical measurements were taken in the 75th row, halfway between the Northern and Southern boundaries of the model, so that the measuring locations were sufficiently away from these boundaries. For three-dimensional flow to prevail in the model it is being assumed in the development numerical model, the distance between the Northern and Southern faces are assumed to be infinity.

4. Results and Discussion

The transient MODFLOW simulations were carried out for different flow situations to study the changes of flow scenario for different water level in the ditches (H_1 & H_3), for different hydraulic conductivities (K_x & K_y) and Specific Storages (S_s) values. The simulation results are then use for drawing hydraulic head contour in the GIS plateform, to observe the changes of hydraulic head contours for the specific flow problems. The hydraulic head countors generated by the simulation results show, how transient hydraulic heads are affected by different anisotropic ratio, water lavel in ditches and specific storage values of the soil. It was observed that, among the other factors remaining constant, steady state situations are reached at relatively much faster rate in a soil media with a higher anisotropy ratio than one with a lower ratio which can be ascertain by the Fig. 5 (a) & (b). The head loss in case of higher anisotropy ratio is more than the head loss in case of lower anisotropy ratio as can be seen in Fig. 3 (a) & (b) and Fig. 4. The numerically obtained hydraulic heads at all the chosen time steps for the considered flow situations indicates that soil with higher anisotropic value i.e, $K_x/K_y = 10/1$. are mostly influeced throughout the flow domain than the soil having lower anisotropic ratio i.e. $K_x/K_y = 1/1$. Further, incase of the lower anisotropic ratio, most of the flow is confined in the vicinity of the ditces as can be seen from Fig.3. (b), but in case of higher anisotropic ratio the flow of water from ponding surface is found to be uniformly distributed over the flow domain as can be seen from Fig, 3(a). Also, Fig. 3 (a) & (b) shows the chosen times steps and hydraulic head distribution of flow domain both for an isotropic and higher anisotropic soil for uneqal level of water in the ditches and Fig. 4 shows flow scenario for unequal level of water in the ditches. The simulation shows almost similar trend of flow situation for both isotropic and anisotropic soil but incase of unequal level of water in ditches (as shown in Fig. 4), it was observed that ditches with higher level of water influences the flow domain in its neighborhood only.But the hydraic head of distribution in influennced to a greater extent for ditch with lower water level in ditch. The Fig. 5 (a) & (b) shows graph for the transie-



(a)



(b)

Fig. 3. MODFLOW generated contours of hydraulic head for the proposed flow problem of Fig. 1 for a flow situation at corresponding few time intervals (50 s & 300 s) when $\varepsilon_a = 0.1\,\text{m}$ and the soil parameters are taken as $S_s = 0.001\,\text{m}^{-1}$ and (a) $K_x/K_y = 10/1$ ($K_x = 0.5$ m/day, $K_y = 0.05$ m/day) and (b) $K_x/K_y = 1/1$ ($K_x = 0.5$ m/day, $K_y = 0.5$ m/day)

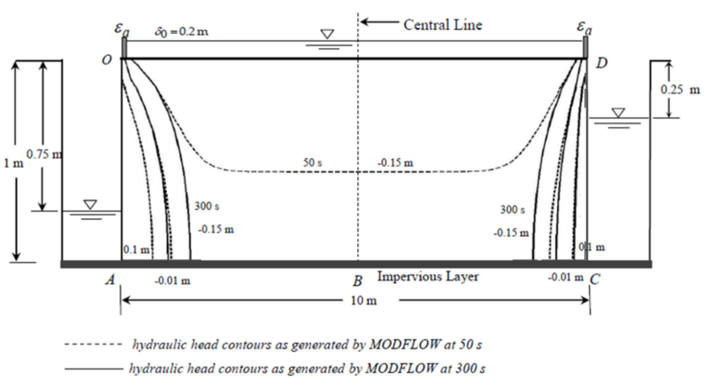


Fig. 4. MODFLOW generated contours for the proposed flow problem of Fig. 2 for a flow situation at corresponding time intervals (50 s and 300 s), when $\varepsilon_a = 0.1\,\text{m}$ and the soil parameters are taken as $S_s = 0.001\,\text{m}^{-1}$, $K_x/K_y = 1/1$ ($K_x = 0.5$ m/day, $K_y = 0.5$ m/day) when $H_1 = 0.75\,\text{m}$ and $H_3 = 0.25\,\text{m}$

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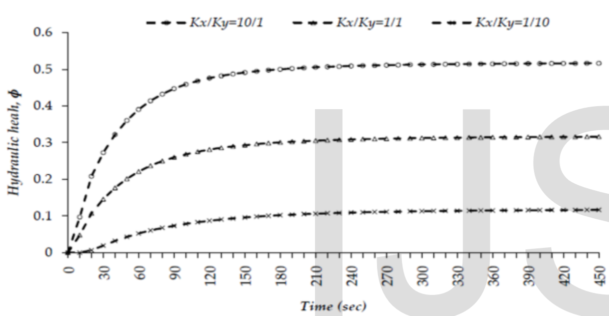
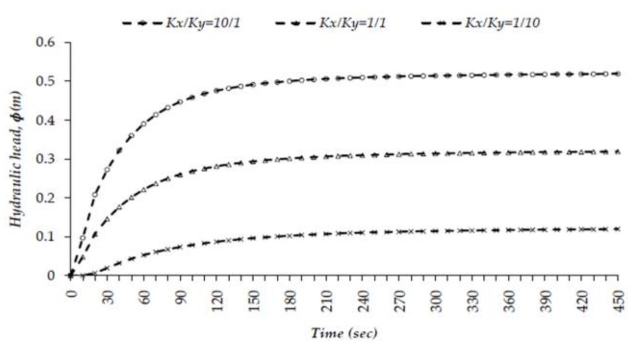
-nt the the hydraulic head variation with respect to time in certain chosen locations of the flow domain (i.e. at a depth of 0.4 m from the top surface and 5 m from the ditches) for different anisotropic and isotropic condition for both the flow problem of Fig. 1 & 2 respectively. As can be seen from the graph that the fall of hydraulic head is greater in case of higher anisotropic ratio than isotropic and lower anisotropic condition. This is due to the horizontal influence of change in hydraulic head and coverage of of flow domain. For transient flow situation, it was observed {Fig. 5 (a) & (b)} that it takes loger time to reach the steady state or quasi- steady state condition for the flow at higher anisotropic ratio as compared to the lower anisotropic and isotropic situation of soil as horizontal flow dominates the vertical flow. Thus, it indicates that the hydraulic head are dependent on the anisotropy of the soil media to reach to a steady state situation for the flow different flow situation. The similar treand is observed for both the cases i.e with uniform ponding and equal level of water in ditches and unequal level of water in ditches.



(a)



(b)

Fig. 5. Graph showing the transient hydraulic head variation for problems of Fig. 1 & 2 shown in (a) & (b) respectively for a flow situation when $\varepsilon_a = 0.1\,\text{m}$ and the soil parameters are taken as $S_s = 0.001\ \text{m}^{-1}$; $K_x = 0.05\,\text{m/day}$; $K_y = 0.05$ m/day; when (a) $H_1 = H_3 = 0.5$ m and (b) $H_1 = 0.75m$ & $H_3 = 0.25$ m

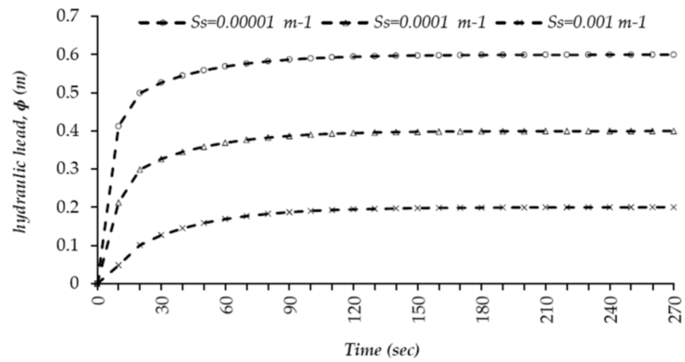


Fig. 6. Graph showing the comparisons transient hydraulic head variations for problem Fig. 1 wr.t different Specific storages (Ss) for flow following situations $\varepsilon_a = 0.1\,\text{m}$ and the other soil parameters are taken as $K_x = 0.05\,\text{m/day}$; $K_y = 0.05$ m/day; $H_1 = H_3 = 0.5$ m.

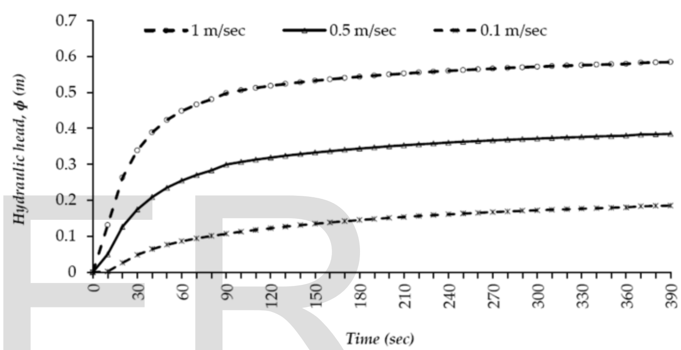


Fig. 7. Graph showing the comparisons transient hydraulic head variations for problem Fig. 1 wr.t different hrdrauic conductivity values K_x and K_y for flow following situations $\varepsilon_a = 0.1\,\text{m}$ and the other soil parameters are taken as $S_s = 0.001\ \text{m}^{-1}$; and $H_1 = H_3 = 0.5$ m.

The Fig. 6 shows the variation of transient hydraulic head for he similar flow situation and soil parameters with varying specific storages (S_s) , i.e. S_s at 0.001m^{-1}; 0.0001m^{-1} and 0.00001m^{-1} respectively. It is shows that hydraulic head drop is more incase of lower specific storages value of soil and drop in hydraulic had is more. But, in case of higher anisotropy head loss is less as well as time required to rech steady state is more. This shows the impacts of soil parameter on the distribution hydraulic head in the flow domain. Moreover, the transient hydrauic head is very sensitive to the different soil hydraulic conductivity values. Fig. 7 shows the comparisons of variation of hydraulic head for different hydraulic conductivity ($K_x \& K_y$) values. The drop in the hydraulic head is more in case of higher hydraulic conductivity values and also steady state situation is reached at higher time steps. The all comparsions for the study for Figures 6 and 7 were carried out at a

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grid point 0.4 m below the surface and 5 m away from the ditches of the flow domain. The following results shows the flow scenario in a parallaey placed ditches mostly depends on the depth of ponding, anitropy of soil or homogeneity of soil as well as the level of water in the consequtive ditches. Thus this technique plays a very important role in deciding the quantity of water that will be required to be used for reclaiming the salt contaminated soil, if the soil properties are known. This will also help in optimizing the quantity of water as well as time required with the experimental knowledge of soil parameters.

5. Comparison with a few available analytical solutions

The simulation results obtained for different flow scenario using MODFLOW are now compared with the existing analytical results already published by different researchers. In order to perform a few checks to ascertain the validity of the above flow problems solved by MODFLOW developed models and their simulations a few comparisons were made with existing analytical solutions. Figs. 8 (a) & (b) shows the comparison of MODFLOW generated hydraulic head contours with analytical solutions results of Barua & Alam (2013). The plots are for ditch drain receiving water from a field having a negligible depth of ponded water (0.2 m) over it. The spacing between the adjacent drains is given a very large value, around 10 m, so that the flow behaviour around each ditch can be taken as independent of the flow behaviour around neighbouring ditches. The water levels in ditches are kept at equal level i.e $H_1 = H_3 = 0.5$ m for Fig. 8. (a) and for Fig. 8 (b) water levls are kept at different depth, i.e. $H_1 = 0.75$ m & $H_3 = 0.25$ m. A comparision was made for different time steps (50 s and 300 s) for the hydraulic head contours. As can be seen in Fig. 8 (a) & 3 (b), the numerically obtained hydraulic heads at all the chosen time steps for the considered flow situations are found to be matching accurately with the corresponding analytical values obtained by transient analytical solution by Barua & Alam, 2013, for the flow problem of Fig. 1 and Fig. 2 respectively. The transient MODFLOW simulations were carried out to see the time required by MODLFOW simulation to reach the steady steady state solution obtained by Kirkham, 1965. It was observed from the Fig 9. (a) & (b) that the transient numerical values reach the steady stae situation at 250 s for the given steady state analytical solution problem defined by Kirkham, 1965. The simulations were performed for both flow situations when ponding depth is zero (0) and 1 m, respectively as shown in Fig. 9 (a) & (b). The time required to rech the steady stae condition for the analytical problem is similar for both cases of ponding. Thus, it shows identical results generated by MODFLOW simulation contours and steady state solution of Kirkham, 1965, for given flow situations, which shows perfect matching of hydraulic head contours.

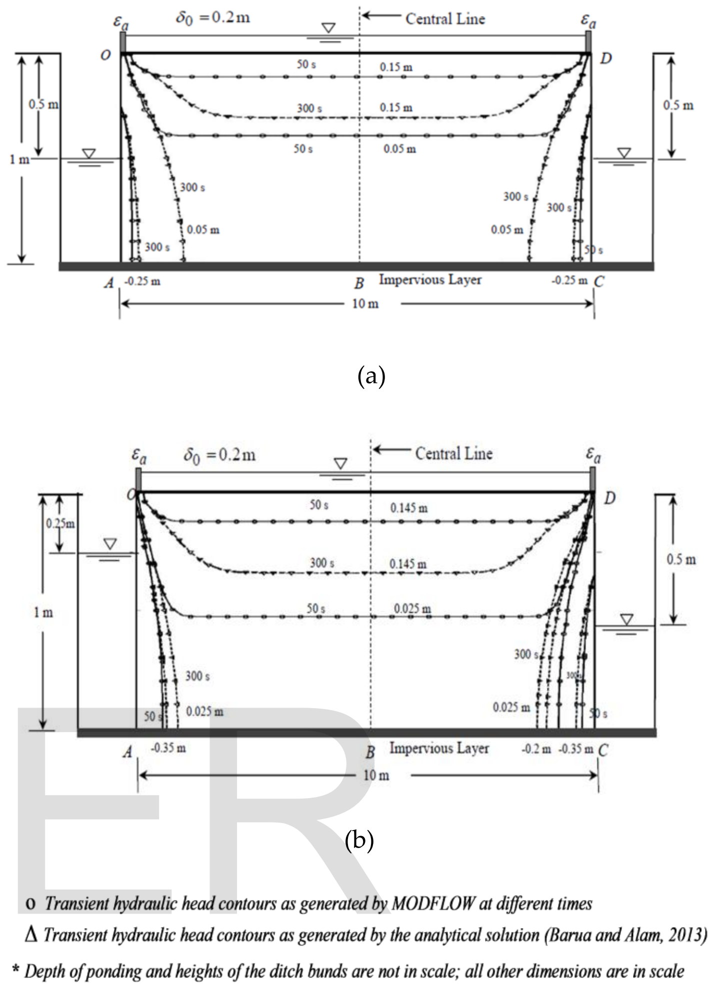

Fig. 8. Comparison of hydraulic head contours obtained by MODFLOW simulation and analytical solution obtained by Barua and Alam (2013) for the proposed flow problems (a) for Fig. 1 and (b) for Fig. 2. for the flow situation at corresponding few time intervals when $\varepsilon_a = 0.1$ m and the soil parameters are taken as $S_s = 0.001\,\text{m}^{-1}$ and $K_x/K_y = 1/1$ ($K_x = 0.1$ m/day, $K_y = 0.1$ m/day), $K_x/K_y = 1/1$ ($K_x = 0.5$ m/day, $K_y = 0.5$ m/day)

6. Conclusion

The comparison of numerical simulation results for different flow scenario and soil parameters, obtained by the following MODFLOW simulation study and their comparisons withtransient analytical solution of Barua and Alam (2013) and steady state solution obtained by Kirkham (1965) shows the validity of MODFLOW generated numerical models. The simulation results obtained through MODFLOW study shows that the seepage of water from the ponded surface of soil are more concentrated within the immediate neighbourhood of the drains and as one move away from the centre of the ditch,

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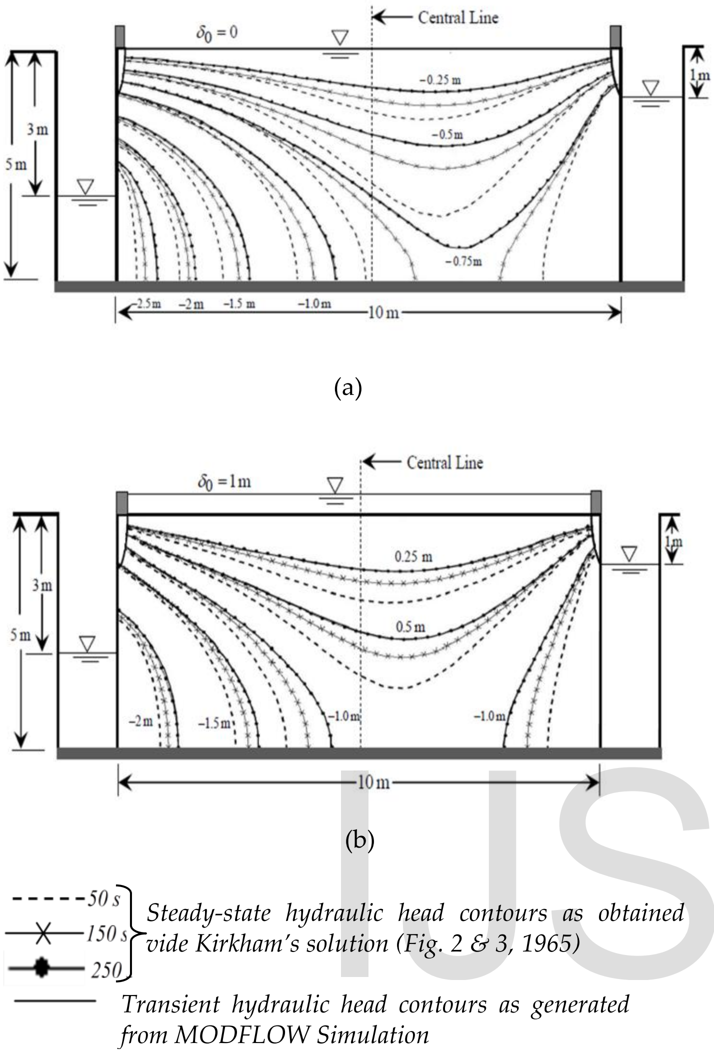

Fig. 9. Comparison of hydraulic head contours as obtained by MODFLOW transient simulation of ditch drain for the flow problem of Fig. 2. with the steady state solutions of Kirkham (1965) when the flow parameters are considered as follows: $h = 5\,\text{m}; H_1 = 3\,\text{m}; H_3 = 1\,\text{m},\ K_x = 0.00011\,\text{m/sec},\ K_y = 0.00011$ m/sec and $S_s = 0.001\,\text{m}^{-1}$; for (a) $t_0 = 0$; (zero ponding) and (b) $t_0 = 1\,\text{m},\ K_x/K_y = 1/1$, ($K_x = 0.5\,\text{m/day},\ K_y = 0.5$ m/day)

there is less influence on hydraulic head and rapid fall in the steady surface flux. Moreover the time required for attaining steady state flux of flow to the ditch drains depends mostly on the soil parameters, ponding depth of water and the level of water in the ditches. Knowing these parametesrs beforehand an optimized procedure can be formulated and executed for the purpose of attaining reclaimied the salt affected soil, water logged soil or achieving of bioremediation of soil by minimizing the wastage of water, time and efforts.

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