DISSERTATION

DEVELOPMENT OF FRESH WATER SKIMMING WELL TECHNOLOGY FOR SUSTAINABLE IRRIGATION AND DRAINAGE

Submitted by

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(93-Ph.D-WRM-02)

For the Degree of

DOCTOR OF PHILOSOPHY
IN
WATER RESOURCES MANAGEMENT

CENTRE OF EXCELLENCE IN WATER RESOURCES ENGINEERING
University of Engineering and Technology,
Lahore, Pakistan

1999

ABSTRACT

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The problem of saline groundwater intrusion/upconing is very serious in the central parts of 'doabs' in the Indus Basin of Pakistan. Disposal of saline effluent in canals and rivers is even more serious as it deteriorates the quality of water for downstream users. It has been estimated that approximately 200 billion cubic meters (bm^3) of fresh groundwater exists in the form of thin layers, which is underlain by saline water. These thin layers of fresh water overlying the saline water could be exploited to supplement the deficit irrigation supplies in addition to enhancing the drainage facilities. Therefore, it is absolutely necessary to skim this thin layer of fresh groundwater without disturbing the underlying saline water. The major aim of this study was to identify feasible approach(es) for skimming the thin fresh water layer under the conditions prevailing in the Indus Basin.

A density dependent three-dimensional finite element groundwater model, VDGWTRN was selected and applied for this purpose and modified by including viscosity parameter to study the behaviour of different skimming well designs i.e. single, multi-strainer, radial collector, recirculation and compound or scavenger wells. From regression analysis of observed viscosity, density and temperature data of saline water, an empirical relationship/equation for calculating viscosity of saline water was developed. The newly developed equation was used to update hydraulic conductivity of the saline

layer. The computer model VDGWTRN was also modified by introducing this equation. The modified model is called as VDVGWT. The model solves continuity equation for the fluid pressure using Darcy's law for the three velocity components (v_x, v_y and v_z). These velocities were used to solve the advection dispersion equation to find out the concentration and this information was used to update the density of the profile in the flow equation. The viscosity computed using the empirical relationship developed during the present study was used to upate the hydraulic conductivity to be used in the flow equation of the model's control algorithm.

Physical modelling of skimming wells was undertaken, which resulted in establishing promising basis for evaluation in the subsequent stages. The numerical model was calibrated using results yielded by the physical models. The numerical model was applied for different parameters like discharge, penetration depth, application of aquitard and intermittent pumping. Results of the study reveal that multi-strainer, radial and recirculation techniques for skimming fresh water are better alternatives as compared to compound or scavenger wells. Though scavenger well technique could suppress saline water upconing in a better way, yet it has severe problem of saline effluent disposal and environmental hazards. Keeping in view the overall performance of various skimming configurations, the 2-strainers well (15 m apart) performed better than all other suggested techniques, evaluated for this purpose. The radial collector wells with 30% penetration provided usable groundwater (1126 ppm). These wells may relatively be easy to install at shallower depths, which can further improve their efficiency. The recirculation technique of fresh water skimming well having recharge of 30% of main well discharge

under gravity pressure and recharging near abstraction end showed worthwhile results as the pumped water quality was 858 ppm.

Based on the results of this study, it is recommended that radial collector and recirculation wells being recently introduced should be tested in the field for their performance evaluation under field conditions.

It has been observed that introduction of an aquitard plays an important role in controlling upconing of saline water. The present study shows that presence of an aquitard improved the water quality by about 26%. It is recommended to carry out a survey in the Indus Basin for delineating the areas having aquitards separating fresh water and saline water layers.

The intermittent pumping having fifty percent utilization efficiency showed good results by improving water quality about 20%. The physical and numerical model results of proposed skimming well configurations are attractive, however, an economic analysis is necessary in order to establish their economic viability.