THESIS

COMPARISON BETWEEN DENSITY AND NON DENSITY DEPENDENT MODELS FOR SIMULATING SALINE-UPCONING IN FRESH SALINE AQUIFER

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ABSTRACT

The occurrence of saline water along with fresh water in inland aquifers is due to different reasons. The native groundwater in the central regions of the doabs of the Indus basin of Pakistan is deep and salty because of marine origin of the hydrogeologic formation. Percolation of fresh irrigation waters has formed a relatively- fresh groundwater lens above the underlying native salty groundwater layer. The thickness of this relatively fresh groundwater lens varies from a few meters to 15 m. The extraction of fresh water from these aquifers is severely hampered by the underlying saline water. The problems of saline water upconing and intrusion are of major concern in the Indus basin of Pakistan. The withdrawal of fresh water overlying saline groundwater has resulted in inferior quality of pumped water and degradation of the aquifer. When pumping from an aquifer is increased the upconing of the underlying saline water may become a problem.

Flow in aquifers is driven mainly by, potential forces resulting from pressure and elevation difference, coupled with buoyancy resulting from density difference, and osmosis caused by temperature and concentration gradients. The decision, whether or not to include the density coupling, would depend on the hydraulic properties of the system of interest, as well as, the density differences.

In this study three numerical models, MODFLOW, MT3D and SEAWAT were used to model the interface movement in an unconfined aquifer in Punjab Pakistan. Data collected by other researchers was used to calibrate and validate the models. With the development of scientific knowledge and mathematical techniques, transition zone

models were introduced which takes into consideration the mixing between freshwater and saline water. These models are further grouped into two classes on the basis either they consider density component of fluid driving force as primary variable or not. The percent error introduced by ignoring the density component of fluid flow can be assessed. Depending upon the variability of concentration between layers, density and non density dependent models simulations are equally valid for skimming wells. To simulate the interface (multi-layered medium, upconing of saline water into a well field, vertical flow components, etc.) a MODFLOW family of programs are sufficient. The error in ignoring density component is negligible for forced convection flow (e.g. during the pumping) but is significant for mixed and free convection flow (e.g. during the recovery of pumping). The effect of density difference can sometimes be significant, if the concentration difference between layers is in the range of 500 (mg/l), then the error will be 30 % and concentration difference between layers is in the range of 1000 (mg/l), then the error will be approximately 47 %.

The corrections for density in simulating hydrosalinity behavior under skimming wells and in any identical salt water intrusion problems are important, and a density dependent model should be used. In brines and waste depository site, where the saline concentration is usually very high, the use of density dependent models are advisable to minimize the error in simulated results.