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Research paper

Assessment of groundwater quality of major industrial city of Central Ganga plain, Western Uttar Pradesh, India through mass transport modeling using chloride as contaminant

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ABSTRACT

Present work deals with the simulation of a three-dimensional groundwater flow and solute transport model of Moradabad city lying between rivers Ramganga and Gagan. Present study is used to predict the response of aquifer and the migration of contaminant (chloride in this case) over a period of time using MODFLOW and MT3D software. A grid system of 500 m × 500 m was designed and the various input parameters such as hydraulic head, layer thickness, recharge, pumping etc. were applied under various packages available in the software. Pumping rates of 500 m^3/day, 1000 m^3/day and 1500 m^3/day were used for the simulation of abstraction. Hydraulic conductivity ranging from 13 to 18 m/day was assigned block wise. The model was run for steady state condition until a match between observed and computed heads was obtained. Sensitivity analysis was done by varying hydraulic conductivity and recharge parameters in the model. Solute transport modeling is carried out considering Cl as contaminant. Concentration of chloride is higher in northern, central and southern part of the study area. The data obtained from the water quality analysis of June 2012 was used initially in the steady state simulation. The predictions made from transport model indicate that the concentration of chloride would continue to increase if the current situation is not controlled and this will lead to further deterioration of groundwater quality.

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1. Introduction

The Ganga basin is one of the largest repositories of groundwater in India where groundwater is an important criterion for the urban-industrial development. A large number of shallow and deep tube-wells have been drilled in the last few decades resulting in the decline of water table in the Ganga plain. In addition to this, disposal of domestic and industrial effluents affects the water quality and soil of the Gangetic plain adversely (Ansari et al., 2000) Urban agglomeration is causing drastic changes in groundwater recharge and modifying existing mechanisms as most of the cities depend upon river water and groundwater for their water supply. Disposal of most of their liquid effluents in rivers and solid residues on the ground is causing pollution to surface and subsurface water resources (Misra, 2011). Moradabad city also experiences the similar situation. Therefore, to protect groundwater resource a proper management is necessary. In such a situation groundwater modeling can be used as an effective tool to identify the aquifer response under varied input output stresses and to predict the behavior of contaminants in the subsurface environment with flowing water.

Groundwater modeling is considered an excellent way to present the hydrogeological situation of groundwater system and to predict the socioeconomic impacts of the groundwater abstractions (Himmelsbach and Buter, 2001). Groundwater models provide additional insight into the complex system behavior and can assist in developing conceptual understanding. Furthermore, once they have been demonstrated to reasonably reproduce the past behavior, they can forecast the outcome of future groundwater behavior, support decision-making and allow the exploration of alternative management approaches (Kumar, 2013). Numerical modeling employs approximate methods to solve the partial differential equation (PDE), which describes the flow in porous medium. A computer program or code solves a set of algebraic equations generated by approximating the partial differential equations that form the mathematical models. The hydraulic head is obtained from the solution of three dimensional groundwater flow equation through MODFLOW software (McDonald and Harbaugh, 1988).

Rapid expansion of human activities has become a major cause of the dispersion of pollutants in the subsurface environment which is a matter of concern for the quality of groundwater. To

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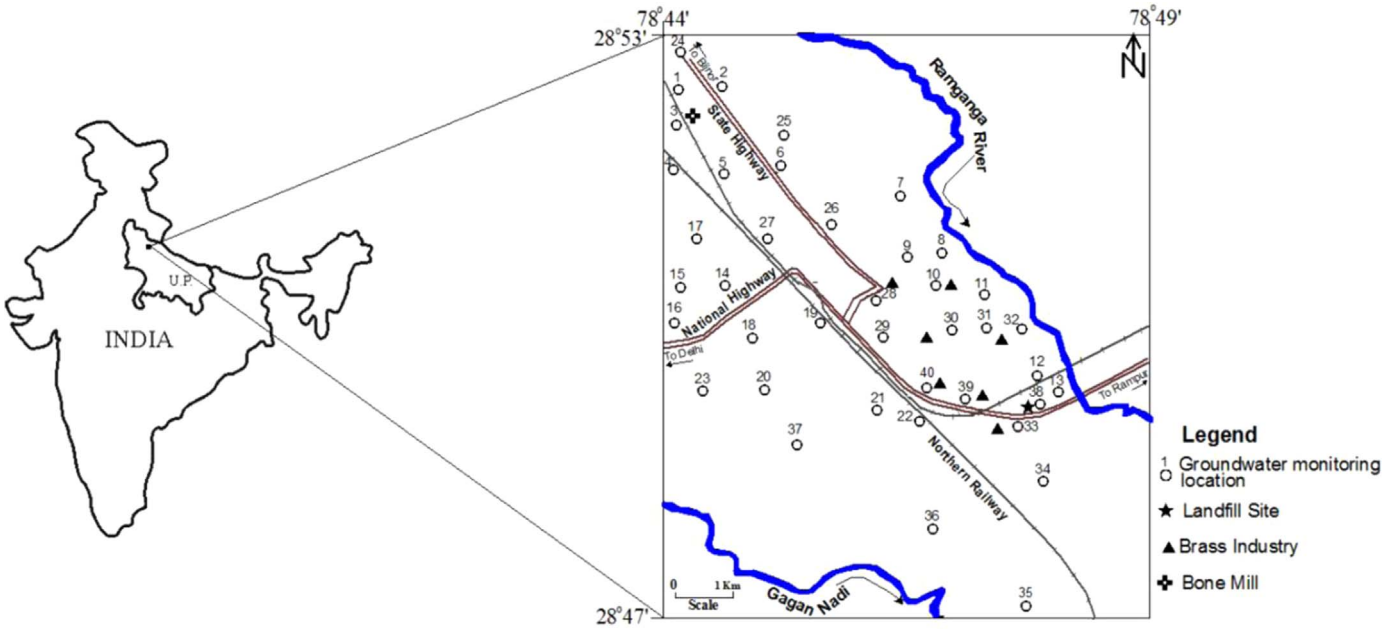

Fig. 1. Location map of the study area.

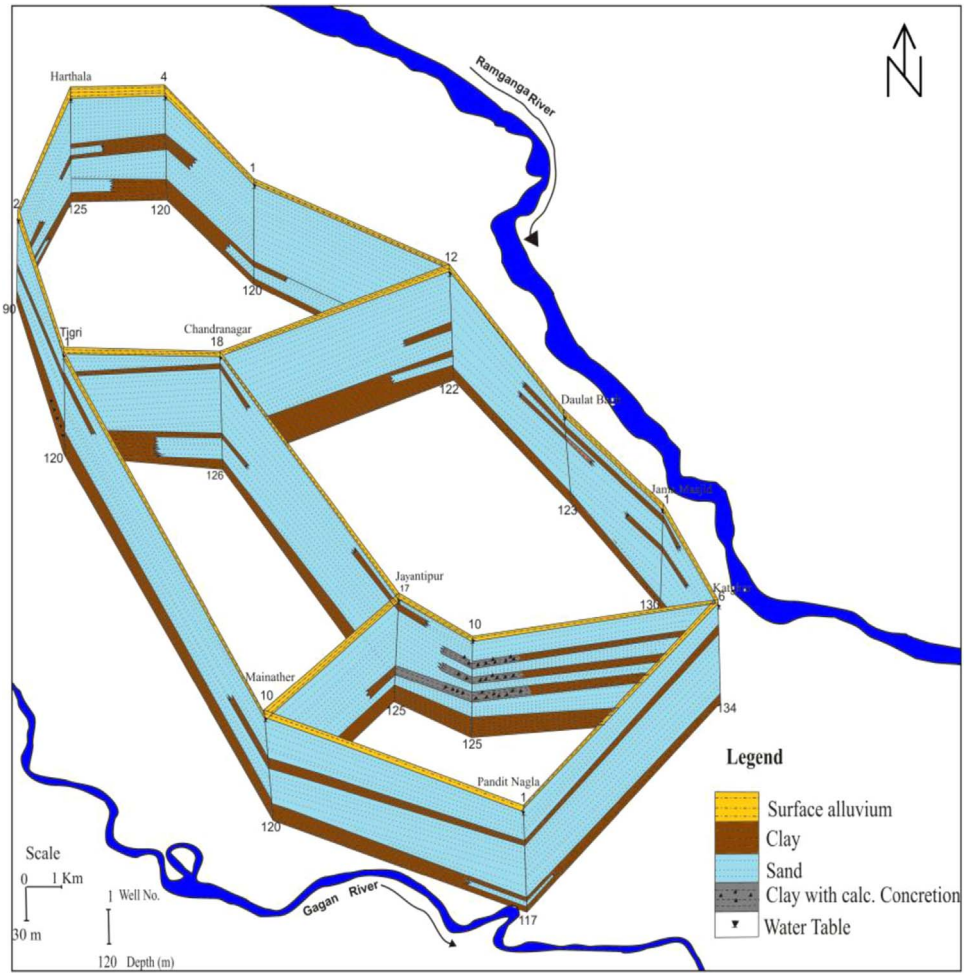

Fig. 2. Fence diagram showing aquifer disposition in the area.

determine the extent of contamination groundwater flow and transport modeling are being extensively employed. Numerical groundwater flow models help to solve the distribution of hydraulic head and describe the flow whereas numerical transport models solve the distribution of solute concentration due to advection, dispersion and chemical reactions (Rajapakse, 2009).

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