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Simulation of Contamination of Groundwater Using Environmental Quality Model

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ABSTRACT-- Ground water is an important source of water supply for municipalities, agriculture, and industry. Ground water contamination is the degradation of the natural quality of the ground water. While determining the degree of contamination, both the presence of a substance and its concentration must be considered. The level at which a substance could be harmful is different for each substance. Ground water contamination occurs, or can occur, when ground water in the zone of saturation is recharged with contaminated water or other liquid contaminants, or when a contaminant is placed or buried in the saturated zone. Contamination may result from wells, improperly sealed or abandoned and landfills that allow contaminated surface water to reach an aquifer. Hence hydrological and environmental simulation modelling needs increasing attention from the hydrology and environmental modelling communities. Present case study in a paper emphasises on groundwater contamination due to septic tank effluent.

Keywords — ***Groundwater contamination, Septic tanks, MODFLOW, Simulation***

I INTRODUCTION

Groundwater pollution may be defined as the artificially induced degradation of natural groundwater quality. Pollution can impair the use of water and can create hazards to public health through toxicity or the spread of disease. Most pollution originates from the disposal of waste water which is being used for variety of purposes.

Thus, the large number of sources and causes can modify groundwater quality, ranging from septic tanks to irrigated agriculture. In contrast with surface water pollution, subsurface water pollution is difficult to detect and is even more difficult to control, and may persist for decades. With the growing recognition of the importance of underground water resources, efforts are needed to increase to prevent, reduce, and eliminate groundwater pollution.

II GROUNDWATER CONTAMINATION

The occurrence of groundwater contamination and quality of groundwater has become major issues since some decades. Environmental contamination of groundwater due to extensive use of fertilizers, pesticides in agriculture and toxic chemicals in industry and in manufactured products has magnified the toxicity for plants, animals and society. Contaminants that can dissolve in groundwater will move along with the water, potentially to wells used for drinking water. A combination of moving groundwater and a continuous source of contamination can, therefore, pollute very large volumes and areas of groundwater. This presence and the transport of contaminants constitute a potential threat to human health and ecosystem. The quantity and the suitability of groundwater for human consumption and for irrigation are determined by its physical, chemical and bacteriological properties.

A. GROUNDWATER MODELING

A groundwater model is a mathematical tool designed to represent a simplified version of the physical, chemical and biological processes taking place in a real field site. It is generally, a computer-based approximation of observed groundwater behaviour. Groundwater modelling requires the development of as good a simplification of the geometry, aquifer properties and source / sink terms of the system as is achievable. The first parts of the modeling involve developing a groundwater model that adequately simulates the groundwater flow observed in long term monitoring. The second phase of model development is to couple the groundwater flow model with a pair of contaminant transport models.

B. MODELING OBJECTIVES

Ground water models are commonly used to,

- Identify data gaps during hydro geologic characterization.
- Aid in the design of a monitoring well network.
- Determine the potential impacts of contaminated ground water on nearby wells.
- Aid in selection and design of remedial actions to control, or remove and treat, contaminated ground water.

C. COMPUTER MODEL MODFLOW

Three-dimensional numerical model Processing MODFLOW was developed by USGS. MODFLOW numerically evaluates the partial differential equations for groundwater flow. The interface of MODFLOW is divided into three modules, the Input Module, the Run Module, and the Output Module. The input Module provides the ability to create a graphical three-dimensional representation of the study area. The values can be directly assigned to the study area and the software creates the appropriate files.

The Run Module allows the user to alter the parameters and options that are run specifically, such as the solver package, recharge and wetting applications and the tolerances for convergence. The Output Module provides the display of all the modeling and calibration results.

III CASE STUDY

A Area of Study

Figure 1 Study Area (google earth)

Septic tank and soak pit considered in a case study is located near girl's hostel of the V.J.T.I. college campus and an observation well is located at a distance of 120m from the soak pit. All the wastewater from toilets, latrines and bathrooms of six hostel blocks occupying 500 students is discharged into septic tank. Effluent from the septic tank is then transferred to soak pit. Normal annual rainfall in the area is 1800mm to 2400mm.

B Development of Groundwater Flow Model

Aquifer type of the study area is confined aquifer consisting of alluvial sand layer of thickness 15m. The total area of 15625m^2 is dived in a smaller grids sizes 5m x 5m each with 25 rows and 25 columns. A groundwater flow model is developed using MOFLOW package. Soil parameters, recharge rate and pump rate of the observation well were assigned and the model was run for 1800days.

Table 1 Soil characteristics (Todd & Mays, 2005)

Soil type	Porosity	Hydraulic conductivity	Specific yield
	(%)	(m/day)	(%)
Gravel	28	150-450	23-25
Sand	0.43	2.5-45	23-27
Silt	46	0.08	8
Clay	42	0.0002	3

C Solute Transport Modeling For Chloride Concentration With MT3DMS Package

The concentration of chlorides in septic tank effluent i.e. at source was determined by experimental analysis which is found to be 2500mg/lit. Daily domestic discharge in a septic tank is 5m^3/day during working days of college and 1.25m^3/day during vacation period. The pump rate of observation well is 1.5m^3/day during its 12 hours operating period. Assigning all these parameters the MODFLOW package was run for 1800 days and hydraulic head and groundwater flow pattern outputs were simulated.

Table 2 Details of the parameters used in MT3DMS package

Parameter	Details
Chloride concentration at source	2500 mg/lit
Longitudinal dispersivity	12.5m
Freundlich equilibrium constant	1
Freundlich Exponent	0.5531

D Results

1 Model Calibration

The present study calibrates the model for groundwater flow. The observed hydraulic head in the observation well is 8.5m and simulated hydraulic head obtained by MODFLOW is 8.3m. Observed hydraulic head is nearly matching with simulated head. Hence software is working effectively.

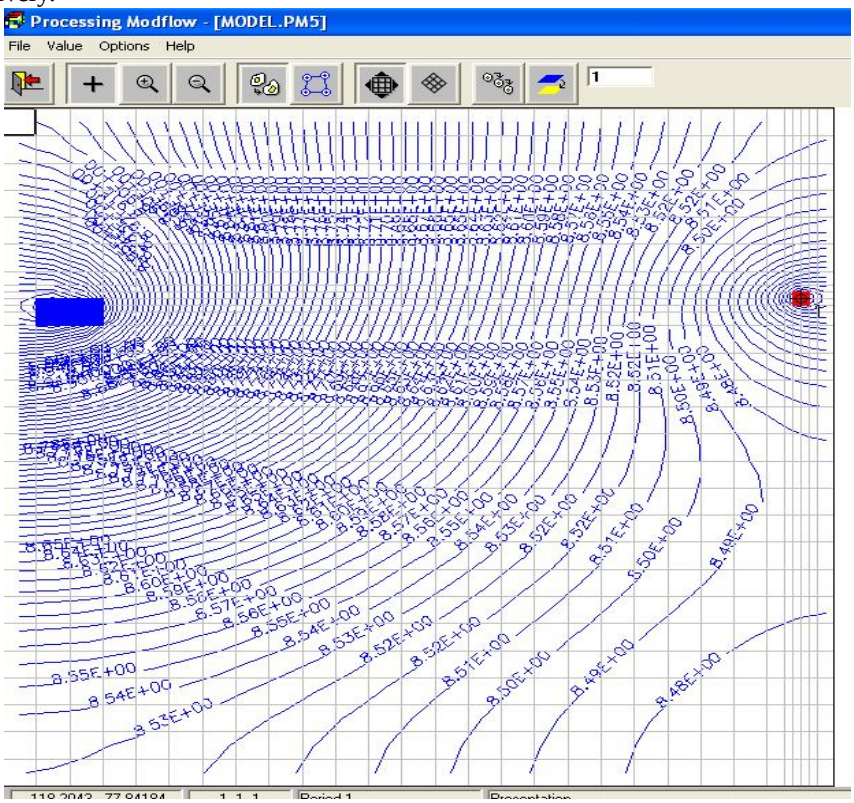

Figure 2 MODFLOW window showing the groundwater flow pattern developed after simulation

2 MODFLOW Application

In the present study, concentration of chlorides in observation well for the months January, February, March and April were calculated using experimental analysis. And the solute transport model was run for the same. Also from the simulated results it was found that the chlorides concentration requires 690 days of period to reach up to the observation well.

Table 3 Details of observed and calculated chloride concentrations on monthly basis

Time	Observed concentration using experimental analysis (mg/lit)	Simulated concentration using MODFLOW (mg/lit)
15th Jan 2014	76	63.45433
15th Feb 2014	79.5	66.25002
15th March 2014	80	69.26227
15th April 2014	80.5	72.45611

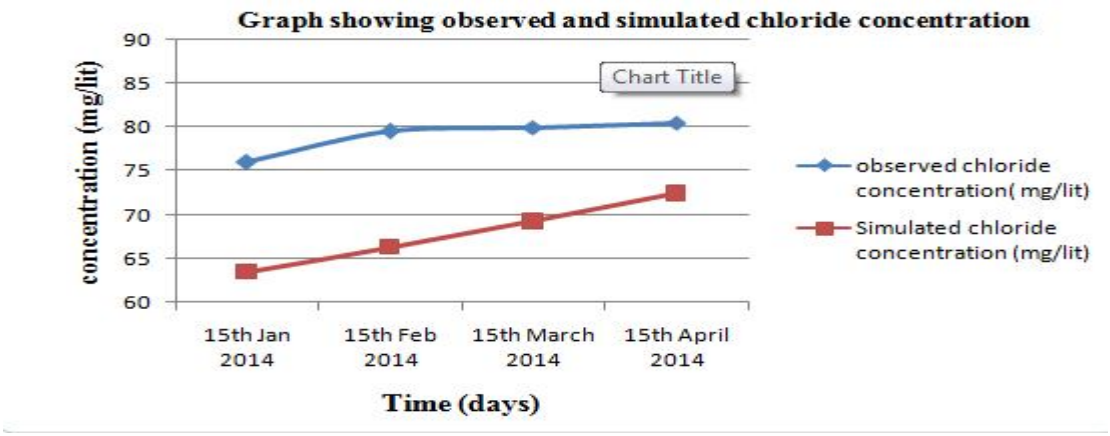

Figure 3 graph showing observed and simulated chloride concentrations in observation well

Fom the graph it can be observed that the chloride concentration in the observation well is increasing with time. Also from trnd of graph, it can be seen that the simulated results of the model are also increasing with time.

IV CONCLUSION

A computer tool MODFLOW was used to simulate the groundwater contamination study. Also the tool was effectively in the study to study the groundwater contamination caused due to septic tank effluent. . From the study it is observed that chlorides concentration is increasing with time. Also, MODFLOW simulation tool can be used in different groundwater contamination simulation studies.

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