Spatially distributed regional recharge-rate estimation to guide an aquifer-sensitivity assessment for mid-continental glacial environments, USA

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Abstract

A method of spatially distributed estimation of groundwater recharge was evaluated for the glaciated portion of Indiana, USA. The model uses a multiple regression approach to quantify the groundwater recharge rate, based on a conceptual model that relates recharge to near-surface processes that control the recharge rate. The model was applied to near-surface geologic and land-cover data for the study area to map groundwater recharge rates. The spatial distribution of the recharge rates was compared to data collected from 1998 on groundwater chemistry and contaminant concentrations. The results of the multiple regression analysis were compared to the observed data to assess the sensitivity of the model to contamination. To assess the sensitivity of near-surface aquifers of Indiana (north of the Wisconsin glacial limit) is a slight underestimate of -0.04 cm/year. Groundwater-quality studies in this region are over-estimated by up to 10 cm/year; however, the median residual for the entire glaciated portion of Indiana upstream area occupied by forest.

Conceptual Model

The multiple regression analysis of annual recharge rates as an independent variable. The model was evaluated using multiple regression analysis to determine the factors that control recharge. The conceptual model for recharge is based on a combination of factors such as climate, geology, and land cover. The model takes into account the influence of topography, geology, and land cover on recharge. The proportion of recharge to runoff in stream hydrographs were controlled by topography, geology, and land cover. The model was tested using least-squares regression analysis of regional recharge in a humid environment. The best-fit model was used to identify and rank the most statistically influential variables. The model was evaluated using a local-minima approach with a recession slope test to assess the recharge rate. The resultant spatially distributed groundwater recharge map (predicted) is shown in Figure 5.

Multiple Regression Analysis

The regression model had the form: \( R^2 = 0.74. RMSE = 1.5. \) The regression model was evaluated using ordinary least-squares regression analysis of regional recharge in a humid environment. The best-fit model was used to identify and rank the most statistically influential variables. The model was evaluated using a local-minima approach with a recession slope test to assess the recharge rate. The resultant spatially distributed groundwater recharge map (predicted) is shown in Figure 5.

Statistical Model Background

The statistical model was evaluated using multiple regression analysis of regional recharge in a humid environment. The best-fit model was used to identify and rank the most statistically influential variables. The model was evaluated using a local-minima approach with a recession slope test to assess the recharge rate. The resultant spatially distributed groundwater recharge map (predicted) is shown in Figure 5.

Relating groundwater recharge to near-surface aquifer sensitivity to contamination


References


Figure 1. Conceptual model of factors that influence near-surface aquifer sensitivity to contamination.

Figure 2. Map showing the distribution of groundwater recharge for the glaciated portion of Indiana, USA, for the study area. The map was generated by a multiple regression analysis of regional recharge in a humid environment. The best-fit model was used to identify and rank the most statistically influential variables. The model was evaluated using a local-minima approach with a recession slope test to assess the recharge rate. The resultant spatially distributed groundwater recharge map (predicted) is shown in Figure 5.

Table 1. Logarithmically distributed \( \log_{10} R \) values that have demonstrated significant differences at \( p \leq 0.01 \) (denoted by *). The regression model had the form: \( R^2 = 0.74. RMSE = 1.5. \) The regression model was evaluated using multiple regression analysis of regional recharge in a humid environment. The best-fit model was used to identify and rank the most statistically influential variables. The model was evaluated using a local-minima approach with a recession slope test to assess the recharge rate. The resultant spatially distributed groundwater recharge map (predicted) is shown in Figure 5.

Figure 3. Scatter plot of observed versus predicted groundwater recharge rates (cm/year) based on multiple regression analysis. The regression model had the form: \( R^2 = 0.74. RMSE = 1.5. \) The regression model was evaluated using multiple regression analysis of regional recharge in a humid environment. The best-fit model was used to identify and rank the most statistically influential variables. The model was evaluated using a local-minima approach with a recession slope test to assess the recharge rate. The resultant spatially distributed groundwater recharge map (predicted) is shown in Figure 5.

Figure 4. Modelled of significant parameters used in the multiple regression analysis. The regression model had the form: \( R^2 = 0.74. RMSE = 1.5. \) The regression model was evaluated using multiple regression analysis of regional recharge in a humid environment. The best-fit model was used to identify and rank the most statistically influential variables. The model was evaluated using a local-minima approach with a recession slope test to assess the recharge rate. The resultant spatially distributed groundwater recharge map (predicted) is shown in Figure 5.

Figure 5. Predicted groundwater recharge rates (cm/year) based on multiple regression analysis. The regression model had the form: \( R^2 = 0.74. RMSE = 1.5. \) The regression model was evaluated using multiple regression analysis of regional recharge in a humid environment. The best-fit model was used to identify and rank the most statistically influential variables. The model was evaluated using a local-minima approach with a recession slope test to assess the recharge rate. The resultant spatially distributed groundwater recharge map (predicted) is shown in Figure 5.

Figure 6. Aquifer sensitivity assessment based on multiple regression analysis of recharge rates in near-surface aquifer materials.