Simple model for accurate simulation of nitrate concentration in groundwater at nitrate-contaminated site

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Abstract

These days, groundwater, which is one of the most important natural-water resources for citizen, is becoming more severely polluted with a rapid technology development, especially nitrate pollution. There are growing concerns about nitrate contamination in Kumamoto City, where has over 700,000 people who completely depend on groundwater as a source of drinking water. Therefore, it is really required that an appropriate management to control nitrate concentration in groundwater and have timely intervention before groundwater is seriously contaminated. Modeling of nitrate concentration might be helpful to ensure proper groundwater management and utilization, especially for a drinking water supply.

We have already developed Groundwater nitrate tank model (GNTM) to simulate nitrate concentration in groundwater in Kumamoto City. However, simulated results obtained from GNTM were not always enough to fit the observed data depending on the season. In this study, we developed a new GNTM (nGNTM) to achieve more accurate simulation of nitrate concentration in groundwater by addition of nitrogen load from the layer above groundwater aquifer in heavy rain season. Still using Shuffled Complex Evolution-University of Arizona (SCE-UA) algorithm, which was introduced and modified to minimize the root-mean-square error (RMSE) between simulation and observation data for parameter calibration and assessed the accuracy by Nash-Sutcliffe efficiency (NSE) coefficient, when comparing two results of the simulation, it can be concluded that adding parameters of nitrate load on the unsaturated zone under the influence of heavy rainfall makes the simulation results more accurate. Thus, we have a new thought about the source of contamination of groundwater nitrate also affected by surface nitrate and rainfall intensity. Although there are some additional parameters, the model still ensures simplicity and does not need to concern about complicated hydrogeological parameters. As a result, nitrate concentrations at two observation wells in nitrate contaminated area were more accurately simulated than GNTM, which showed that nGNTM was effective and better applicate.