論文名

Classification and assessment of groundwater chemistry in the regional basin, using self-organizing maps

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Groundwater studies such as groundwater contamination, groundwater depletion, and the changes of groundwater-dependent ecosystems have been increasingly concerned issues in many countries. In the present research, we have primarily discussed two topics based on sustainable utilization and the preservation of groundwater resources. The first one is how the 2016 Kumamoto earthquake influenced groundwater chemistry. Another is that the effects of the Nitrate Directive Plan have been quantitively assessed in the Miyakonojo River Basin by using statistical approaches such as self-organizing maps and time-series trend analysis. The discussions and conclusions of the study have been described in Chapter 2 and Chapter 3, respectively.

Due to a lack of data and observations, the possibility of performing pre-and post-seismic groundwater chemical comparisons on regional groundwater flow systems is rare. The Kumamoto earthquake provides an unusual opportunity to improve the knowledge on earthquake hydrology and earthquake effects on groundwater hydrochemistry due to a wealth of pre-and post-quake observations. We analyzed 12 physiochemical parameters (SiO_2, $(NO_3^-+NO_2^-)$-N, Fe_{total}, Mn_{total}, pH, F^-, Cl^-, SO_4^{2-}, Na^+, K^+, Ca^{2+}, and Mg^{2+}) using self-organizing maps (SOM) combined with hydrological and geological characteristics to improve the understanding of changes in groundwater chemistry after a significant earthquake. The results indicate the earthquake-induced hydrological and environmental change via fault forming (Suizenji fault systems), liquefaction, rock fracturing, and ground shaking. These geological processes created new rock reactive surfaces, rock loosening, and enhanced hydraulic conductivity. In turn, this led to secondary processes in groundwater chemistry by advection, dilution, and chemical reaction.

The most apparent hydrological and environmental change indicator was the increased dissolved silica content stemming from fracturing and Si-O bond cleavage in silicate rocks. Besides this, the decreasing concentration of common ions (Cl^-, F^-, Na^+, K^+, Ca^{2+}) was found due to dilution from mountain-side water release. An increase in $(NO_3^-+NO_2^-)$-N, SO_4^{2-}, and Mg^{2+} concentration occurred locally due to soil leaching of contaminants or agricultural fertilizers through surface ruptures in recharge areas. Increase of SO_4^{2-} content also originated from leaching of marine clay in coastal areas and possibly sporadic deep crustal fluid upwelling. An increase in $(NO_3^-+NO_2^-)$-N and Cl^- content occurred from sewage water pipe breaks in the Suizenji fault formation in urban areas. A decrease in pH occurred in a few wells due to the mixing of river water and different types of aquifer groundwater. The increase of

In most cases the water chemistry changes were subtle, thus not resulting in any groundwater quality deterioration of water supplies. These contents and discussions are included in Chapter 2.

Then, for a better understanding of the effects of regional groundwater management for different land-use types on nitrogen content in groundwater, we investigated the Miyakonojo River Basin in south of Japan where the Nitrate Directive Plan has been in practice since 2004. For this purpose, we used nitrogen concentrations in 420 groundwater samples from 420 wells from 2000 to 2017 together with eight different land-use categorizations. The data were analyzed using self-organizing maps (SOM) and results showed that forest recharge areas have lowest mean nitrogen concentrations of about 2.9 mg/L. Urban areas displayed a mean nitrogen concentration of about 4.4 mg/L. Agricultural land such as paddy fields had a mean nitrogen concentration of about 5.1 mg/L. Groundwater discharge and residential areas had mean groundwater nitrogen concentrations of 8.2 and 7.1 mg/L, respectively. Intensive agricultural land-use and wastewater discharge from urban areas caused the main groundwater nitrogen contamination in these areas. About 70% of the wells had a decreasing trend of groundwater nitrogen concentration ($p<0.05$, $p\geq0.05$) during the period 2009-2017. About 20% of the wells displayed a trend reversal from 2000-2008 (increasing) to 2009-2017 (decreasing). In general, the Nitrate Directive Plan appears to have had positive effects for mitigating groundwater nitrogen problems. However, 30% of the wells still did not display a decreasing trend and some wells exceeded maximum permissive level for drinking water. Thus, management needs to continue to improve groundwater conditions regarding nitrogen content. These discussions and conclusions are summarized in Chapter 3.