Hyporheic exchange and associated nitrogen transformation at groundwater-surface water interface in an alluvial aquifer beneath farmland

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A hydrogeochemical study of an alluvial aquifer beneath a farmland, Korea, was conducted to examine the nitrogen transformation in a large-scale hyporheic zone developed along long flow paths (>500 m) within a gravel aquifer adjacent a meandering river. The hyporheic zone is affected by river meandering, agricultural irrigation, topography, and alluvial hydrogeology. There is a systematic spatial change in groundwater chemistry in 4 multi-level wells and 24 shallow (6 m deep) irrigation wells, as determined by end-member mixing analysis (EMMA) and reaction path modelling. A mixing model based on orthogonal regression using principal component analysis indicates that oxygen (or hydrogen) isotopic composition can be used as a chemical tracer to calculate the mixing fraction and mass balance of surface water-groundwater interaction. Agricultural contamination characterized by enrichments of Ca^{2+}, Mg^{2+} and NO_3^- and decrease of pH and alkalinity is pervasive in the aquifer beneath the groundwater recharge zone. A slightly reduced zone characterized by gradual depletion of dissolved oxygen, DOC and NO_3^- and concomitant increase of pH and alkalinity is developed near the river. Reaction path modelling shows that DOC originated from surface water is the dominant control of hydrochemistry and can remove about 90% of nitrate by denitrification. This study illustrates that a hyporheic exchange may significantly attenuate agricultural nitrate even in an aquifer with insufficient organic carbon.

Kohonen Self Organizing Map (KSOM) approach for assessing hydrochemistry of deep thermal groundwater in Korea

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Deep thermal groundwaters are geologically old and highly mineralized, but they exhibit diverse chemical compositions due to complicated origin and evolution. Water in deep thermal reservoirs is also affected by complex geochemical processes during ascent, such as mixing and dilution and various geochemical reactions. Thus, it is difficult to evaluate hydrogeochemical data and to classify the phases of deep thermal groundwater. In this study, a large dataset of deep thermal groundwaters (> 300 samples) in South Korea is assessed by the Kohonen Self Organizing Map (KSOM) approach to classify them and to understand their hydrogeochemical evolution. The KSOM approach is based on artificial neural networks (ANNs) with unsupervised learning and is conducted for the non-linear dimensionality reduction to analyze, cluster, and model various types of multivariate dataset including water quality or environmental data. The major findings of this study are: 1) deep thermal groundwaters of South Korea can be clustered into three major types, i.e., alkaline, acidic CO_2-rich, and high-TDS saline; 2) hydrochemistry of thermal groundwaters can be explained by varying degrees of mixing between three end members; 3) among the three types, alkaline-type groundwater is predominant and occurs typically in granitic rocks; 4) examination of the relationships between hydrochemical parameters indicates that each type of thermal groundwater is characteristically evolved through distinct water-rock interaction (characterized by varying degrees of silicate hydrolysis with subordinate sulfide oxidation) and progressive mixing with diluted shallow groundwater during ascent. The results of this study help to evaluate deep subsurface environments of South Korea, which may be required for site assessment for geological disposal of nuclear waste and CO_2.