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Source identification and Pathway analysis of Nitrate contamintation in "Cultural village", Jeungpyeong

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Abstract

The purposes of this research are to identify the source and to analyze the pathway of nitrate contamination in "cultural village", Jeungpyeong. In order to examine recharge processes and flow pattern that closely related to the influent of nitrate contaminant, the flow field was simulated and the oxygen and hydrogen stable isotopes were analyzed. The nitrogen isotope was used to delineate contaminant sources. The shallow groundwater was mainly composed of precipitation, but leakage of domestic water and sewage contributed to the recharge. Nitrate contaminants were possibly from the leakage of sewage and animal waste. The nitrate concentration decreased due to dilution by low concentration water.

key word : nitrate, oxygen and hydrogen isotope, nitrogen isotope, groundwater recharge

I. Introduction

Nitrate contamination is a major problem in shallow aquifer and is increasingly becoming a threat to groundwater supply. In drinking water, nitrate-nitrogen in excess of 10 ppm may be toxic for infants and may be responsible for increases in stomach cancer for others. Furthermore the impact of high loading of nitrate and other nutrients is a major environmental concern, causing eutrophications of streams and rivers (Kendall et al., 2000).

The major investigations about nitrate contamination had focused on chemical concentration and remediation technique itself. There are a few study about sources using nitrogen isotope in Jeju (Oh et al., 1997) and Gyeonggi (Yoo et al., 1999). The study related with recharge using stable isotope was reported in Jeju (Woo et al., 2001).

The purposes of this research are to identify the source and to analyze the pathway of nitrate contamination in "cultural village", Jeungpyeong. In order to examine recharge processes and flow pattern that closely related to the influent of nitrate contaminant, the flow field was simulated and the oxygen and hydrogen stable isotopes are analysed. The nitrogen isotope was used to delineate contaminant sources.

II. Results and Discussion

II-1. Site description and groundwater flow system

The study site named "cultural village" is located in Jeungpyeong Eup, middle inland of Korea (Fig.1). The Samgi stream that located at the middle of site flows from south to north and meet Bogam stream. The geology is composed of Jurassic porphyritic granite and the basin is composed of Quaternary alluvium sands (KARICO, 2001).

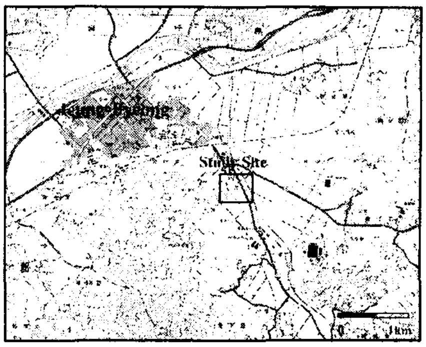

Fig. 1. Location of the study site

The groundwater levels have been measured every month. The levels slightly changed each month, but the general flow pattern did not change. The groundwater flows from south to north in accordance with the flow direction of the nearby stream. The circular equipotential line of northern part reflects the influence of local pumping. The observed hydraulic gradient was about 7×10^{-3}. As the reported hydraulic conductivity is in the range of 4.5 to 11m/day(KARICO, 2001), the horizontal flux rate is in the range of 3.1×10^{-2} to 7.7×10^{-2} m/day. The groundwater flow system was simulated using the visual MODFLOW. The result of flow modeling shows that the groundwater flows from southwest to northeast in the local area but it flows from south to north in the study site (Fig. 2).

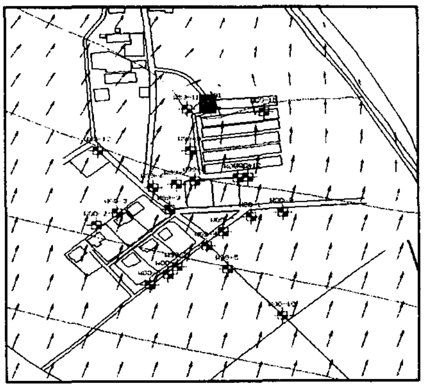

Fig. 2. Simulated flow field

II-2. Oxygen and hydrogen stable isotope

Since November 2001, groundwater samples for analyzing oxygen and hydrogen isotopes had been collected in the study area once a month. The groundwater was collected at 10-20cm below the water table. The water of Samgi stream was also collected for the analysis. The precipitation has been collected at the study site since January 2002.

The values of $\delta^{18}O$ and $\delta^{2}H$ are ranged in typical isotopic values of the precipitation of Korea. The results of the groundwater in November and December 2001 and January 2002 are plotted on $\delta^{18}O$ versus $\delta^{2}H$ (Fig. 3). The data plot of December are below GMWL, and average d-value is 4.8.

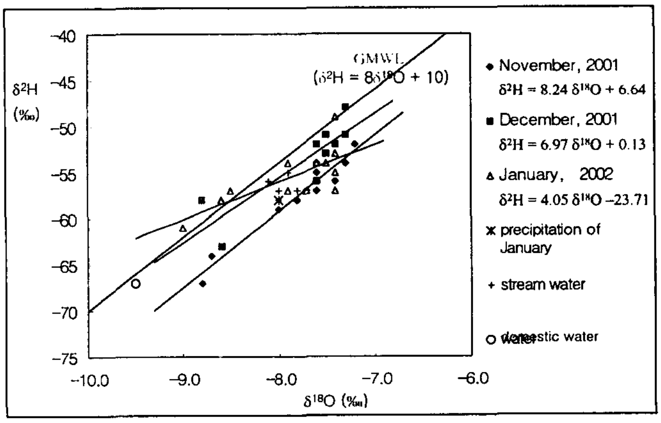

Fig. 3. Plot of $\delta^{18}O$ and $\delta^{2}H$

Shallow groundwater of November was mainly composed of summer precipitations. The data of December and January are plotted near GMWL and have average d-values 8.1 and 7.3. This means that autumn or winter precipitation recharged the groundwater during that period. Every month, a few data have lower isotopic values, it is the influence of mixing with leakages of domestic water supply system.

Fig. 4 shows the spatial distribution of the $\delta^{18}O$ value in November 2001 and January 2002. The trend of distribution is not closely related to flow pattern. Otherwise, two parts have lower isotopic values. It means that shallow groundwater have the other recharge sources other than the precipitation. As domestic water has a low isotopic value, one of the other recharge sources may be leakages of domestic water or sewage. It may be considered that the cause of lower isotopic value in southern cropland may be caused by fast recharge of precipitation or direct inflow into the well through the passage between the formation and the well casing. But further closer examination is needed.

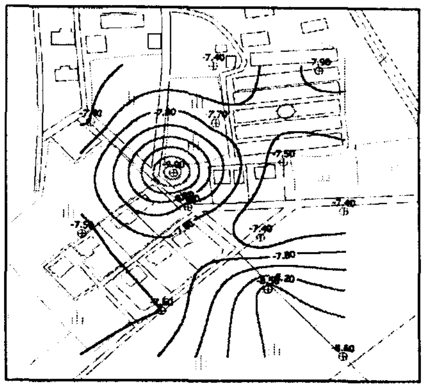

Fig. 4. Spatial distribution of $\delta^{18}O$

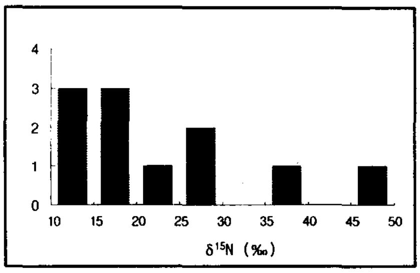

Fig. 5. Distribution of $\delta^{15}N$

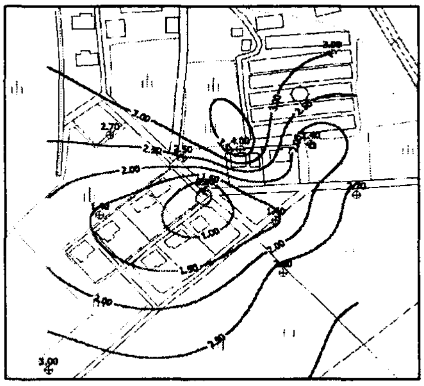

Fig 6. Spatial distribution of [NO_3-N]

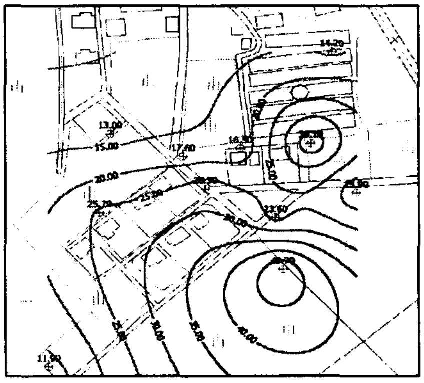

Fig. 7. Spatial distribution of $\delta^{15}N$

Ⅱ-3. Nitrogen isotope

The samples for analysis of nitrogen isotope in ammonium and nitrate were collected in December 2001. But the sampling points for nitrogen isotope were not accordance with those for oxygen and hydrogen isotopes because of the difference in sampling volumes.

The concentrations of ammonium-nitrogen and nitrate-nitrogen were not as high as expected, so they existed in the maximum permissible limit. Additionally the isotopic values of ammonium-N in many samples were not detected. Many nitrate-N have $\delta^{15}N$ values in the range of 10-30‰ (Fig. 5).

The spatial distribution of nitrate concentrations and $\delta^{15}N$ value are shown in Fig 6. and 7. Although the data are insufficient for kriging, they roughly show a trend of distribution. The nitrate concentrations are lower in human residential area than in the other areas. The relative high nitrate concentration are distributed northern part and southern part. Northen part may be related to leakage of sewage and animal waste, and southern part may be related to usage of fertilizer or compost.

Fig 8. is a plot of nitrate concentration versus $\delta^{15}N$ value of groundwater and stream water. For the estimation of the natural attenuation, the DO contents may be used. The measured DO values in the study area were in the range of 3~5 mg/l. Therefore it may be said that the denitrification rarely had occurred. The dilution of groundwater also has some problem with which to explain the source distribution because of too high $\delta^{15}N$ values.

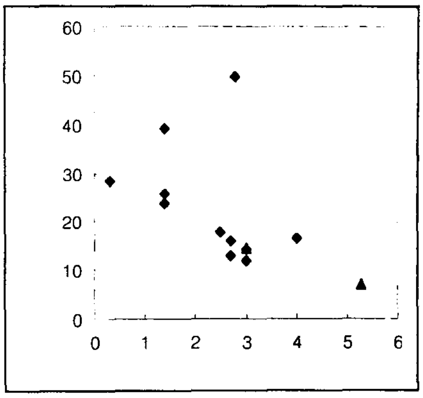

Fig. 8. Plot of [NO_3 -N] and $\delta^{15}N$

Ⅲ. Summary and conclusion

In order to identify nitrate contaminant source and to analyze pathway of nitrate, the basic researches by hydrological and isotopic methods were used. According to the result at present, the groundwater flow direction in the study site is from south to north. The results by oxygen hydrogen stable isotopes indicate that the precipitation is the main source of the groundwater recharge, and also the leakage of domestic water and sewage contribute recharge. The contaminant sources of nitrate are mainly from the leakage of sewage and animal waste. The lower concentration of nitrate was mainly caused by dilution of a lower concentration water, but some denitrification had occurred.

Ⅳ. Reference

1. Coplen, T.B., Herczeg, A.L. and Barnes, C., 2000, Isotope engineering using stable isotopes of 67
the water molecule to solve practical problems, *In Environmental tracers in subsurface hydrology*, eds Peter G. Cook and Andrew L. Herczeg, pp. 79-110. Kluwer Academic Publishers.
2. Kendall, C., 1998, Tracing sources and cycling of nitrate in catchments, *In Isotope Tracers in Catchment Hydrology*, eds. C. Kendall and J. J. McDonnell, pp. 519-576, Elsevier, Amsterdam.
3. Korea agricultural and rural infrastructure cooperation, 2001, *Groundwater remediation techniques in rural area*, 118-243, Ministry of agriculture and forestry.
4. Lee, K.S. and Lee, C.B., 1999, Oxygen and Hydrogen Isotopic composition of precipitation and river waters in South Korea, *Journal of the Geological Society of Korea* **35**, 73-84.
5. Oh, Y.K. and Hyun, I.H., 1997, Estimation of nitrate-nitrogen contamination sources in Jeju island groundwater using $\delta^{15}N$ values, *Journal of KoSSGE* **4**, 1-4.
6. Woo, N.C., Kim, H.D., Lee, K.S., Park, W.B. and Koh, G.W., 2001, Interpretation of groundwater system and contamination by water-quality monitortin in the Daejung watershed, Jeju island, *Econonical and Environmental Geology* **34**, 485-498.
7. Yoo, S.H., Choi, W.J. and Han, G.H., 1999, An investigation of the sources of nitrate contamination in the Gyeonggi province groundwater by isotope retios analysis of nitrogen, *Journal of Korean society soil science fertilizer* **32**, 47-56.