한국지하수토양환경학회 추계학술대회
2001년 9월 21-22일 전 주 대 학 교

# Hydrogeochemical and isotopic characteristics of spring water in a carbonate terrane, Yeongweol area: Time-series variation during a storm event

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## 1. Introduction

Karst aquifers are highly complicated due to a heterogeneity within the aquifer system. Thus, their fundamental properties such as water recharge, groundwater flow, and subsurface water storage are extremely variable. There have been two ways for studying the karst aquifer. One way was the monitoring of the variability in temperature, specific conductance, hardness, saturation states with respect to calcite and dolomite, and stable isotopes as a means of identifying physical characteristics of karst aquifer systems. For these studies, waters have been sampled on a weekly to monthly time frame. The other method was an examination of the changes of spring discharge and stable isotopes (mainly, oxygen and hydrogen) in response to a short-time rainfall event, and have been focussed to quantify the amount of rainwater contributing to the storm discharge.

The present study aims to identify the contribution of rain and pre-storm water in a karstic groundwater system, using a two-component mixing model based on monitored $\delta^{18}O$ and $\delta D$ values. The discharge hydrograph separation curves are constructed for two springs at the Yeongweol area over the testing period lasting 5 days after a storm event.

## 2. Study Area and Methods

The study area is located in the Yongweol-Danyang basin. The topographic elevation ranges from 200 to 500 m a.s.l. There are a myriad of sinkholes, caverns, and doline. The field investigation was conducted for 5 days (from September 15 to 19 of 2000) during a storm event called 'Saomai'. The sampling and field measurement were conducted two or three times per day for four chosen karstic springs. The parameters monitored include discharge rate, pH, EC(electrical conductivity), Eh, D.O., turbidity, alkalinity, silica, major ions ($SO_4^{2-}$, $NO_3^-$, $Cl^-$, $Na^+$, $K^+$, $Ca^{2+}$, $Mg^{2+}$), trace metals (Al, As, Ba, Cd, Cr, Cu, Co, Fe, Li), stable isotopes ($^{18}O$ and $^{2}H$ of water, and $^{13}C$ of dissolved inorganic carbon).

## 3. Results and Discussion

3.1. Hydrological response of springs to a storm event

The main hydrological characteristics of two representative springs (S-41 and S-45) during a storm event are summarized in Table 1. During the event, the total amount of rainfall was 115 mm with a maximum rainfall intensity of >10 mm/h.

Table 1. Main hydrological characteristics of two springs.

| | Spring S-41 | Spring S-45 |
|---|---|---|
| Base flow (l/s) | 24 | 13 |
| Main peak flow (l/s) | 138 | 78 |
| Final discharge (l/s) | 31 | 6 |
| Total storm flow (l/s) | 19,139 | 5,473 |

3.2. Isotopic compositions of various waters

(a) Pre-storm water

The sampling of pre-storm water was performed during a typical dry season (date: May 31 and June 2 of 1999). Therefore, the samples collected may record the isotopic compositions of base flow. Results of isotopic analysis are shown in Table 2. The isotopic compositions of pre-storm water are -9.6 ‰ $\delta^{18}O$ and -70.8‰ $\delta D$.

Table 2. Isotopic compositions of pre-storm water collected during a dry season.

| Ground Water (n=8) | $\delta D$ | $\delta^{18}O$ | Spring Water (n=11) | $\delta D$ | $\delta^{18}O$ |
|---|---|---|---|---|---|
| Min | -73.1 | -9.9 | Min | -74.6 | -10.0 |
| Max | -68.8 | -9.1 | Max | -68.5 | -9.3 |
| Avg | 70.9 | -9.6 | Avg | -70.7 | -9.6 |
| Stdev | 1.61 | 0.25 | Stdev | 1.83 | 0.23 |

(b) Rain water

The sampling of rain water was performed during the monitored storm event. The oxygen isotopic composition of rain waters were nearly constant around -12.0‰.

(c) Spring water

For the spring S-41, the oxygen isotope composition of spring water was changed from -10.5‰ at the beginning of the storm event through -10.7‰ to -10.1‰ at the end of the storm event. The spring S-45 showed the similar pattern, with a gradual decrease of the oxygen isotopic composition from -10.5‰ through -10.7‰ to -10.0‰.

3.3. Results of hydrograph separation

(a) Spring S-41

The obtained storm hydrographs were separated into two components (pre-storm water and rainwater) using oxygen isotope data. The results are shown in Figure 1. At the peak flow, rainwater accounted for approximately 42% of the instantaneous discharge. The greatest percentage of rainwater on hydrograph was found with a time lapse of about 24 hours after a maximum rain event. For the entire 5 days of monitoring, rainwater made up 38.67% of the total discharge.

(b) Spring S-45

The spring S-41 also showed a similar pattern: at the peak flow, rainwater accounted for approximately 25% of the instantaneous discharge; the greatest percentage of rainwater on hydrograph occurred after 16 hours from a maximum rain event; for the entire 5 days of monitoring, rainwater made up 34.12% of the total discharge.

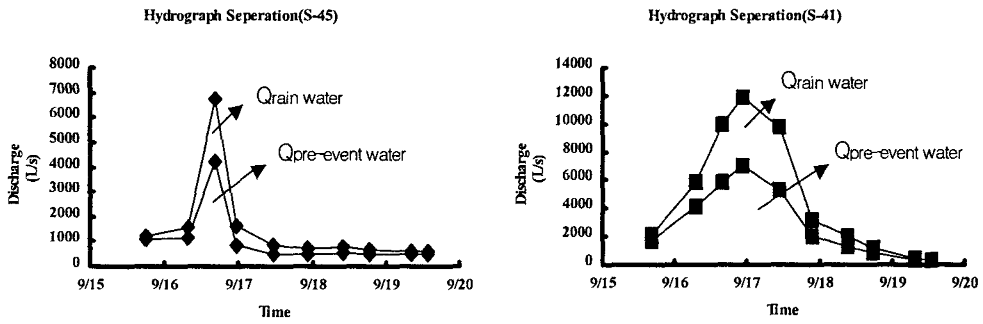


Fig. 1. The results of hydrograph separation for two springs

## 4. Conclusion

The two springs monitored for both discharge and oxygen water isotope showed a similar pattern in response to a storm event. The results of hydrograph separation indicate that the percentage of pre-storm water discharge during the storm event is larger than that of rainwater; total discharge percent of rainwater is only about 35%. However, the two springs showed a difference in time of peak discharge after the start of a storm event, suggesting their different hydrogeologic situation at subsurface. Possibly, the spring S-45 flow preferentially through more permeable conduits such as dissolution cave and doline.

The present study shows a successful applicability of isotopic tracers for evaluation of subsurface groundwater flow.

## 5. References

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