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BASEFLOW RETENTION TIME ESTIMATION ON THE BASIS OF WATER ISOTOPE COMPOSITION

J. URBANC
Geological Survey of Slovenia, Ljubljana, Slovenia

A certain information about groundwater dynamics can be obtained by observations of groundwater isotope composition during precipitation events (Rank & Papesch, 1997). However, under usual hydrogeological conditions, single precipitation events account for a rather small amount in the joint base flow reservoir. The consequence is that the changes in base flow isotope composition are very slight and therefore very difficult to measure.

Because of the above difficulties, the sampling period in our test was extended to approximately 6 months, a period in which isotope composition of water in the discharge mostly starts showing more distinct changes. Observations of oxygen isotope composition of ground waters under Slovenian climatic conditions show that the most negative $\delta^{18}O$ values are obtained in spring and the most positive values in fall (Pezdič et al., 1986, Stichler et al., 1997). On the basis of this data the observation period from spring to autumn was selected, a period when the largest deviations in outflow isotope composition can be expected. During this period, precipitation is enriched in the heavy oxygen isotope compared to the homogeneous isotope composition of water in the discharge.

The research approach was tested on two springs in central Slovenia with comparatively small recharge areas. The Hotenjka spring near Logatec has a recharge area with prevailing Upper Triassic dolomite rocks, and the recharge area of the Nadgorica stream near Ljubljana is built of Carboniferous and Permian clayey shale. In measuring the isotope composition of base flow it is difficult to ensure that the water sample contains base flow only and not also direct runoff, which of course has the composition of the latest precipitation. To avoid this, samples were collected only after a period of several days without precipitation, thus providing only base flow conditions in the outflow. The precipitation samples were decanted into a bigger container, so that finally a composite sample of precipitation over the entire observation period was attained. Results of isotope measurements are presented in the table:

Hotenjka

date	$\delta^{18}O$ stream (‰)	$\delta^{18}O$ precipit. (‰)
18.4.1997	-8.80	
10.10.1997	-8.70	-6.67

Nadgorica stream

date	$\delta^{18}O$ stream (‰)	$\delta^{18}O$ precipit. (‰)
14.3.1997	-8.55	
10.10.1997	-8.41	-5.86

The table shows a variation of only 0.1‰ in the isotope composition of waters from springs, in spite of the fact that precipitation in the observation period was enriched in the heavy oxygen isotope by over 2‰. The results lead to the conclusion that only a small amount of new precipitation water entered base flow reservoirs of both streams during the observation period, which indicates longer retention times of both reservoirs. Other part of infiltration water from the precipitation was discharged as direct runoff, which had not been influenced by base flow reservoir. At the beginning of observation period base flow reservoir had a homogeneous isotopic composition δ_0. During the observation period, a certain amount of new precipitation water entered the reservoir and was mixed with the old water. Because the new water originates from precipitation during the observation period it can be assumed that its isotope composition is approximately in correspondence with the cumulative isotopic composition of precipitation during the observation period. In this case the proportion of new water in the base flow reservoir can be calculated on the basis of equation 1:

$$V_n = \frac{(\delta_t - \delta_0)}{(\delta_n - \delta_0)} \qquad (1)$$

δ_t ... isotope composition of water in the outflow at the end of observation period

δ_0... isotope composition of old water in the base flow reservoir

δ_n ... isotope composition of new precipitation water

V_n ... volume of new precipitation water in base flow reservoir.

Solving equation 1 by using isotopic data for the Hotenjka ($\delta_0 = -8.8\ ^0/_{00}$, $\delta_n = -6.67\ ^0/_{00}$, $\delta_t = -8.7\ ^0/_{00}$), gives $V_n = 0.047$, hence only barely 5% of new water entered the base flow reservoir of the Hotenjka during the observation period. This means that under these conditions, approximately 8% of old water in the aquifer would be exchanged for new precipitation water during one-year period. Mean base flow retention times were calculated on the basis of this data: for the Hotenjka stream T = 12.2 years and the Nadgorica stream T= 11.1 years

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