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Use of spring recession curves for groundwater reservoir assessment in flysch areas (High Bieszczady Mountains, SE Poland)

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The groundwater storage capacity of the Outer Carpathians in Poland is believed to be low due to fast surface runoff and low retention rates of flysch areas. Moreover, flysch Carpathian areas are characterized by a large number of very small springs with discharge at less than 0.5 l s^{-1}, which are recharged by slope deposits, while large groundwater reservoirs are not to be found. However, hydrology condition research in the High Bieszczady Mountains (SE Poland, Outer Eastern Carpathians) revealed the presence of high discharge springs in the PoŁ onina Wetlińska Massif. The aim of the study was to characterize runoff variability of the springs and to assess the storage properties of groundwater reservoirs based on spring recession curves. The four selected springs are located on the northern slope of the PoŁ onina Wetlińska Massif at high elevations near the ridgeline (995–1,101 m a.s.l) and have small topographic catchment areas (<0.5 km^{-2}). Hourly discharge measurements for the springs were logged in the period 2012–2015 and hydrographs were created. Slopes of the recession curves of hydrographs (α – recession coefficient) were obtained on the basis of an exponential recession equation. Furthermore, the obtained recession curve parameters enabled a storage capacity and residence time assessment.

The selected springs were characterized by average discharge ranging from 3.1 to 9.9 l s^{-1} with maximum flow in April and May (under favorable meteorological conditions exceeding 30 l s^{-1}), whereas minimum flow occurs in September and October. Despite similarities in elevation, precipitation, and lithology in the studied drainage areas, we found substantial variation in the recession coefficients and groundwater reservoir parameters. Due to the magnitude of total precipitation and its frequency, spring recession curves usually cover less than 20 days. Analysis of falling limbs of the obtained spring hydrographs showed both fast and slow recession segments. The fast recession phase indicates shallow groundwater drainage, whereas the slow phase indicates outflow from a deeper and more capacious reservoir. The recession coefficients for both segments increase with the decline of spring discharge and topographic catchment area. The average storage capacity of groundwater reservoirs drained by the selected springs strongly varied in the small study area, and differences between the average storage capacity of adjacent catchments reached one order of magnitude ($5.5 \cdot 10^3$ to $5.3 \cdot 10^4$ m^3). Likewise, the mean groundwater residence time varied from 13 days to about 50 days depending on the volume of groundwater drained by the studied springs. Differences in discharge, recession coefficients, groundwater capacity, and residence time for the studied springs were related to recharge areas of different size. Simple relationships between the topographic catchment areas of springs and their hydrologic parameters can become altered by local structural features such as faults and fissures. Tectonically-produced structures may facilitate a larger supply of groundwater and the occurrence of high-discharge springs in a given area.