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Stream Depletion in Variably Saturated Hyporheic Zones

Yunjung Hyun[1*] · Kang-Kun Lee[1] · Yoon Young Kim[2]

[1]*School of Earth and Environmental Sciences, Seoul National University, Seoul, 151-742, Korea*
[2]*Industrial Management Institute, Chung-Ang University, An-Seong, 456-756, Korea*
E-mail: yjhyun@snu.ac.kr

ABSTRACT

The interaction between stream and groundwater flow has been recognized as one of important subjects to environmental scientists due to its significant implications to biogeochemistry, ecology, and water resources management. Consequently, water exchanges between streams and aquifers have been quantified with the hydrologic concept of stream depletion for analyzing the hydrologic processes in the areas where the stream interacts with groundwater in the adjacent aquifer (Fox and Durnford, 2003; Bruen and Osman, 2004). This area is called a hyporheic zone. Hyporheic zones are variably saturated depending on the hydraulic connection between stream and groundwater flow. The variation of saturation may change the characteristics of flow, influencing stream depletion rates. For a disconnected stream, it is obvious that stream depletions are dependent on to which degree the underlying aquifer is saturated. The objective of this paper is to assess stream depletion rates affected by various hydrologic conditions and analyze the sensitivity of stream depletion to aquifer properties in variably saturated hyporheic flow. First, we analyze the stream-aquifer interaction and quantify the stream depletion rate for variably saturated hyporheic flow. Next, the sensitivity of stream depletion is investigated with respect to aquifer properties in the variably saturated zone. In this study, a simple hypothetic stream-aquifer flow system is considered with a stream, with a semi-pervious streambed, partially penetrating an alluvial aquifer. Numerical modeling is performed with the variably saturated modeling program, MODFLOW-SURFACT. For sensitivity analyses, the hydraulic conductivity of the aquifer, the thickness of streambed, and aquifer

anisotropy are considered. Results show that hydraulic conductivity makes a most influence on the stream depletion regardless of saturation. For unsaturated hyporheic flow, the stream depletion is more sensitive to the streambed thickness than anisotropy under intermediately unsaturated conditions; it is more sensitive to anisotropy than the streambed thickness under highly unsaturated conditions.

Key words: Stream depletion, Hyporheic, Variably saturated zones, Anisotropy

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