

The representativeness of water samples from the outlet of flowing wells in an unconfined aquifer

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The representativeness of a groundwater sample is often confused by the mixture of groundwater from different depths of a well, especially when length of well screen is long. In a basin where groundwater flow is driven by topography, a well without casing could become a flowing well in topographic lows as long as the well is drilled deep enough. In this case, a water sample could be easily collected at the outlet of the flowing well without pumping. A recent field study in the Ordos basin shows that groundwater samples from the outlets of flowing wells with different depths differs greatly in chemical components. For the flowing wells penetrates to the deep part of the basin with depths ranging between 700 m and 970 m, it was found out that the concentrations of most chemical components of waters sampled at the outlets increases significantly with well depth. However, the hydraulic mechanism of the well depth-dependent hydrochemistry of mixed water sample is not clear.

In this study, a 3-D unit basin expanded from Tóth's classic 2-D unit basin model was adopted to study the origin of water from different depths and the representativeness of water sampled at the outlet of a flowing well. The flowing well was modeled by the revised multi-node well (MNW2) Package in MODFLOW by setting a limit head equaling to the land surface and specifying an artificially high discharge rate. By considering well loss, we found the zone with development of flowing wells is smaller than the zone with positive values of head exceeding land surface. As long as the water table is a subdued replica of the land surface, the deep part of the flowing well receives discharge from the aquifer, while part of groundwater in the shallow part of the flowing well returns to the aquifer. The boundary between groundwater inflow and outflow is found to be sensitive to the ratio of water table to land surface, the distance away from the valley and the depth of the flowing well. In the segment of groundwater inflow to the flowing well, it was found that the flow rate is the highest in the deepest point and decreases from the deep to the shallow. Therefore, most water collected at the outlet of the flowing well comes from the deep part of the inflow segment.

By assuming that the concentrations of chemical components in the aquifer remain unchanged before and after digging wells and the mixture of chemical components only happen in the inflow segment, the water sample at the outlet of the flowing well could represent the groundwater in the deep part of the flowing well. Moreover, for the wells drilled a little deeper than the upper boundary of the zone with development of flowing wells, the chemical components of groundwater sampled at the outlet of the flowing well are close enough to that from the bottom of the flowing well.