Arsenic variations induced by groundwater extraction in the Hetao basin, Inner Mongolia

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High As groundwater has widely been found in the world. Spatial-temporal variations of groundwater As are not only connected to natural conditions, but also related to anthropogenic activities, especially groundwater extraction, which may endanger the drinking water resources. Mechanisms of extraction-induced As variations in groundwater are not fully understood. Intensive investigation of groundwater As and dissolved organic matter was carried out in the western part of the Hetao basin, where extensive extraction of deep groundwater has been carried out for decades. Results showed general increasing trends in groundwtater As, Fe, and NH_4^+, and decreasing trends in groundwater ORP, NO_3^-, and SO_4^{2-}/Cl^- along the flow path. Deep groundwater extraction increased As concentrations in the flat plain, while slightly decreased deep groundwater As in the distal of alluvial fans. The increase in As concentration resulted from the change of groundwater recharge from the alluvial fans to the surface water with labile organic matter. In addition, extraction induced vertical mixing of shallow groundwater into transition groundwater, and changed As concentrations in transition groundwater and deep groundwater. The proportion of recharge from shallow groundwater to transition aquifer was up to 53% in the alluvial fans, which increased to 86% in the flat plain. In the flat plain, the increases in As contrations in transition aquifer resulted from both the recharge of shallow high As groundwater and the introduction of labile organic matter triggering reductive dissolution of Fe(III) oxides. It was shown that surface water and shallow groundwater had more organic matter with high bioreactivity. In the distal of alluvial fans, the decrease in As concentrations in transition aquifer contributed to the recharge of oxygen-containing shallow groundwater, which oxidized Fe^{2+} and scavenged As in oxidation product of Fe oxides. This investigation provides an insight into mechanism of As variations in groundwater induced by intensive extraction.