Estimation of the groundwater recharge processes using end-member mixing analysis in a paddy-dominated alluvial fan, Japan

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The Tedori River Alluvial fan in central Japan has abundant groundwater resources, serving as sources of the regional drinking and industrial water. The study area is bounded by the Kakehashi River to the south, the Sai River to the north, the Japan of sea to the west, and the mountains to the east. The rice paddy and crop-rotated paddy fields occupy 45% of its total area (170 km^2). The paddy plots are irrigated from the early of May to end of August. Highly turbid water was observed in early of May 2015 and has been continued for a while. This is due to a large-scale landslide occurred at 60 km upper mountainous area from the river outlet. The landslide area has 150 m length 300 m width. Decrements of groundwater level occurred in both 2015 and 2016. The durations with the low groundwater levels were about 6 months in 2015 (from the early of May to the early of November) and 2016 (from the middle of March to the middle of September). Large decrements was observed in the middle section along the Tedori River. From the non-irrigation period, groundwater level raise up to the previous water level before the turbidity accident. Mechanisms of these groundwater fluctuations and the relationship between the groundwater decrements and turbid river water were absolutely not clear. Our study objective is to identify the mechanisms of the changes by the observations of spatial distributions and its temporal changes of groundwater qualities.

We collected 57 water samples including 33 shallow groundwater, 1 deep groundwater, 1 spring water, 11 river water along three rivers, 1 precipitation, and both of paddy irrigation water and standing water at 6 paddy plots during the irrigation period. Water sampling has been conducted with 2 months interval from April 2016. We analyzed stable isotope ratios of hydrogen, oxygen, and strontium and concentrations of major dissolved ions. We had carried out similar water samplings and analysis 4 times from 2008 to 2011. In this area, water samples from the Tedori River show the lowest oxygen and hydrogen isotope ratios and precipitation water samples show the highest. The paddy infiltration water samples show the influence of evaporation. Then, end-member mixing analysis (EMMA) were performed to estimate the contributions of each groundwater source for oxygen and hydrogen isotope ratios of shallow groundwater samples. We compared the EMMA results from the view point of temporal changes in contributions rates.

During the irrigation and non-irrigation period in 2016, groundwater recharge from the Tedori River contributed water balance of the shallow groundwater throughout the alluvial fan. In 3 km buffer area along the river, contributions of the river water ranged from 18% to 97%. Large contributions (over 60%) were calculated around the lower part of the fan. From the comparison between June in 2011 and June in 2016, contributions of river water decreased at the left side of the river, but did not significantly change at the right side. At near the right bank of the Tedori River, contributions of infiltration water from the irrigated paddy fields decreased and contributions of precipitation increased to compensate for it. Turbid water might cause siltation at paddy fields because the irrigation water is derived from the Tedori River. Groundwater recharge from the irrigated paddy fields would be reduced due to the siltation. Future work of this study is quantitative evaluations of groundwater recharge processes by a transient groundwater modeling.

Keywords: shallow groundwater, alluvial river, oxygen and hydrogen isotopes, groundwater level

