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Hydrological Responses to Vegetation Restoration in Fine Temporal Scale in a Catchment on the Loess Plateau, China.

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The implementation of “Grain for Green” program since 1999 in China resulted in a great land use/cover change on the Loess Plateau, China, which fundamentally influenced hydrological cycle and then streamflow-sediment transportation behavior. It is important to fully evaluate the characteristics of the trends of streamflow, sediment discharge and their behavior in the fine temporal scale in the seriously eroded area in the world. A typical hilly-gully catchment, the upper reaches of Beiluohe river, was selected to investigate the hydrological responses to LUCC and their driving forces. The daily and events data of streamflow and sediment load were used from 1963 to 2009. The nonparametric Mann-Kendall test and Pettitt test were employed to identify trend and change point in the streamflow and sediment load records. Both the streamflow and sediment load had a significant negative trend ($P<0.01$) with the annual rate of -0.31 mm.a-1 and -0.24 x 103 t.km-2.a-1. And the change points of 1980 and 2002 were detected for both steamflow and sediment load ($P < 0.05$). Compared to the period 1 (1963 to 1979), the high (5%) and median (50%) percentile flow decreased with -17.0%, -5.2% in the period 2 (1980 to 2002) and -40.2%, -26.8% in the period 3 (2003-2009). While the low (95%) flow dramatically increased with 94.2%, 128.1%, respectively, in the latter two periods. The sediment load in high and median percentiles reduced with -34.6% and -40.1% in period 2 and further to -95.7% and -96.8% in period 3. The number of zero-sediment load days increased period by period. The streamflow-sediment behavior in the basis of monthly data in the rainy season showed a “clockwise loop” and the magnitude and width of the loop decreased period by period especially in period 3 which was characterized with a 10 years’ vegetation restoration. A power function could be fitted well to the relationship of daily flow and sediment load. And the constant in the equation during the three periods showed a decreasing trend with a reduction of -2.0% in period 2 and -57.3% in period 3, while the power index an increasing trend with 0.9% in period 2 and 14.0% in period 3. Compared to the period 1, the annual mean frequencies of the flood events showed a decreasing trend by -28.6% in period 2, and -6.0% in period 3. The annual mean of the max flood peak and the max sediment load also decreased by -26.63% and -13.74% in period 2 and -76.26% and -35.76% in period 3. The frequencies of the flow peak which occurred early the sediment peak in the flood process increased by 3.64% in period 2 and 30.38% in period 3. And the frequencies of the flow peak which lagged behind the sediment peaks reduced by -12.47% in period 2 and -26.4% in period 3. The double mass curve and empirical formula were used to evaluate the driving forces of hydrological responses in the catchment and found that human activities like the implementation of soil conservation measures and “Grain for Green” project was the major reason for the changes of streamflow and sediment load in the later two periods.

Key words: Trend, Relative change, Relationship of Streamflow and sediment load; Fine temporal scale, Vegetation restoration; Loess Plateau.