Concentrations and fluxes of dissolved uranium in the Yellow River estuary: seasonal variation and anthropogenic (Water-Sediment Regulation Scheme) impact

Sui Juanjuan*a, Zhigang*ab, Bochao*ab, Wenhuan*c, Dong*ad, Xiaoyan*ab

Introduction
Naturally occurring uranium-series nuclides have been used extensively as tracers and chronometers in many geological, geochemical, and oceanographic studies. The Loess Plateau is the most physically eroded region in the world, making the Yellow River the most turbid major river in the world, second only to the Ganges-Brahmaputra system in terms of sediment transport. In order to ease the situation of the lower river channel and to transport the sediment deposited in the Xialangdi Reservoir (XLD, Fig. 1) as well as the sediment derived from the channel erosion to the sea via floodwater, the Yellow River Conservancy Committee (YRCC) began to implement the Water-Sediment Regulation Scheme (WSRS) in June 2002. According to the principle of the WSRS of 2010, it can be divided into two stages: (1) floodwaters released from XLD accreted the riverbed sediment deposited in the lower reaches of the Yellow River; (2) muddy flow containing sediments of scoured the riverbed sediment deposited in the lower reaches of the Yellow River via floodwater, the Yellow River (XLD, Fig. 1) as well as the sediment derived from the channel erosion to the sea via floodwater, the Yellow River. The Water-Sediment Regulation Scheme in June 2002 was the first attempt to evaluate the effect of the WSRS on concentrations in different seasons of 2010 was described. The percentages of total river water discharge, sediment load and dissolved U during the period of the WSRS was 25.3%, 45.3% and 25.5%, respectively. The WSRS in the Yellow River is an important period for dissolved U transport. The WSRS in the Yellow River is an important period for dissolved U transport.

Methods
- Uranium analyses followed the procedures of Luo et al. (1987) and Ku et al. (1998) with minor modifications. U was measured with a α-spectrometer.
- Laboratory simulation experiments
- Wet sediment samples
- Yellow River water
- Zhengzhou: 129 g
- Jinan: 140 g
- Xialangdi: 528 g
- 101 filtrated water
- Equilibration with electric stirring for 24 h
- Filtration through a 45 µm filter
- Determination of dissolved U by α-spectrometry

Study Area
Fig. 1. Map of the Yellow River, showing the Xialangdi reservoir (XLD) and the sampling site. The shaded area represents the Chinese Loess Plateau (after Gu et al., 1997). *The yellow color represents the Huang He River system in China.

Results and Discussion
Seasonal variation of dissolved U concentration
Fig. 2. Monthly variations of U, 234U/238U, water discharges and suspended sediment at Station Zhengzhou.

Variability of dissolved U concentrations and 234U/238U activity ratios influenced by the WSRS
Fig. 3. Daily variations of U, 234U/238U, water discharges and suspended sediment at Station XLD during the WSRS.

Leachable U from the suspended sediment
Table 1. Results of simulation experiments.

Coarse particles on the riverbed of the lower reaches were stirred up by the flushing water in the first stage of the WSRS. The fine suspended sediments were mainly from the XLD eroded by artificial hypopycnal flow in the second stage.

Annual U flux from the Yellow River to the sea
Fig. 4. U vs. water discharge and U vs. suspended sediment.

The results of the laboratory experiment indicated that (1) a significant U removed from particle to the river waters after stirring for 24 h. (2) The 234U/238U activity ratios of leachable U from sediments was calculated.

Zhangzhou: 1.57, Jinan: 1.48, XLD: 1.03.
(3) The high 234U/238U activity ratios of Zhangzhou and Jinan may come from weathering of sediments exposed to the air during the dry season. While the sediments submerged in the bottom of XLD may show little isotopic fractionation.

Acknowledgements
This study was funded by the Natural Science Foundation of China (NSFC grants 40976044, 41376085 and 41206064), and the Natural Science Foundation of Shangdong Province (No. ZR2011DM010).