The integrated use of stable isotopic and CSSI fingerprinting techniques to identify the sources of N pollutant in surface water and sediment in an agricultural catchment, north China

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INTRODUCTION

- The intensive farmland in north China accounts for more than 17% of China's arable land, which is main wheat and corn production area in China.
- Consequently, excessive use of chemical fertilizers and pesticides, as well as rural household waste, are the environmental problems in this region.
- How the surface water quality responses to large scale of intensive agricultural activities in north China remains unclear.

The study aims to identify the sources of nitrogen (N) pollutant in the surface water and to understand the contributions of different land use types to sediment at catchment scale.

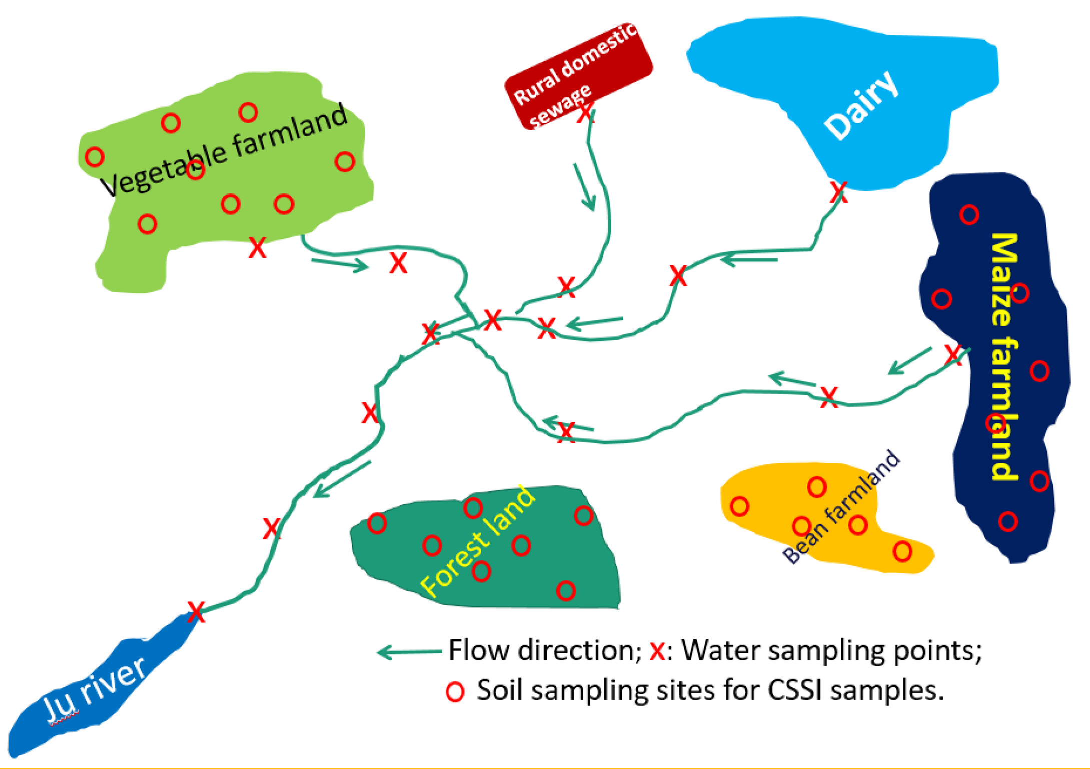
MATERIALS AND METHODS

➢ **Study Site**

- Jiangou Catchment (2.1 km^2) located in north China where is the China's main wheat and corn production areas (40° 5'N, 116° 57'E). The mean annual rainfall of this area is 656 mm that mainly occurs from June to August. Forest, maize/wheat, vegetable, and rural village including a cattle farm were the four main land-use types in the upstream of the catchment, and downstream of it was Ju River.

➢ **Sampling strategy**

- Water samples were collected at the 5 monitoring sites: maize farmland representing chemical fertilization, vegetable farmland representing organic fertilizer, dairy representing excrements of livestocks and village representing domestic sewage where discharged into Ju river, and outlet of Jiangou catchment from July to August 2019. Totally 15 water samples were obtained with three samples in each land type and outlet.
- Surface soil samples (top ~2 cm) were obtained from different land use type (sources). ~10 subsoils for each source (forest, farmlands with different vegetables and crops) and sediments and mixed into a composited soil sample for each site. Every composited sample has 5-8 replications. Totally 27 source samples and 5 sediments were achieved.



➢ **Measurement and analysis**

- The compound specific stable isotope (CSSI) analysis for soil samples and stable isotopic ($\delta^{18}O$, $\delta^{2}H$, $\delta^{15}N$-NO_3 and $\delta^{18}O$-NO_3) analysis for surface water were measured by GC-IRMS.
- Source proportion of N pollutant in water body and sediment of Jiangou catchment estimated by isotopic mixing model IsoSource (Phillips and Gregg, 2003).

RESULTS

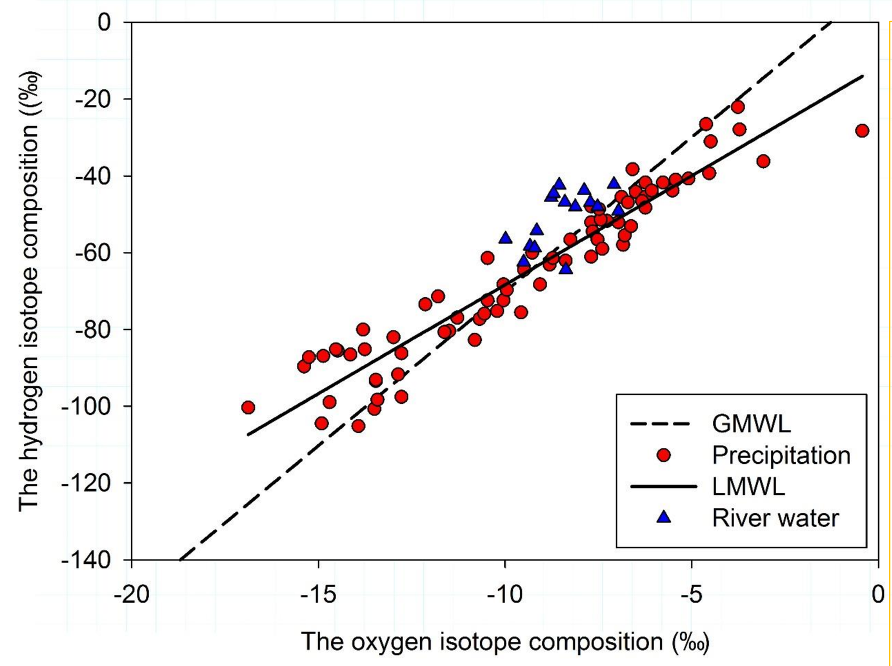


Fig.1 The relationship between isotopic ratios in precipitation and soil water

- The $\delta^{18}O$ and $\delta^{2}H$ values of collected water samples along the Ju river, were ranged from -7.72 ~ -9.33‰ and -43.76 ~ -58.74‰, respectively, which were in the LMWL range of $\delta^{18}O$ (-19 ~ -1‰) and $\delta^{2}H$ (-144 ~ -20‰) in this area.
- The results suggested that the water source of these samples dominantly came from the local precipitation.

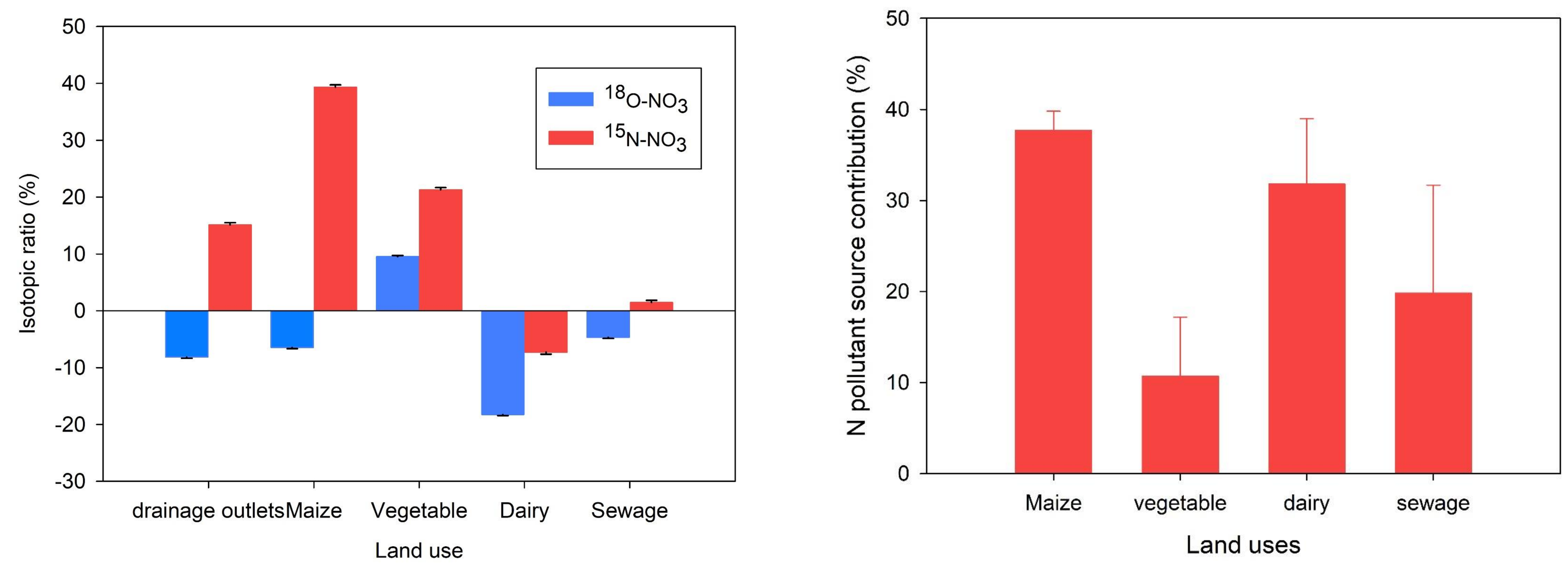


Fig.2 Source contribution of N pollutant in water body of Jiangou catchment identified by $\delta^{15}N$-NO_3 and $\delta^{18}O$-NO_3 data using IsoSource model

- Chemical fertilization from maize farmland (38±2%) and excrements of livestocks from dairy (32±7%) were the dominant nitrate pollutant sources in the water body.
- 20±11% and 11±7% were attributed to discharge of manure from vegetable farmland and rural domestic sewage from village, respectively.

Table 2 Measured soil C, bulk ^{13}C and $\delta^{13}C$ in soil fatty acids from specific land uses in Yangjuangou catchment

Land use	Bulk C-13	C%	C14:0	C16:0	C18:0	C20:0	C22:0	C24:0	C26:0	C28:0	C30:0
Maize	-20.58	0.65	-24.74	-24.21	-23.30	-29.16	-30.77	-30.38	-30.62	-32.17	-32.35
Bean	-24.78	1.14	-25.27	-25.56	-23.46	-27.65	-31.98	-33.63	-31.76	-33.42	-33.48
Vegetable	-21.53	1.23	-25.44	-24.32	-23.39	-23.81	-24.67	-26.46	-29.49	-33.24	-33.45
Forest	-23.98	1.59	-27.09	-27.41	-24.90	-31.59	-31.68	-34.20	-35.62	-35.49	-34.04
Sediment	-21.89	0.94	-26.98	-28.06	-25.11	-28.18	-30.19	-30.76	-30.54	-31.94	-33.98

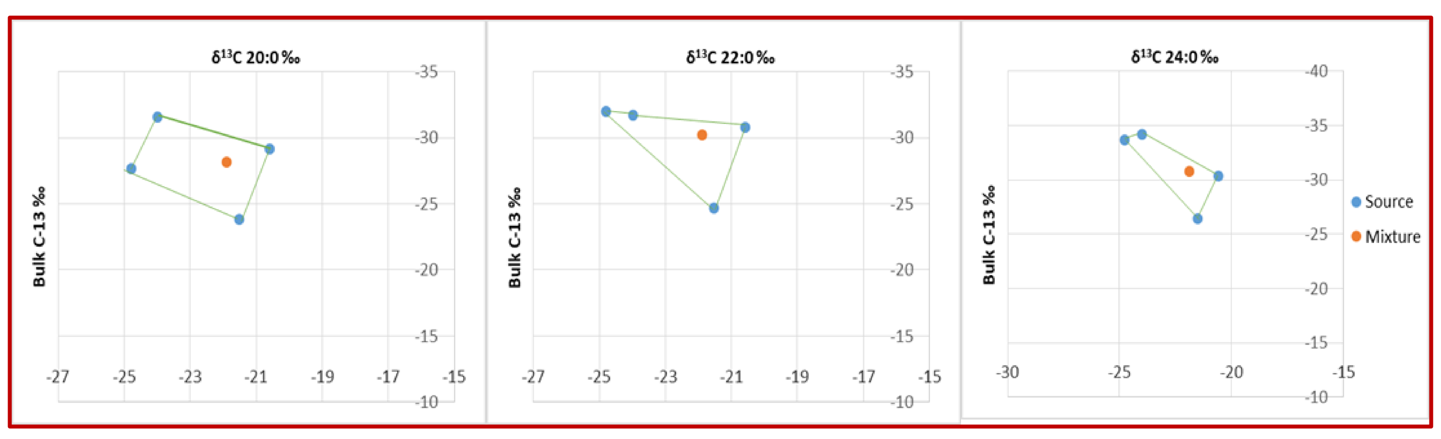


Fig.3 Mixing polygons of selected FAs contributing to the mixture

The sediment source was mainly derived from maize farmland which contributed by 71±8 %, the followed were bean and vegetable farmlands which accounted for 14±6% and 10±3%, respectively, and least contribution from forest land (5±2%).

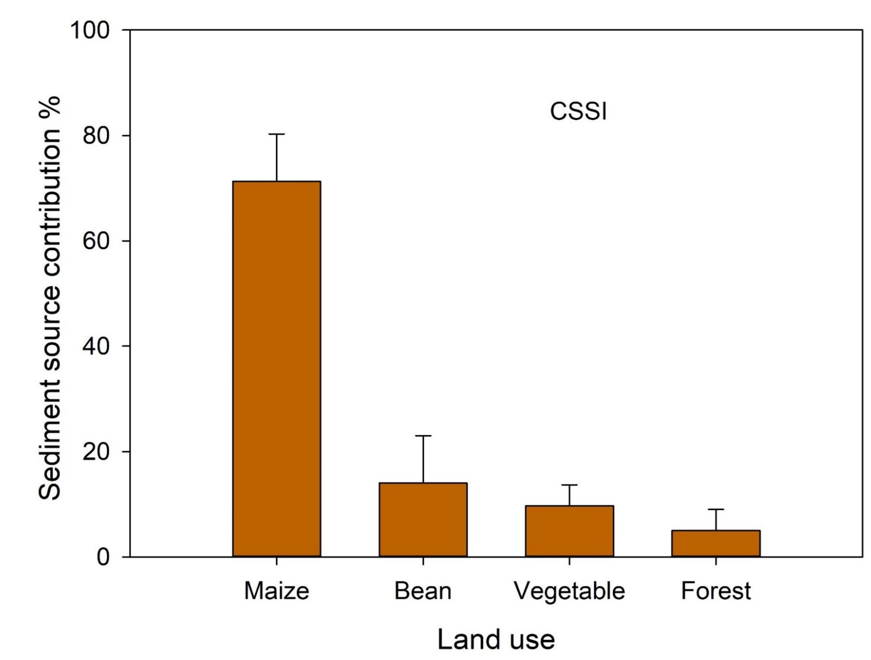


Fig.4 Sediment source contribution of Jiangou catchment identified by FRN and CSSI techniques

CONCLUSIONS

➢ Chemical fertilization from maize farmland, excrements of livestock from dairy and manure from vegetable farmland were the dominant nitrate pollutant sources in the water body. The sediment source was mainly derived from maize farmland, the followed were bean and vegetable farmlands.

➢ The combined use of CSSI fingerprinting and stable isotopic techniques could quantitatively identify the source contribution of N pollutant in surface water and sediment in the catchment, which is critical to the assessment and implementation of optimised agricultural and land management practices.