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# Effects of natural rainfall on soil and nutrient erosion on sloping cropland in a small watershed of the Dan River, China

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ABSTRACT

Soil erosion and nutrient loss are two important aspects influencing crop production and water quality in the Dan River. In this study, a field experiment was conducted in the Yingwugou Watershed. A corn field of slope 23° with an area of 243 $m^2$ was selected to study the spatial variability of soil properties for cropland and to determine the loss amounts of soil total nitrogen (STN), soil total phosphorus (STP), soil organic carbon (SOC) and silt–clay under natural rainfall. Geostatistical analysis indicated that generally STN, STP, SOC and silt–clay had strong spatial dependence (with nugget ratio <25%) primarily induced by structural factors. Kriging successfully interpolated the studied soil properties. There were some intrinsic relationships among STN, STP, SOC and silt–clay. The effect of rainfall on the spatial autocorrelation for STN and STP was more significant than that for SOC and silt–clay. Natural rainfall had a weak effect on SOC. The total loss of STN, STP and silt–clay in the sloping corn field decreased by 348.7 g, 2640.4 g, and 0.47% during the study period, respectively. The results provide useful information for understanding the nutrient loss and soil erosion on sloping cropland.



## 1. Introduction

Soil organic carbon (SOC) plays an important role in enhancing crop production and mitigating greenhouse gas emissions. In agricultural ecosystems, soil total nitrogen (STN) and soil total phosphorus (STP) are major determinants and indicators of soil fertility and quality, and are closely related to soil productivity. In environmental science, nitrogen (N) and phosphorus (P) are the main non-point source pollutants of surface water and groundwater. The reduction of STN and STP levels can result in decreases in soil nutrient supply, fertility, porosity, penetrability and consequently soil productivity (Wang et al., 2009). The serious soil losses from sloping land can damage cultivated land resources, reduce land productivity, and threaten the security of territory and grain. Additionally, soil erosion results in a large amount of sediment and organic pollutants entering rivers, lakes and dams, thus increasing risks of flood disaster and non-point source pollution (Hua et al., 2010).

Rainfall has a great effect on soil fertility, especially in the top layer of soil, because typically nutrients and soil erosion are concentrated in the top few centimeters of soil. Soil properties can also be altered over time by rainfall and soil erosion, inducing spatial variability of soil fertility along the slope and possibly modifies the soil profile (Oztasa et al., 2003; Papiernik et al., 2005; Su et al., 2010). Soil erosion during rainfall is strongly affected by runoff and slope steepness. Runoff production is drastically increased when a seal is formed at the soil surface during rainfall (Assouline and Ben-Hur, 2006). Therefore, it is urgent to evaluate soil erosion and erosion-induced depletion of soil nutrients and reduction of crop production, so as to understand the process of nutrient loss and soil erosion due to rainfall and to establish sustainable soil management practices to prevent further soil degradation.

The Dan River originates from Shangzhou in Shaanxi province, with a drainage area of about $1.68 \times 10^4$ $km^2$ and a length of 443 km. It is the water source area of the middle route of the South to North Water Diversion Project. The project seeks to promote Northern China's economic growth by relaxing water constraints in

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a region now facing severe water shortage (Feng et al., 2009; Jiang, 2009; Xu et al., 2013). However, water quality is severely degraded in the central route, which partly results from serious uncontrolled agricultural non-point source pollution. Increased fertilizer application have contributed large amounts of nutrients to downstream water bodies (Liu and Qiu, 2007), resulting in very poor water quality in the main rivers. Accordingly, water pollution control is vital for success of the central route. Soil erosion and nutrient loss are two important aspects influencing water quality. However, few studies have studied soil erosion and soil nutrient loss on sloping cropland under natural rainfall. Furthermore, there have been almost no studies investigating the spatial distribution of soil nutrients and the spatial variability of soil nutrients after a series of natural rainfalls on sloping cropland. In this study, we studied the distribution of STN, STP, SOC and silt–clay and their spatial variability after a series of natural rainfalls on sloping cropland using geostatistics theory. The purposes of the study were to (1) analyze the soil erosion and the distribution of soil nutrient on sloping cropland in the water source area of the South-to-North Water Diversion Project and (2) study the spatial variability of soil nutrient and the amount of soil nutrient loss on sloping cropland under natural rainfall.

## 2. Materials and methods

### 2.1. Description of study area

The Dan and Han Rivers in southern Shaanxi are the main water source region of South-to-North Water Diversion Project. The sloping farmland of the region mainly has slopes of 15–25° and corn is one of the main crops (Chen et al., 2011). The study was conducted in Yingwugou watershed (33°31′23″–33°30′35″N; 110°53′38″–110°55′18″E), located 2 km southeast of Shangnan County, Shaanxi Province, China (Fig. 1). The watershed has an altitude of 427–1156 m, and covers an area of 3.34 km$^2$. It has a warm and semi-humid monsoon climate, with average annual temperature of 14 °C. The average annual sunshine each year is 1974 h and the mean annual frost-free period is 216 d. The average annual precipitation is 814 mm with 50% occurring in July–September. The topography of this area is characterized by low mountains and hills, and soil types are typically yellow brown soil and sandy soil. The parent rock material is granite-gneiss and limestone. The major arboreal vegetation is pine (*Pinus tabuliformis* Carr.) and robur (*Castanea mollissima* Blume.). The dominant crops are peanut (*Arachis hypogaea* L.), corn (*Zea mays* L.) and wheat (*Triticum aestivum* L.). The land use types investigated were mainly woodland, farmland, and grassland. These plots have been under their present land use for at least 10 years.

### 2.2. Soil sampling and analysis

The total rainfall in September 2011 was 312.8 mm in southern Shaanxi, which was the greatest precipitation in the same period since 1961. Similarly, total rainfall in September 2011 was 306 mm (Fig. 2) in Yingwugou watershed, which was also the greatest since 1961. This provided good conditions for our research. The research was corn field of slope 23° and the soil type was yellow brown soil (Haplumbrepts). The first soil samples were collected on 26 August 2011 and the last on 30 September 2011. The first soil samples were termed L1 in 26 August and soil samples taken after the 306 mm of natural rainfall in September were termed L2. There was no anthropogenic influence on the land between the first and last soil samples. Because there were drains around the corn area, the adjacent plots had no effect on it in terms of runoff.

Soil sampling points were derived from 3 m × 3 m grids (Fig. 1). At each site, within a radius of approximately 30 cm, five separate sub-samples were taken from the upper 5-cm soil layer using a cylindrical metal core of height 5 cm and volume 100 cm$^3$. Sub-samples were mixed together as the representative soil

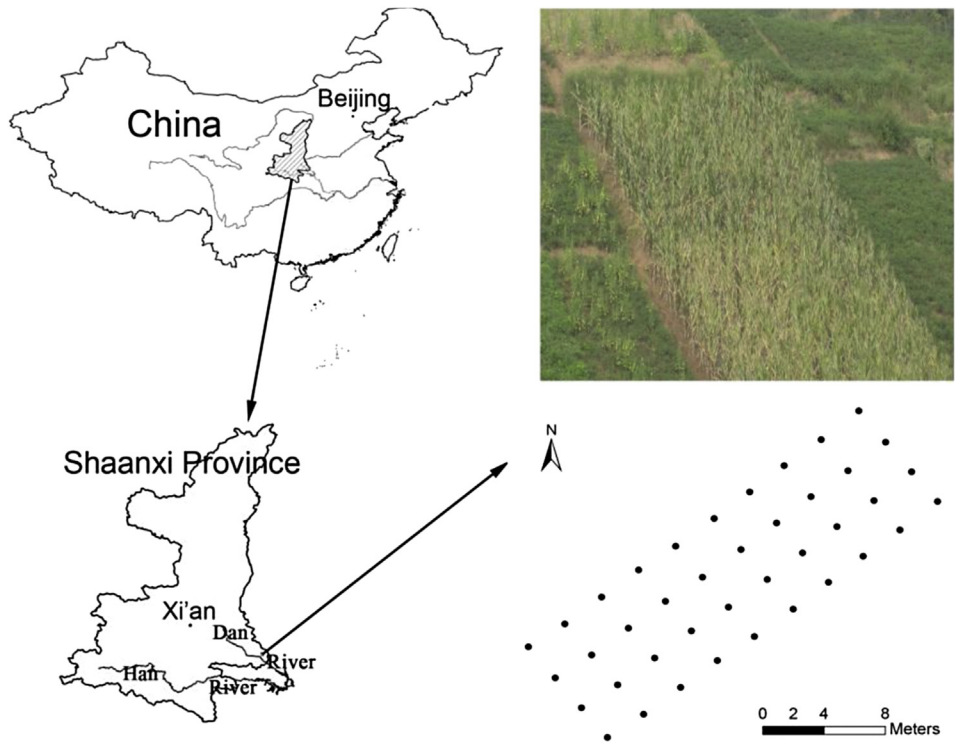


**Fig. 1.** Location of the study area.

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