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Distribution Characteristics of Soil Total Nitrogen and Total Phosphorus under Different Land Use Types in the Loess Hilly Region

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Abstract

Land use change is a key factor driving changes in Soil total nitrogen (STN) and Phosphorus (STP) around the world. We investigated the variations of STN and STP under different land uses (cropland, jujube orchard, 7-yr-old grassland and 30-yr-old grassland) on hillslopes in the Yuanzegou watershed of the Loess Plateau in China. The results showed that the variation coefficients of STN and STP moderately variable, the variation coefficients of STN and STP stocks high variable. land uses significantly ($p<0.05$) influenced the distribution of STN and STP concentrations and stocks in surface layer (0-20cm) but not subsurface layers (20-60cm). The results provide insights into STN and STP dynamics following land use changes.

Keywords

Loess Hilly Region; Land Use; STN&STP.

1. Introduction

Soil total nitrogen (STN) and phosphorus (STP) are two major elements influencing both plant growth and global biogeochemical cycles[1-2]. In terrestrial ecosystems, STN and STP play important roles by affecting soil properties[3], plant growth[4], and soil microbial activities[5]. In agricultural ecosystems, STN and STP are the major determinants and indicators of soil fertility, which are closely related to soil productivity. The reduction of STN and STP levels can result in a decrease in soil nutrient supply, fertility, porosity, penetrability, and, consequently, in soil productivity[6].

The Loess Plateau of North China is famous for its deep loess, unique landscapes and intense soil erosion[7]. In 1999 a large-scale ecological engineering program called "Grain for Green" was initiated to control serious soil erosion there by the central government of China. Since then, the type of land use has changed. Estimating soil N and P content under different land uses can help evaluate the impact of patterns of land utilization conversion on soil N and Preserves[8-9].Thus, the primary objectives of this study were to assess STN and STP in shallow layerwith different land use types.

2. Materials and Methods

2.1. Study Area Soil Sampling

The study site is located in the Yuanzegou watershed (37°150′N, 110°210′E) at the center of the Loess Plateau. In April 2015, a total of 55 sampling locations were established randomly in

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the watershed: 17, 17, 11 and 10 in cropland, jujube orchard, 7-year-old grassland and 30-yearold grassland areas, respectively. At each location, a hand auger (40-mm diameter) was used to collect soil samples at 20cm intervals within the 0~60cm layer at three neighboring points.

2.2. Calculations

The stocks of STN and STP were calculated using the following equation [10]:

$$STNS_i = D_i * BD_i * STNC_i * \frac{1}{100}$$

$$STPS_i = D_i * BD_i * STPC_i * \frac{1}{100}$$

Where STNS and STPS are the stocks of STN and STP ($kg \bullet m^{-2}$), respectively, i is the ith soil layer, D is the soil layer thickness (cm), BD is the bulk density ($g \bullet cm^{-3}$), and STNC and STPC are the concentrations of STN and STP ($g \bullet kg^{-1}$), respectively.

2.3. Study Area Soil Sampling

Summary statistics comprising the minimum, maximum, mean, and coefficient of variation (CV) were calculated for the datasets. One-way analysis of variance was used to analyse effects of land uses on STN and STP concentrations and stocks.

3. Results

3.1. Summary Statistics for STN and STP

As shown table 1, the concentrations of STN and STP ranged from 0.097 $g \bullet kg^{-1}$ to 0.348 $g \bullet kg^{-1}$, and from 0.400 $g \bullet kg^{-1}$ to 1.192 $g \bullet kg^{-1}$, respectively; and the stocks of STN and STP ranged from 0.030 $Mg \bullet ha^{-1}$ to 0.180 $Mg \bullet ha^{-1}$, and from 0.109 $Mg \bullet ha^{-1}$ to 0.861 $Mg \bullet ha^{-1}$,respectively too. The variation coefficients of STN and STP ranged from 17.4% to 24.0% and 14.6% to 18.5%, respectively, thereby indicating moderately variable. The variation coefficients of STN and STP stocks ranged from 33.4% to 44.2% and 41.7% to 47.0%, respectively too, thereby indicating high variable. Except for cropland, the variation of STN concentrations and stocks in other land use were higher than that of STP.

3.2. STN and STP Concentrations and Stocks Across Land Uses

The STN concentrations found under each of the land uses in the shallow profiles are shown in Fig. 1a. Generally, they declined with depth and were significantly higher ($P<0.05$) in the surface layer (0-20 cm) than in subsurface layers (20-60 cm) under each land use. In addition, as shown in Fig. 1c, STNS also declined with depth and were significantly higher ($P<0.05$) in the surface layer (0-20cm) than in subsurface layers (20-60cm) under 30-year-old grassland and jujube orchard. However, as shown in Fig 1b and 1d, the change of STP and STPS with soil depth is not obvious in each land use type.

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Table 1. Statistics for the STN and STP levels under indicated land uses

Land use	Variable	min	max	mean	sd	cv/%
Grassland (30yr)	STN	0.118	0.348	0.231	0.054	23.2
	STP	0.608	1.192	0.935	0.138	14.7
	STNS	0.031	0.085	0.059	0.012	20.1
	STPS	0.159	0.317	0.241	0.038	15.6
Grassland(7yr)	STN	0.114	0.221	0.162	0.032	19.9
	STP	0.630	1.112	0.884	0.129	14.6
	STNS	0.029	0.056	0.041	0.008	19.1
	STPS	0.159	0.287	0.228	0.034	15.1
Jujube orchard	STN	0.097	0.294	0.194	0.047	24.0
	STP	0.439	1.001	0.761	0.137	18.0
	STNS	0.026	0.078	0.051	0.013	24.9
	STPS	0.113	0.266	0.200	0.036	18.1
Cropland	STN	0.109	0.243	0.182	0.032	17.4
	STP	0.400	0.818	0.539	0.100	18.5
	STNS	0.028	0.060	0.046	0.007	16.1
	STPS	0.106	0.206	0.135	0.023	17.2

In 0-20cm soil layer, STN concentrations was significantly different among the four land uses, which was characterized by 30-year-old grassland > jujube orchard > cropland > 7-year-old grassland ($p<0.05$) (Fig. 1a). In addition to jujube orchard and cropland, STP concentrations has significant differences in land use, which is represented by 30-year-old grassland > cropland > jujube orchard >7-year-old grassland ($p<0.05$) (Fig. 1b); in 20-60cm soil layer, STN concentrations of the 30-year-old grassland was significantly higher than that of the other three types of land use, while there was no significant difference between the jujube orchard and the cropland and the 7-year-old grassland ($p<0.05$) (Fig. 1a). STP concentrations has significant differences in land use, except Jujube orchard and cropland(Fig. 1b). Because the difference of soil bulk density between different land uses, the changes in STN and STP stocks are different. STN and STP stocks were the largest in the 30-year-old grassland, and the 7-year-old grassland was the smallest, and there were significant differences (Fig. 1c and 1d).

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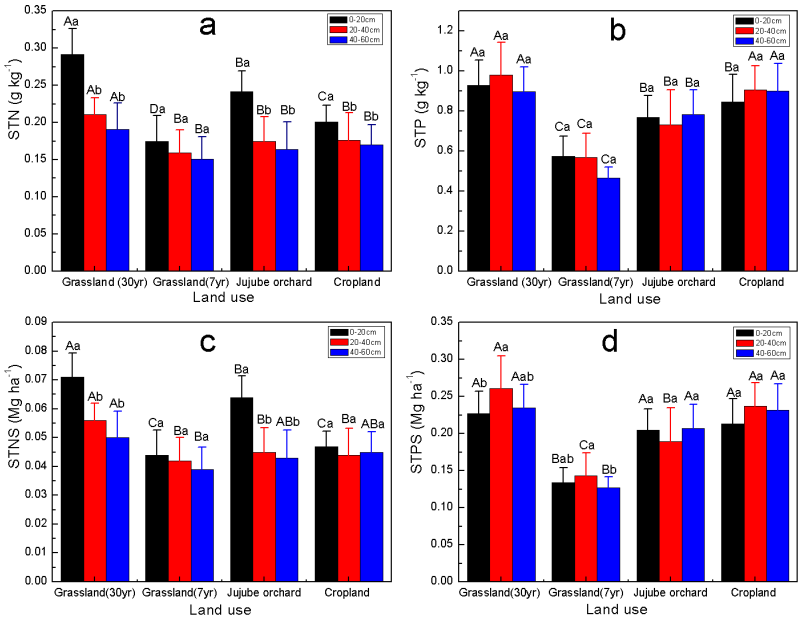

Fig 1. STN and STP concentrations and stocks under different land uses. The error bar represents ±standard deviation.

4. Conclusion

(1) Soil total nitrogen and total phosphorus had moderate variation, but soil total nitrogen and total phosphorus reserves had high variation.

(2) Land uses significantly ($p<0.05$) influenced the distribution of STN and STP concentrations and stocks in surface layer (0-20cm) but not subsurface layers (20-60cm).

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