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Relation between some variations of soil and surface vegetation and desertization in agriculture-pasture interlacing zone——An example from Kangbao County, North Hebei, China

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Abstract: The studied agriculture-pasture interlacing zone has its specific natural conditions, at which the natural systems are unstable, their self-regulation capability is low and the equilibrium is easily broken, and hence the habitat is fairly vulnerable. During last 20 years the increasing population and livestock, over-reclamation, over-pasturing, over-deforesting, and other intensified negative human activities in the zone resulted in coarsening of surface soil, decrease of organic mater content in soil, reduction of vegetation coverage, variation and degradation of flora structure, and hence in desertization of the land, although average of gales and sandstorms some decreased and the climate tended to be better in the region. However, the frequent sandstorms occurring in the springs of last and present years has attracted much attention. Investigations confirmed that the main cause for the phenomena is the unreasonable human activities rather than the natural factors.

Keywords: agriculture-pasture interlacing zone; soil; sandstorm; desertization

Introduction

Desertization is a key factor affecting the economic development and social progress in the region with vulnerable habitat. The studied case indicates that the disordered human reclamation resulting in desertization of the land and the biogeochemical cycle in the deserted land may in turn strengthen the desertization development and continues to accelerate the process of desertization. The superimposed "artificial" and "natural" factors make the habitat to be further worse and the desertization to be accelerated. Therefore, analysis of genesis of the land desertization is aimed to work out the appropriate measures for controlling the desertization. Thus, the significance of the study is self-evident. The ancient culture data(Zhao, 1997) indicated that the agriculture had started to develop in the agriculture-pasture interlacing zone in 6000—5500 years ago and then was developed on a considerable scale in the reigns of emperors Kangxi and Yongzheng of Qing Dynasty(1600—1700). Two large-scale land reclamations were carried out in the years of "Great Leap Forward" and "Cultural Revolution", when food production was put at the first place in the national economic development program.

Taking the Kangbao County Hebei Province as an example, we analyze the factors causing the land desertization in the county and reveal the situation of the agriculture-pasture-interlacing zone.

1 A brief of the zone and study methods

1.1 A brief of the study zone

The study zone is located in a transition zone between Inner Mongolia, Yanshan Mountains, and North China Plain. It is an alternation zone from monsoon to continental climate and from dry to semi-dry climate and one of the agriculture-pasture interlacing zones in China. The specific geographic framework of lava platform and erosional plateau in the zone makes the habitat vulnerable and the climate sensitive in the region.

The Kangbao County is located at the northwestern corner of the zone, where the relief inclines from northeast to southwest. The remainders of Yinshan Mountains run through the county area, which is dominated by low mountains and hills. The desertization is more typical and covers a larger portion (41.15%) of the land area. The Quaternary loose sediments, such as alluvial, delluvial, eolian,

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elluvial, and lacustrine sediments, are widely distributed in the county area and become a main source of sand for the desertization.

1.2 Study methods

1.2.1 Sitting and sampling for the study

According to the geomorphic framework, soil types, and surface vegetation situation, the authors carried out reconnaissance and detailed investigation in the study zone and typical sites, respectively. Then we sampled from sites and plots from layer to layer of soil in a pedogenic sequence from the surface down to depth of 50 cm or more.

1.2.2 Analysis of samples

In accordance with the designed research project, the soil samples were analyzed for their mechanical composition (gramulometric analysis), organic meters (bichrome-sulfate oxidation), total N (selenium powder-copper sulfate-sulfuric acid nitration), P and K (hydrogen fluoride-nitric acid-perchloric acid nitration-ICP-AES), quick-acting N(alkaline hydrolysis and evaporation), P and K(ammonium carbonate digestion-ICP-AES), and effective Fe, Mn, Cu, Zn, Mo(extraction with DTPA digester, determination with ICP-AES), and so on.

2 Results and analysis

2.1 Surface soil grain coarsening

It can be seen in Table 1 that for the three grain-size grades of the soil, >0.05 mm, 0.05—0.005 mm, and <0.005 mm, their percentages are successively 52.96, 18.64, and 28.40 in 1980s, respectively, and changed to 59.23, 17.11, and 23.66 in 1990s, respectively. Of them the grain-size grade >0.05 mm increases by 11.84%; grain-size <0.005 mm decreases by 16.69%; while the grain-size 0.05—0.005 mm is in between them and also decreases, but the decrease amplitude is less than both its former and latter grain-size grades, only by 8.21%. It follows that during nearly 20 years from 1980s to 1990s, coarse grains of the soil increased and the fine grains decreased. The decrease is synchronously with the increase, indicating a development of the land toward sanding and desertization. The result is approximately consistent with the determination data by Zhu Zhenda(Zhu, 1989) in an area with similar soil types.

Table 1 Evident change in mechanical composition of soil

Time interval	Mechanical composition, %		
	>0.05mm	0.05—0.005mm	<0.005mm
1980s	52.96	18.64	28.40
1990s	59.23	17.11	23.66

2.2 Variation in organic meters and three important elements

The main nutrients in soil are listed in Table 2. During 1980s—1990s, organic meters in the soil decreased from 2.33% to 1.51%, by 35.19%. Total N and P of the three important elements decreased by 9.33% and 48.15%, respectively, with increase amplitude of 8.47%. The variation in quick-acting N, P, and K is that N increased by 3.81% and P and K decreased by 9.94% and 11.74%, respectively.

Table 2 Comparison between main nutrients in soil in 1980s and 1990s

Time interval	Main nutrients, %				Quick-acting elements, mg/kg		
	Organic meters	Total N	Total P	Total K	N	P	K
1980s	2.33	1.50	0.081	1.89	106.70	5.12	140.04
1990s	1.51	1.36	0.042	2.05	110.76	2.81	123.60

Comparison between the data in Tables 1 and 2 permits us to know that organic meters, total N and P, and quick-acting P and K in the soil decreased with time, while total K and quick-acting N in the soil some increased. That is to say, during nearly 20 years, from 1980s to 1990s, the contents of nutrients in soil decreases due to coarsening of soil grains, especially organic meters in the soil, the main indicators for

soil fertility, decreased.

In general, with gradually reducing portion of fine-grained soil of 0.05—0.005 mm and < 0.005 mm grades, the main nutrients necessary for plants decreased simultaneously and amount of the nutrients depends on the grain size. The soil of the described above grain sizes has some properties of clay, so it contains relatively high amount of nutrients. Therefore, it is known from the amount of nutrients that the soil tends to continuously coarsen and become sandy with time.

2.3 Variation of microelements in soil

Analysis result of the available microelements is listed in Table 3. During nearly 20 years from 1980s to 1990s, contents of available microelements in soil have fluctuated. Of them Fe and Cu contents increased by 1.0% and 3.4%, respectively; Mn and Zn contents decreased by 2.7% and 34.5%, respectively; while Mo content tended to be relatively stable everywhere.

It can be seen in Table 3 that the contents of available microelements in soil in this county did not significantly decrease with reducing portion of fine-grained soil but slightly fluctuated. However, a general trend is the decrease amplitude larger than the increase amplitude. Therefore, the analysis result of available microelements in the soil in this time interval shows that the correlation between the available microelements in soil and the reducing portion of fine-grained soil appears to be not significant. It may be a result of more complicated relation between contents and behaviors of the microelements in soil and grain size of the soil(Sun, 1990).

Table 3 Comparison between available microelements in soil

Time interval	Available microelements in soil, mg/kg				
	Fe	Mn	Zn	Cu	Mo
1980s	10.75	5.88	0.55	0.58	0.05
1990s	10.86	5.66	0.36	0.60	0.05

2.4 Variation of surface vegetation

Desertization is an important indication for variation and degradation of vegetation. The deflation of cultivated, matured soil layer, the uninterrupted reducing portion of fine-grained soil containing more amount of nutrients, and the gradual degradation of soil environment in which plants grow caused the vegetation community, structure, and coverage, the average stock height of plants, and the fresh weight of biomass to vary and degrade significantly during last 20 years. The data listed in Table 4 confirm this situation.

Table 4 Variation of surface vegetation

Time interval	Coverage, %	Structure of plant community	Average stock height of plants, cm	Weight of fresh biomass, kg
1980s	> 50	Semi-shrub, perennial grass, and wormwood are dominant species, mainly *Artemisia frigida* Willd., *Artemisia scoparia* Willd. et Kit, *Artemisia halodendron*, *Artemisia gmelinii* Wib. et Stechm., *Artemisia sieversiana* Willd., *Aneurolepidium chinense* (*Trin.*) Kitag., *Pennisetum centrasiaticum* Tzvel., *Hedysarum fruticosum* Pall., *Lespedeza Hedysaroides* Kitag., and *Polygonum divaricatum*. l., and so on	50—60	250—300
1990s	10—25	The species are principally similar to former, but amount significantly decreased. The representative species are mainly *Salix gordejevii* Chang. et Skv., *Artemisia Halodendron*, *Setaria viridis* (L.) Beauv., and so on	30—40	100

2.5 The causes for desertization

Comparison between the mechanical composition of soil in 1980s and that in 1990s listed in Table 1 indicates that the soil of three grain-size grades, > 0.05 mm, 0.05—0.005 mm, and < 0.005 mm, largely vary, especially the soil grains of > 0.05 mm and < 0.005 mm grades clearly increase and

decrease, respectively. This phenomenon did not be caused by the climatic factors, such as sharply increasing number of gales and sandstorms(Table 5), but by the negative human activities(Table 6).

Data in Table 5 show that climatic factors in the county, such as average number of gale days, average wind velocity, and average number of sandstorms, some decreased in 1990s in comparison with those in 1980. But only the average precipitation amount increased. Average of gale days decreased 10 days, by 18.18%; the average wind velocity reduced 0.4 m/s, by 11.11%; and the average number of sandstorms decreased 1.3, by 21.31%. The precipitation increased 45.20 mm, by 15.37%. The result is basically consistent with that obtained by Xiao Sirong *et al*.(Xiao, 2000) in the same area in the same time intervals.

Table 5 Variation of main climatic factors

Time interval	Average number of gale days, d	Average wind velocity, m/s	Average number of sandstorm, *n*	Average precipitation, mm
1980s	55	3.60	6.1	294.10
1990s	45	3.20	4.8	339.30

Table 6 Comparison between social and economic elements

Time interval	Total population (people)	Agricultural population	Crop land, hm^2	Domestic animals, *n*
1980s	264989	251659	117953	199675
1990s	277537	260458	121090	237800

Data in Table 6 show that the main social and economic data, such as total population, agricultural population, cropland, and amount of domestic animals fluctuated to different degree in 1990s compared with those in 1980s. During last 20 years, population grew by 4.7%; agricultural population grew by 3.5%, cropland increased by 2.7%, and amount of domestic animals increased by 19.10%.

Total population and total domestic animals increased. Thus, the requirements for existence must lead to over-reclamation, over-pasture, and deforestation, and hence to increase the load on environment and cause the vegetation to be thinned, the surface soil to be exposed, fine-grained soil to be deflated and reduce and coarse-grained soil to be concentrated, and hence sanding and desertization to further occur.

3 Conclusions

During last 20 years, soil grains were coarsened and the ground surface more sanded on the study area. Organic meters as an indication for soil fertility decreased significantly.

Total and quick-acting N, P, K amounts and contents of main elements necessary for life in soil generally decreased with time. Microelements also similarly varied.

Vegetation coverage in the area reduced, structure of plant community varied and degraded, average stock height of plants reduced, and weight of fresh biomass decreased.

The causes for coarsening soil grains, land sanding, and hence land desertization are the total population and agricultural population growth and increasing amount of domestic animals, which led to unreasonable land use, over-reclamation, over-pasture, and over-deforestation. These phenomena did not caused by worse climatic factors.

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