Journal of Environmental Sciences Vol. 7, No. 3, pp. 352–359, 1995 ISSN 1001–0742

Characteristics of frail eco - environment in Hebei plateau

Sun Jianzhong, Yang Minghua, Sheng Xuebin, Liu Quanyou

Research Center for Eco - Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China

Abstract—This paper dealts with the characteristics of eco - environmental deterioration in Hebei plateau and with measures of eco - environmental improvement by land use management and eco - engineering. In the past decades, the eco - environment of the plateau has been deteriorated, which may be related to climate changes and human actions. Wind erosion and desertification have increased in the area, and result in the depletion of grassland and lakes. Recently, landuse management and eco - engineering have been built in some places, and the eco - environment of the places has been proved.

Keywords: eco - environment; frailty; deterioration; reversibility.

1 Introduction

Global change is one of the very important environmental problems in the world, in which frail eco - environmental area change is an even more important environmental problem. Frail eco - environment area is a sensitive area of environmental change (ecotone) because its geographical position and special natural conditions have made the eco - environment very sensitive to the change in the original status from natural and anthropogenic factors, but there could be many vestiges left during its the change. These vestiges are very important and useful to study on global change. Frail eco - environmental areas distribute in different regions in China, such as crossed zones of sea and land, transitional zones between different climates and landscape types and environment areas (Zhao, 1994). The most typical frail eco - environment zone is located inside and outside the Great Wall in North China, which is the transitional zone between agricultural area and livestock farming area, especially the area of Hebei plateau which is a typical sensitive area of environment change.

Some valuable researches on environmental problems in Hebei plateau have been carried out (Li, 1994), including local diseases, land desertification (Bao, 1994) and grassland degradation (Zhao, 1994). Additionally, basin environment treatment (Li, 1994) and regional environment programme (Zhao, 1988) have been carried out.

The main purpose of this paper is to study the characteristics of the frail eco - environment of Hebei plateau, the effect of climate change and anthropogenic factors on the eco - environment and on the possibility of prevention and control of the eco - environment deterioration.

2 Study area

The plateau is located in north Hebei and the southern side of the Mongolian plateau. It covers three counties and a city, i. e. Zhangjiakou, Guyuan, Zhangbei and Kangbao, and parts of three counties of Shangyi, Fengning and Weichang with an area of 17687 km^2 (Fig. 1). The population is about 1. 1 million.

The plateau can be divided into three parts according to geological structure and geomorphic type. The southern part belongs to the quaquaversal fold zone of Yanshan Mountain. Original rocks are eruptive rocks in Mesozoic era, such as andesite, basalt and liparite. Geomorphic characteristics are middle mountain and hill from east to west. It is the dividing range of outside and inside basins of the plateau. Middle part of the plateau belongs to anteklise of Inner Mongolia, original rocks are gneiss, schist and other metamorphic rock in Palaeozoic era. Basins were formed in the period of Yanshan Mountain movement, and thick sediment deposited in the basins in Mesozoic era. In the same period, granite intrusion and volcanic emanation occurred, thus the frame of the plateau was formed finally. After that time several eruptions of basalt along rift were caused by Himalayan movement in Cainozoic era, but it was at this period that different kinds of sediments were deposited on depressions. Hence, the undulating plateau was formed. North part belongs to the quaquaversal fold of Yanshan Mountain. Bed rock consists of granite and metamorphic rocks. Geomorphic characteristic of low mountain and hill is formed due to weathering, and bed rock is covered by residual deposit and talus material. The geological structure and geomorphic characteristics mentioned above form the basic pattern and material of the eco - environment of this area. And this area is the transitional zone of Inner Mongolia plateau - Yanshan upland - north China plain, the boundary of monsoon and continent climate and of arid and semiarid regions. It is also the transitional zone of north temperate broad - leaved forest and bushveld, transitional district of agriculture and pasture, and exchanging belt of inland and exterior drainage. It is the special geomorphic environment that has formed a frail eco - environmental system with sample level and structure of landscape type and ecosystem, short food - chaining and less self - regulating ability. This eco - environment is liable to be destroyed by calamities and human activities.

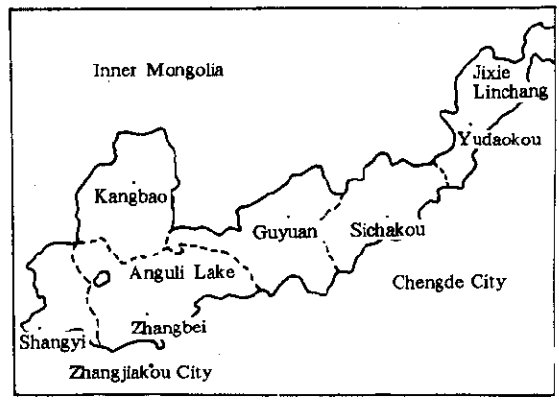

Fig. 1 Regional distribution of Hebei plateau

3 Characteristics of climate change in Hebei plateau

The results of the temperature change are listed in Table 1, which shows that the temperature of Hebei plateau has been raised since 1950s, on the basis of the average of five observatories, but there are different changes in different places. The temperature change observed at Lin-

chang was the highest one. The temperature rise is about 3. 66℃ from 1950s to 1980s, and the about 3. 73℃ from 1960s to 1980s. At Guyuan, the temperature rise is about 0. 735℃, from 1960s to 1980s, and about 0. 372℃ at Zhangbei, 0. 29℃ at Kangbao and 0. 867℃ at Shangyi, respectively.

Table 1 Temperature change of Hebei plateau in 40 years

Unit: ℃

Site		50s/60s	60s/70s	70s/80s	50s/80s	60s/80s
Guyuan	average	0. 022	0. 598	0. 137	0. 757	0. 735
	highest*	0. 830	-0. 760	1. 360	1. 430	0. 600
	lowest**	1. 860	1. 280	0. 450	3. 590	1. 730
Zhangbei	average	0. 227	0. 318	0. 054	0. 595	0. 372
	highest	0. 340	-1. 820	0. 720	-0. 760	-1. 100
	lowest	1. 910	-0. 220	-0. 450	1. 240	-0. 670
Kangbao	average	-	0. 170	0. 120	-	0. 290
	highest	-	-0. 330	0. 110	-	-0. 220
	lowest	-	0. 100	0. 600	-	0. 700
Shangyi	average	-	0. 000	0. 867	-	0. 867
	highest	-	-1. 320	0. 740	-	-0. 580
	lowest	-	0. 270	0. 180	-	0. 450
Linchang	average	-0. 070	0. 640	3. 090	3. 660	3. 730
	highest	2. 130	2. 730	-2. 640	2. 220	0. 990
	lowest	3. 155	-0. 050	0. 990	4. 095	0. 940

*: Highest is the highest temperature difference between decades; **: Lowest is the lowest temperature difference between decades; Positive value shows temperature increase.

In the plateau, precipitation has been reduced since 1970s (Table 2). The largest reduction is at Shangyi, but precipitation is increased at Linchang. Average reduction is about 10. 2 mm from 1960s to 1980s, and about 30. 6 mm from 1970s to 1980s. It is shown that precipitation reduction is about 7% from 1970s to 1980s, about 2% from 1960s to 1980s. The reduction is disadvantageous of the eco-environment of Hebei plateau.

Not only has precipitation decreased in the plateau, but the relative humidity in the area has changed as well, although the change is smaller than the precipitation change. The humidity decreased at Zhangbei and increased at Shangyi from 1960s to 1980s, and it increased from 1960s to 1980s, and decreased from 1970s to 1980s at Kangbao, but it hardly changed at Guyuan and Linchang from 1960s to 1980s. Average humidity of this area increased about 2. 6 (Table 2).

Table 2 Change of precipitation and humidity in Hebei plateau*

Site	Change of precipitation, mm			Change of humidity, %		
	60s/70s	70s/80s	60s/80s	60s/70s	70s/80s	60s/80s
Guyuan	64. 2	-57. 5	6. 5	1. 2	-1. 3	-0. 1
Zhangbei	16. 7	-44. 46	-27. 76	-0. 91	-1. 0	-1. 91
Kangbao	35. 26	-56. 22	-20. 96	6. 69	-2. 7	3. 9
Shangyi	67. 06	-70. 4	-3. 34	2. 7	9. 0	11. 7
Linchang	-31. 32	-25. 92	-5. 4	-3. 9	3. 2	-0. 7

*: Positive value shows precipitation increase, and vice versa.

Wind velocity is very high in the area, especially in spring, the largest velocity being about

15—20 m/s. There are about 50—70 times strong wind as high as wind scale 8 or higher every year. There are 119 days in a year lowing strong gales. Although it often blows gales in winter and spring with velocity, both wind velocity and the days blowing gales have decreased in recent years (Table 3), but wind velocity at Shangyi and days blowing gales at Kangbao slightly increased in the past. Wind velocity decrease of Guyuan and Kangbao was obvious from 1960s to 1980s, decreased about 1 m/s. Decrease in windy days was remarkable, about 9—42 days in the past three decades.

Table 3 Change of wind velocity and days blowing gales in Hebei plateau

Site	Wind velocity, m/s			Days		
	60s/70s	70s/80s	60s/80s	60s/70s	70s/80s	60s/80s
Guyuan	-0.52	-0.65	-1.17	-25.5	-17.2	-42.7
Zhangbei	-0.44	-0.30	-0.74	-10.1	-15.1	-25.2
Kangbao	-0.32	-0.69	-1.01	7.3	-6.3	1.0
Shangyi	0.02	0.09	0.11	-31.1	17.2	-13.9
Linchang	—	—	—	-13.6	4.0	-9.6

4 Effect of climate change and human activities on eco - environment of Hebei plateau

Temperature rises have caused droughts year after year in the plateau. According to statistic data of 580 years from 1368 to 1949, there were 407 droughts. In the first half of the century, there were 8 successive two - year droughts, about one in every 7—8 years. There were 3 successive 3 years droughts, and a spring drought in every 2—4 years and a heavy drought every 12 years in the same half century. Drought frequency is 75%—90% since early 1960s. In recent 20 years only, there were 13 heavier spring droughts, 10 of which spring droughts were linked with summer droughts.

Precipitation decreased and evaporation increased because of climate change. Precipitation decrease and evaporation increase have caused decrease in ground water table and shrinking surface water area and depletion of some fresh water lakes to be developing in the plateau. For example, Angoli lake, located in Zhangbei County about 26 km away from Zhangbei City is the largest lake in the plateau with an area of 733.3 ha and a water depth of about 6m at present. It can be found by field survey that the lake area has shrunk to one twelfth of original scope during 10000 years (Fig. 2). The aerial photo shows that the lake shrank three times greatly. According to survey in situ, the first shrinkage of the lake may have taken place in early

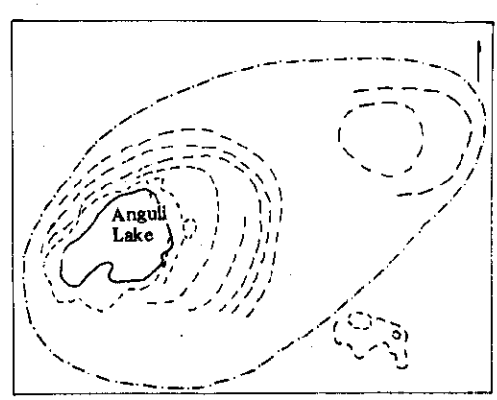

Fig. 2 Change of Angoli Lake water area

Holocene, and the lake has dried up several times in recent years.

Desert area is gradually extending in the plateau. The area of different desertification degree is listed in Table 4. It is shown that light and heavy desertification areas in 1980s are nearly twice as large as the desertification areas in 1970s and that medium desertification areas in 1980s is almost 4 times as large as those in 1970s. The desertification area of different kind land is given in Table 5. The desertified area of farmland is the largest one, it is about 50 percentage of the total desertification area in the plateau. In 1988, desertified area is about 580000 ha, which makes up 33 percentage of the whole area. The heavy desertified area is about 73300 ha, and wind-drift sand modulus is about 3000 t/(km^2. a).

Table 4 Desertification status of Hebei plateau in recent decades*

Unit: km^2

County	Light desertification		Medium desertification		Heavy desertification		Sum	
	70s	80s	70s	80s	70s	80s	70s	80s
Zhangbei	529.65	1033.06	2.13	4.25	0	0	531.76	1037.38
Shangyi	147.14	604.38	0	121.0	0	0	147.14	725.38
Guyuan	254.37	312.59	0	16.94	0	0	254.37	329.44
Kangbao	740.33	1000.90	33.01	333.47	0	0	323.34	1347.37
Fengling	296.72	487.31	42.38	80.75	3.14	7.85	342.24	575.91
Weichang	313.03	602.62	105.96	156.06	0	0	418.99	760.66
Sum	2281.24	4040.86	183.48	712.47	3.14	7.85	2017.83	4776.14

* , by courtesy of Zhu Zhengda, 1991

Table 5 Desertification type of Hebei plateau and its change

Unit: km^2

County	Sandy desert		Gravel desert		Wind abrasion farm land		Sum	
	70s	80s	70s	80s	70s	80s	70s	80s
Zhangbei	19.61	43.43	180.86	374.79	331.37	599.11	531.78	1017.33
Shangyi	8.26	45.75	96.55	351.73	42.33	327.90	147.14	725.38
Guyuan	79.80	16.48	38.95	83.39	135.62	229.57	254.37	329.44
Kangbao	121.66	132.60	207.08	492.44	499.60	722.3	323.24	1347.37
Fengning	127.16	237.74	0	0	215.08	302.17	342.24	575.91
Weichang	302.13	624.09	0	0	116.86	136.59	418.99	760.66
Sum	658.62	1100.09	523.44	1302.35	1240.86	2318.67	2017.86	4756.11

Desertification in Hebei plateau is related with the rise in temperature and the decrease in precipitation. According to observation results at the site of Kangbao wind-drift sand observatory from June 1990 to June 1991 (Fig. 3), wind erosion of farmland is about 3.3 cm, but in the same period of the next year, it deposited sand about 0.6 cm on the farmland. The difference is due to different precipitation, especially in early winter, the end of fall and early next spring. The higher the soil moisture is in winter and spring, the less land was abraded by wind. Farmland deposit sand between June 1991 to June 1992 is principally related with precipitation in Sept. —Oct. 1991 and May 1992. The results in Sept. —Oct. (1989 and 1990) also show that the relationship between precipitation and soil wind abrasion is negative. In Sept. —Oct. 1989,

precipitation was 92.7 mm, soil wind abrasion hardly took place, but at the same time in 1990, farmland was abraded by wind about 3.33 cm because precipitation was only 7 mm. Drought not only causes desertification extension, but also accelerates grassland degeneration. It affects grass growth to make dry grass product per hectare decrease by 20—30 percentage of the product 40 years ago and affects eatable grass for livestock causing it to decrease by 30% because of the change that takes place in the herbage structure.

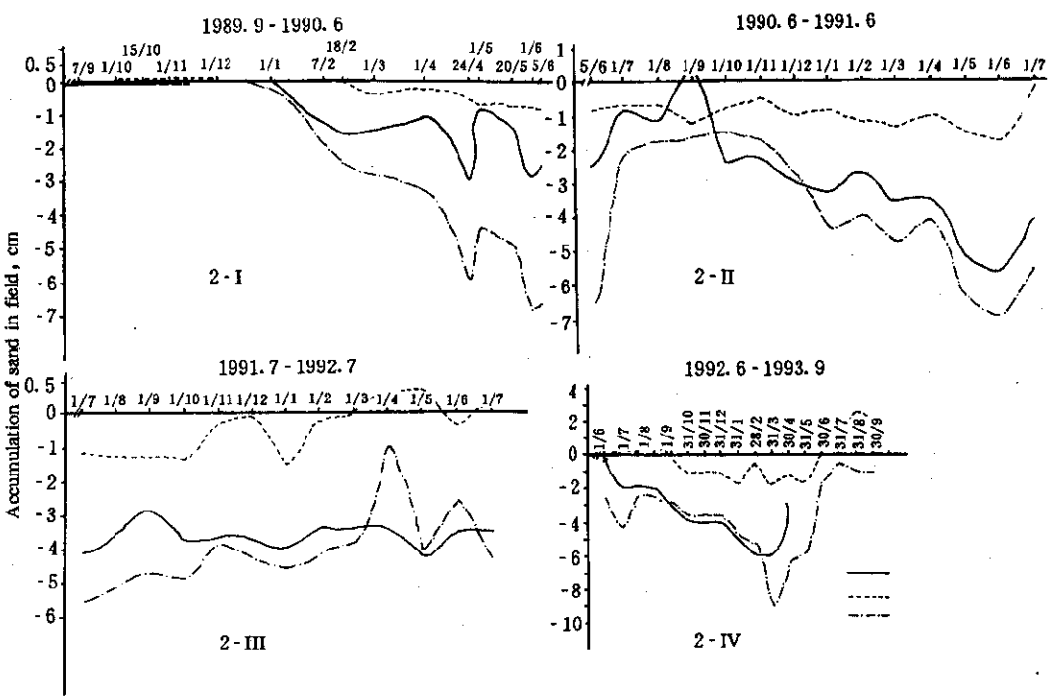

Fig. 3 Change of land wind abrasion at Kangbao

Desertification is related with human activities in the plateau, except for the effect of climate change. In the past 4 decades, grassland decreases by about 40%, but rate of grass cover decreased to less than 50 percentage of the cover rate in 1950s. Irrational land use causes the desertification extension. The main reason is that cultivation accelerates wind erosion because of the sandy soil in the plateau, especially in spring when it often blows strong wind. For example, farmland was abraded by wind about 2.8 cm in April—May 1990, but only 0.73 cm with the uncultivated land (about a fourth), not including young forest land. During fall cultivation in Sept. 1990, farmland was abraded 2.73 cm by wind only with 3 days blowing gale. It is shown that land brought under cultivation accelerates sand transportation or desertification. On the other hand, decrease in vegetation cover rate has caused increase in soil and water loss in the

plateau. The area of soil and water loss is about 133300 ha in 1950s, and more than 400000 ha in 1970s. Soil abrasion modulus in 1970s was about twice as large as that in 1950s, about 500—800 t/(km². a) in 1950s and about 1200—1700 t/(km². a) in 1970s, respectively.

5 Possibility of reversion degenerated frail eco - environment

Although eco - environmental degradation is related with natural factors, anthropogenic factors are not ignored. Degraded frail eco - environment caused by anthropogenic factors may be reverted by using scientific and reasonable measures. It is one of characteristics of frail eco - environment. Hebei plateau is an alternative zone of agriculture and pasture, and a typical area of frail eco - environment. It is easy to be desertified, but it can be reverted by reasonable management (Zhu, 1991). In fact, desertification is a complicated process that man and nature interact in history (Wu, 1993). Man can accelerate desertification of Hebei plateau, but man can also control desertification development (Wang, 1989). For example, wind abrasion was very heavy 20 years ago at Huanggailao County, and topsoil loss was about 45—75 m^3/ha (Cai, 1991). Forest protection for cultivated land was planted in mid 1980s, land wind abrasion was decreased, grain yield was increased. Grain yield in 1990 was 523200 tons more than in 1989 (Cai, 1991). The achievement came from land structure adjustment. The total land area of the country is 16900 hectares. Cultivated land is about 6800 ha before 1984, forest area about 773 ha and grassland about 8900 ha. The increase in forest area is 1200 ha, in grassland area about 2800 ha after 1986. Although cultivated land area has been reduced from 6800 to 4000 ha, grain yield has greatly increased, and animal husbandry has greatly developed. It is shown that rational landuse can control frail eco - environmental degeneration and improve of degenerated eco - environment.

6 Conclusion

Hebei plateau is a typical frail eco - environment zone. Its eco - environmental deterioration is related with climate changes and irrational landuse and management. Drought and land brought under cultivation have caused extension of desertification and increase in soil and water loss in the area. Ground water table decrease and lake drying up are principally caused by the climate change.

Wind abrasion of land is an important factor of eco - environmental degradation in the area, and it is related with bringing land under cultivation. The wind abrasion strength of land is increased with increasing wind velocity, days of blowing gale and sandstorm. There is a good relationship between wind abrasion of land and cultivation area. The relationship between wind abrasion and soil moisture or precipitation is negative.

The eco - environmental deterioration in Hebei plateau can be prevented but even it can be returned to normal. One of the main measures is to build systematical eco - agricultural engineering.

References

Bao Y, Zhang Q, Zhao X, Zhao W, Zhao C, Li Q. J Desert Res, 1994; 14:8

Cai G. J Desert Res, 1991; 11:81
Li J, Zhao X, Bao Y. J Desert Res, 1991; 11:15
Li J, Bao Y, Zhang Q. J Desert Res, 1991; 11:72
Wang T. J Desert Res, 1989; 9:113
Wu Z, Zhong D. J Desert Res, 1993; 13(1):21
Zhao C, Zhao W. J Arid Land Res and Environ, 1994; 8(1):80
Zhao W. J Desert Research, 1994; 14:53
Zhao X, Li J, Zhao W. J Desert Research, 1994; 14:29
Zhu Z. J Desert Res, 1991; 11:11

(Received December 9, 1994)