The Degradation, Prevention and Treatment of Black Soil in Jilin Province*

BIAN Hong-feng¹, SHENG Lian-xi¹, YANG Guang²,³, JIANG Jing¹
1 Key Laboratory of Wetland Ecology and Vegetation Restoration of National Environmental Protection
Northeast Normal University
Changchun 130022
CHINA
2 Special Profession Department
Aviation University of Air Force
Changchun 130022
CHINA
3 Northeast Institute of Geography and Agricultural Ecology
Chinese Academy of Sciences
Changchun130012
CHINA

Abstract: Northeast China's black soil is mainly distributed in the Songliao Basin’s upper reaches of Heilongjiang Province and Jilin Province. The black soil area in Jilin Province is about approximately 45,200 km², which accounts for 24.7 percent of the total area. As the result of human interference with black soil in excess, black soil resources in Jilin have degraded noticeably. Serious erosion of black soil, reduction of soil nutrients, the deterioration of physical and chemical properties, and the escalation of soil pollution, have posed a serious threat on the national food production, the security of ecology and environment and socio-economic sustainable development in the future. This paper mainly puts the natural and human factors resulting in the degradation of the black soil into discussion. The natural factors refer to global climate change, the terrain characteristics as well as vegetation cover and so on. The human factors mainly focus on the rapid growth of population, unreasonable way of farming, soil pollution caused by industrial and agricultural production, and urbanization leading to the transfer of soil’s practical function, etc. Through studying the mechanism and the essence of soil degradation, prevention and treatment of black soil degradation should begin with the basic characteristics and the process of the occurrence. At the same time soil resources and the environment, should be unified, and different types of degradation should be distinguished. According to the basic principles of ecology and from the perspective of ecological balance the measures of biology, engineer, as well as agriculture should be combined together in order to unify the development and protection.

Key-Words: - Jilin Province, black soil degradation, prevention and treatment

1 Introduction
Northeast China's black soil and the Great Plains with Ukraine and the United States along the Mississippi River basin are the three major black soil zones. Generally speaking, the black soil types in the northeast area can be categorized into the black soil, chernozem, and meadow soil, etc., which are mainly distributed in the Songliao Basin’s upper reaches of Heilongjiang Province and Jilin Province (Figure 1). Black soil has a thick layer of humus, good physical and chemical properties, biological characteristics, and high fertility. The black soil zone in Northeast China has an area of 118,000 km², Jilin Province of which is about 45,200 km², accounting for 24.7 percent of the total area. [1] Jilin black soil area is one of the important commodity grain production bases, while even the younger planting area is also more than 100 years old. The black soil resources have been significantly degrading, posing a serious threat on the national food production, the security of ecology and environment and socio-economic sustainable development in the future.

2 The development and Utility of Black soil in Jilin Province
In the past, due to the small population and a relatively light impact of human activities on the northeast area, the ecological cycle was in a primitive

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At the beginning of the 20th Century, with a large number of immigrants moving into this area, they launched a large-scale "Land Cultivation Campaign". After the foundation of New China, the pace of land development was accelerated, and vast new reclamation areas were opened up. Before the cultivation of black soil area, most natural vegetation was forests and grassland meadow plants. And the black soil resources had good natural attributes. Potentially, they can be used for crop production. For example, Da-an, Dehui and Dunhua area in Jilin Province are close to each other and have a similar climate, but because of the different soil types, land productivities are also various. As what can be seen from Table 1, higher proportion of the black soil share of the farmland, the higher unit, of the land yields and the higher productivity of the farmland has. Consequently, black soil is a valuable land resource for cultivation. The changing process of black soil in northeast area of arable land represents the process of black soil s’ cultivation. The area of the arable land in Jilin Province in 1990 was 39,400 km², and expanded to 55,800 km² in 2002 [2], growing by 16,400 km² during 12 years, most of which was received through land reclamation in the black soil zone.

Table 1: Comparison of the productivity of arable land in different types of soil in Jilin Province [3]

<table>
<thead>
<tr>
<th>Agriculture district/Representative county</th>
<th>The proportion of black soil to arable land (%)</th>
<th>Food production in the arable land per unit area (kg/km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Da-an</td>
<td>0</td>
<td>3134</td>
</tr>
<tr>
<td>Dunhua</td>
<td>3.1</td>
<td>4568</td>
</tr>
<tr>
<td>Dehui</td>
<td>40</td>
<td>5478</td>
</tr>
</tbody>
</table>

3 The degradation Situation and Hazard of Black Soil

The black soil degradation in Jilin Province mainly shows in three areas: black soil erosion, deterioration of soil physical and chemical properties and soil pollution.

3.1 Serious erosion of Black Soil

The main types of black soil erosion in Jilin Province are water erosion and wind erosion.

The water erosion mainly occurs in the sloping land. Due to the impact of soil erosion and water loss on large area of bare mountains, a large area of wilderness ranges and corroded ditches appear. Meanwhile, soil erosion and water loss will lead to another serious environmental problem – area-source pollution. According to the survey, in some reaches of River Mushi and River Huifa, the river-beds are more than 1m above the ground, and have become the "above-ground suspended river" of black soil. Only within 15km along the Songhua River in Liujia country, Yushu city, the length of an erosion main stream gully is 1.5km with the average depth of 53m. Among 49 large-scale erosion ditches whose depth reach 10-40m, there are as many as 306 ditches below 10m and the gully density has reached 4440m/km² [2]. The soil erosion and water loss of the slope of arable land in Jilin Province is one of the factors restricting the development of agricultural production. The second national soil survey results show that 20,000 km² farmlands in Jilin Province...
suffer from serious erosion, accounting for 37% of the total cultivated land area. The soil erosion and water loss of black soil are very serious. The annual soil erosion modules reach 110,000 m³/km², which has surpassed the erosion intensity of the Loess Plateau [1]. The black soil zone lost average 3-1cm thick topsoil annually. Because of the soil erosion and water loss for many years, the original thicker black soil layer is now only 20-30cm thick. In Jilin Province, 40% of the soil is less than 30cm thick, and even in some places, loess parent material has emerged and lost its basic production capacity [4]. It is estimated that if the loss of the present arable land of black soil continued for 40 to 50 years, he black soil layer would be lost finally In Sijiazi country of Shuangyang District, people planted corn and the yield was about 4500kg/hm². Due to the soil erosion and water loss, there are 430hm² bare rocks that they have to abandon. The rest land can only be utilized by planting soybeans and grain, instead of corn with the approximate 1000kg/hm² output.

Wind erosion mainly occurs on the flat ground. The period of strong winds in Jilin province is in April and May every year, when there is only softer topsoil without vegetation cover on the arable land surface. With the spring drought, repeated freezing and thawing, and Soil particles in the state of broken bits, the soil turned up in autumn and fallow land plowed over are even like the "fine flour". When strong winds come, topsoil is stripped away by the wind in different degrees. It has been observed in the level planting wheat field, where the topsoil corroded by wind reaches up to 0.5-1.0cm thickness each year [6].

3.2 Reduction of Soil Nutrients and The Deterioration of Physical and Chemical Properties

With prolonging the cultivating time, soil organic matter content tends to drop. As what can be seen from figure 2, organic matter content of 85-year cultivated black soil dropped from 90g/kg to 38.9g/kg [2]. The poor cultivating measures and production management, and excessive use of fertilizers, pesticides and herbicides resulted in the rapid decline of soil nutrient content. Soil bulk density increased year by year, the voyage decreased, and the ability to guarantee water fell. In some areas, there appeared soil Stalinization phenomenon, which resulting in the higher cost of agricultural production for farmers.

3.3 Aggravation of Soil Pollution

The long-term agricultural production by way of plundering and the fast rise of rural enterprises and so on, have led to ecological damage to the black soil environment in various degrees. such as the piling and dumping of solid waste, the use of the agricultural chemicals and chemical fertilizers, the infiltration of toxic and harmful waste water, as well as atmosphere harmful gases and the fly ashes landing onto the soil with the rain. It can be said that the reality of transfer of the municipal pollution to the village has brought a great catastrophe to the black soil resources. Farmers increasingly executed the agricultural chemicals and the chemical fertilizers simply in order to raise the production, which causes the proportion of agricultural chemicals contents higher than the standard and reduction of the produce quality. Consequence, this will be the biggest obstacle of the food economic development in Jilin Province in the future.

4 The exploration for Reasons of Degradation of Black Soil

As a matter of fact, there are many reasons concerned with the black soil degradation, which can be discussed from two aspects: natural factors and human factors.

4.1 Natural Factors

The natural factors which influence the black soil degradation in Jilin province are mainly the climate, the terrain and the vegetation and so on. Global warming causes the frozen soil layer to move to the north, and compared with 100 years ago, the modern frozen soil has already moved approximately 20-30km to the north. With the frozen soil layer moving to the north, the black soil will gradually shrink to the north [7]. Climate warming has accelerated the decomposition of soil organic matter, causing soil organic matter to decrease. With the influence of the East Asian monsoon, black soil area
belongs to the continental humid temperate and sub-humid climate. Spring and autumn are arid and windy. The annual average wind speed is 3.24 m/s, and the maximum wind speed reaches 27 m/s [8]. Near March-May windy days occupy the annual days of strong winds above 65%. The rainfall in summer is rich, annually more than 70% of which concentrates from June to September, and much appears in rainstorm form. Black soil area is mainly distributed on the gentle terrace. The slope face is long and the watershed area is large with the centralization of the run-off and the strong erosion ability. Meanwhile the surface of black soil is loose, and its anti-corrosion and anti-erosion capacities are simultaneously low. Although the forest cover rate in Jilin Province is 43.2 percent, however, due to the uneven distribution of forest resources, they are mainly in the Changbai Mountains. Since the cover rate by trees and grass of the farmland area is low, especially the gentle slope arable land area it is hard to protect the black soil. And a phenomenon comes out: high vegetation cover cannot play a role in the suppression of black soil erosion. These factors intensify the soil erosion and reduce the soil fertility. As a result, the black soil area comes out snowmelt run-off erosion in spring, storm erosion in summer, wind erosion in spring and autumn, which causes the drop of soil quantity and the serious crisis of the degradation of soil quality.

4.2 Human factors
The history of the black soil large-scale reclamation and cultivation is just more than 100 years, but, until then its natural ecological environment has been so good. This demonstrates that human destruction to the ecological environment and irrational cultivation is the main reason for the degradation of black soil. Population growth leads to the excessive use of soil. The population in Jilin Province was 779,000, in 1900, while it was 27,150,000 in 2007, growing 35 times. during more than 100 years. The food products from the flat ground could not meet people’s needs any more. So they turned to the development of slope land, which destroyed trees and grass and reclaimed the fields, and at last resulted in the erosion of soil and aggravation of water loss.

Unreasonable way of farming aggravated the degradation of black soil. The main crops in Jilin Province are corn and soybeans. A lot of farmlands are on the rolling hills, and farmers often make the ridge along the slope, which can easily lead to soil erosion and water loss. In order to pursue the high yield, farmers have harvested corn continuously for many years, and they increase the production depending on the chemical fertilizers completely. Although the black soil has high productivity, under the "less input, multiple output" plundering type management, the soil nutrients lack obtaining the scientific supplements, which causes unbalance of oil nutrients, decline of soil fertility, as well as the sealing of soil.

The industrial and agricultural production causes the soil pollution. In order to pursue the agricultural production, lots of pesticides, herbicides and chemical fertilizers have been used. At present, most of the arable lands in Jilin Province haven’t used organic manure for more than 20 years and they mainly depended on the chemical fertilizers as the nutrient supplement, which seriously influences the soil environment. In addition to the increase of the industrial "three wastes" emission and the quantity of home scrap, and also the area of the landfill covers, urban pollution was gradually transferred to rural areas, and a large number of agricultural residues such as plastic film made the black soil polluted more and more seriously (mainly heavy metals and organic pollution), which caused soil productivity level and quality of agricultural products fall. A lot of crops can not be exported because of the excessive levels of pollutants.

In the black soil area are distributed Changchun, Siping, Dehui and other cities and towns. With the acceleration of urbanization, the agricultural black soil resources have been occupied by a few infrastructure constructions, so that the practical function of soil have transferred, and some of the black soil has suffered from permanent degradation [9]. During 1980 to 1999, in Jilin Province, black soil lands with the good quality cut down nearly 20,000 hm2. [8]

5 The prevention and treatment of black soil degradation
Nowadays, facing the situation of black soil resources only relying on chemical fertilizers to maintain the production and the reality of “broken xipi” and "the yellow earth hillock” with no productivity at all, people have already realized the truth that it is not too late to mend the fold even after the sheep is lost. Therefore, the earlier prevention, the less loss. The prevention and treatment of black soil degradation carried out in Jilin Province have achieved good results and mainly focus on the following aspects.

5.1 To carry out the study of the degradation mechanism
Step up to the understanding of the soil erosion mechanism in the black soil area, and begin with the basic characteristics of the black soil and the starting process in order to study the mechanism and essence of the black soil degradation. Focus on soil erosion, the process and speed of nutrient degradation, the process and the evolution tendency of the black soil degradation, soil pollution and restoration, human interference and impact on soil, and the ecological carrying capacity of the black soil resources and so on. They will theoretically guide the prevention and treatment practice work of the black soil degradation, and provide scientific suggestions.

5.2 To strengthen the comprehensive management of soil erosion and water loss

Unify the soil resources and the environment, distinguish the different types of the degradation, and adopt comprehensive management measures. According to the basic principles of ecology, from the ecological balance’s point of view, we should combine biological measures with engineering and agricultural measures to make the development and protection a unification. On the basis of comprehensive management and research, gradually set up and promote scientific management model to achieve the goal of comprehensively preventing and treating the black soil degradation. In 2003, Songliao Water Resources Commission launched a comprehensive pilot project of preventing and treating soil erosion and water loss in northeast black soil area, marking that the prevention and treatment of soil erosion of this area and water loss have been integrated into national overall plan, which also means the start of carrying out large-scale and high standards to the black soil area. During 2003 to 2006, Jilin Province mainly carried out comprehensive treatment in Huifa River and Yushu channel pilot area. In the three years, the ecological environment in the project area and farmers’ production and living conditions have been remarkably improved. Jilin Province completed the area of total comprehensive management and research of the black soil degradation. Focus on soil erosion, the process and speed of nutrient degradation, the process and the evolution tendency of the black soil degradation, soil pollution and restoration, human interference and impact on soil, and the ecological carrying capacity of the black soil resources and so on. They will theoretically guide the prevention and treatment practice work of the black soil degradation, and provide scientific suggestions.

5.3 To carry out ecological restoration research of black soil

More serious polluted areas in the black soil zone are mainly distributed in urban industrial district and joint of urban and rural areas where more agricultural chemicals and chemical fertilizers are applied. As to the polluted soil, measures should be taken such as using ecological principles, establishing pilot demonstration areas, carrying out the chemical fixation-plant restoration technology of the heavy metal contaminated soil, restoring technology of soil

Note: Data from the "black soil zone in northeast comprehensive soil erosion prevention and control work report", December 2006

Table 2: The quantity of water and soil erosion changes before and after the management in the project area in Jilin Province Unit: (t/km²a)

<table>
<thead>
<tr>
<th></th>
<th>The erosion quantity before the management</th>
<th>The erosion quantity after the management</th>
<th>The reduction of soil erosion</th>
</tr>
</thead>
<tbody>
<tr>
<td>The slope farmland</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constructing the</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>level terraced fields</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>90.27</td>
<td>9.98</td>
<td>80.29</td>
</tr>
<tr>
<td>The slope farmland</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Changing the ridge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>216.06</td>
<td>90.27</td>
<td>125.79</td>
</tr>
<tr>
<td>The block</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constructing the</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cut-ditch</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>153.17</td>
<td>9.98</td>
<td>143.19</td>
</tr>
<tr>
<td>Total</td>
<td>459.5</td>
<td>110.23</td>
<td>349.27</td>
</tr>
</tbody>
</table>

Note: Data from the "black soil zone in northeast comprehensive soil erosion prevention and control work report", December 2006
plants-microorganisms which have contaminated by the petroleum hydrocarbons, biologically cleaning technology research of irrigation and agricultural water.

5.4 To establish early warning and management information systems
At present, we are lacking effective long-term monitoring to the black soil degradation, so we suggest choosing representative places to make the accurate monitoring and research on the black soil loss and its evolutionary process, and using 3S technology and other advanced means to establish the black soil zone’s management information systems and to know the black soil degradation dynamic comprehensively. At the same time, we should establish early warning systems and draw up the ecological risk emergency plans.

5.5 Perfect legislation, and enhance the awareness of protection
There are laws to support the protection of the quantity of black soil. However, as to the protection of the quality, the present laws and regulations are not yet perfect, and lack of maneuverability too. We must unify the province’s situation, and organize relevant departments to carry out the investigation and research actively, and formulate related rules and regulations, and then enter the legislative procedure after the conditions are ripe, in order to include the protection of the quality of black soil in the legal system, and to create a good environment to the protection. Simultaneously, aiming at the protection of black soil, we should carry out propaganda vigorously through posters, lectures, films and broadcasting and so on to teach farmers the knowledge of the construction and protection of the shelterbelt, choice of scientific planting structure and rational maintenance of soil and usage of fertilizers, so that people who cultivate this land can treasure the precious black soil resources, and protect the black soil and also realize the sustainable use.

References: