Key Technology of Land Reclamation and Ecological Restoration in Large-scale Coal Mining Area on Loess Plateau During 30 years

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There are 14 coal mining bases in China, and most of them distribute in Inner Mongolia, Shanxi, Shann’xi, etc, where are ecological vulnerable regions in China.
Distribution of Large-scale Opencast Coal Mines Planned by Chinese Government

Such as Heidaigou, Shengli, Baorixile, etc in Inner Mongolia, Antaibao, Anjialing, Donglutian in Shan xi. The coal production of each mine is more than 20 million ton per year.
There are 14 coal bases in China, three of them are in Shanxi: Jinbei, Jinzhong and Jindong coal bases. Pingshuo is the major coal mining area in Jinbei coal base. Mining area has been 180 square kilometers since 1984. Area of 200 square kilometers will be disturbed in the future, which will impact 150 thousand people.
Xiaoping Deng and Armand Hammer

The first opencast coal mine in Pingshuo is Antaibao, which was constructed in 1984 by the cooperation between China and America after the Reform and Opening-up in China. It is a milestone for coal mining industry in China. The second opencast coal mine is Anjialing constructed in 1997, the third is Donglutian constructed in 2006. Besides, there are three large underground coal mines exploited after 2007. Currently, Pingshuo coal mining area is the largest one that combined opencast mines with underground mines in China. It is also the most modernized one with nearly one hundred years of life span and hundred million tons of production per year. The land and environment damage present the trend of point-line-area-net from 1984 to 2016.
The coal production of Pingshuo coal mining area was 10 million ton in 1990, 20 million ton in 2000 and more than 100 million ton in 2010. 160 million ton of raw coal had been produced. At present, one-sixth of the coal production in Shanxi has contributed by Pingshuo coal mining area.
Pingshuo is located on the Loess Plateau. It is 640 thousand km$^2$ plateau and the area is less than one-fifteenth of the whole China. However, the proved raw coal reserves accounts for two-thirds of the whole China.
However, large scale coal mining in this area with such severe natural conditions (i.e. semi-arid climate, wind and water erosion, fragile ecological environment) may cause serious impact on the ecosystem. Meanwhile, some strict cultivated land protecting policies have been implemented in China, such as Balance of Cultivated Land Requisition and Compensation.
In the process of open-cast coal mining, the original landform and eco-system is strongly destructed, at the end, the new landform and eco-system is re-constructed. How are the landform, the soil, the vegetation and the living condition damaged? And how should we re-constructed these elements and eco-system?
The original geological strata groups and landform disappear. During the past 30 years, original landform disappeared and artificial dumping sites were built in a $80\text{km}^2$ area, and in the coming 60 years, $300\text{km}^2$ original landform will disappear.
Soil damage include direct excavation, machine compaction and artificial displacement. Especially, the off-road large trucks cause severe soil compaction, and the soil bulk density can be up to 1.7g/cm³-2.0g/cm³.
During the past 30 years, **60 original species disappeared**, and 98 species were planted. **Over 20 pioneer and adaptive species were selected. Other 30 species** degraded due to extreme weather conditions, spontaneous combustion or competition of species.
The soil erosion modulus of newly built land (dump site) raises from 5000t/km²*a to 15000 t/km²*a. Run off appears in 7min under intensive rainfall intensity, which is 10min earlier than original farmland and 18min earlier than original unused land.
A coal pit with width of 200m and length of 2km was pushing forward 400m each year. There are three coal pits in Pingshuo coal mining area. All villages, schools and factories moved four times in 30 years, involving 16,000 people from 21 villages. The moving seemed to solve the problem that mining caused, but problems of production, living and ecology begin to appear gradually.
**Scientific Issue**

**Issue 1**
How much will the ecosystem be damaged and degraded under the disturbance of large-scale opencast coal mine?

**Issue 2**
What direction and how fast will developed ecological restoration technology promote ecosystem succession in mining area?

**Issue 3**
How is the resilience of the restored ecosystem under the extreme conditions? Whether it would be more resilience than the original ecosystem?
Proposed and verified the Five-Stage Theory of land reclamation and ecological restoration in severely damaged loess coal mining area
1.1 Revealed ecosystem evolution rule in large-scale coal mine area of loess plateau
1.2 proposed the five-stage theory of land reclamation and ecological restoration in mining area
Innovation Point 2

Researched technology of landform rebuilding and soil reconstruction in large-scale coal mine on Loess Plateau
Main Innovation Point

2.1 Technology of landform rebuilt combining platform and slope based on nature imitation theory

Reconstruction of ‘Yuan’-like landform, each cultivated plot is from 0.20 to 0.67km², and 10-30 times larger than the original plot.
Main Innovation Point

2.2 Land saving technology base on integrity of ‘stripping-mining-transporting-dumping-reconsolidating-reclaiming’

Land use rate increased to 70%-90%
2.3 Technology of reshaping micro landform to control erosion and promote water use efficiency

The annual soil erosion modulus is less than 1000 tons/km², 5-8 times less than that of the original land.
2.4 Innovation of soil reconstruction and regulation for quantitative characterization (using CT scanning)

Enrichment of methods to test physical properties of highly compacted soil
2.5 Invention of using weathered coal to ameliorate artificial soil of coal mine in loess area

Yield of reclaimed land increased by 10%-40% with no pollution
Researched technology of vegetation regeneration and ecological diversity reconstruction in large-scale coal mine on Loess Plateau
Long-term and located observations based on sampling from point- quadrat- area- belt transect
3.2 Screened Pioneer and Adaptive Species for Loess Coal Mining Area

10 Pioneer Species and 20 Adaptive Species
3.3 Breaking the Tradition of Using Grass as the Pioneer Plants for Opencast Reclamation.

Vegetation cover increases more than 60, which is 50% higher than that of original land. Water conservation function has been improved greatly.
Constructed optimizing technologies of spatial landscape pattern in compound area of mine-rural-urban
4.1 Monitoring Land Use and Environmental Effect During 30 years

Innovation Point 4

Land use changing maps

Temperature changing maps
Ecological risk increased by 50% after mining, and it decreased by 70% after land reclamation and restoration.
4.3 Constructing green ecological industrial chain and optimizing landscape pattern in compound area of mine-rural-urban

Reclaimed land is up to 3000 ha, and the reclamation ratio is up to 90%
Issues

**答案一 No.1**
The extent of damage and degradation of ecological system under severe disturbance.

**答案二 No.2**
The reversing speed of damaged eco-system by the application of key technologies.

**答案三 No.3**
The intensity of defending natural disaster under extreme climate conditions.

*Publications and appraisal from international experts*

We have answered
More than 200 papers were published on Ecological Engineering, CATENA, Transactions of the Chinese Society of Agricultural Engineering, etc, and there were 38 papers indexed by Science Index, 40 papers indexed by Engineering Index. These papers were referred more than 200 times by SCI/SSCI, and more than 2000 times by EI/CSCD/CSSCI.
Publications and appraisal from international experts

Series books published with high academic impact
Applications and social-economic benefits

6 industry regulations and 1 enterprise regulation

It is effective for pushing ecological restoration engineering in different mines, and it is the important guide for the integration of land reclamation planning and geological environment restoration planning in mines.
Applications and social-economic benefits

Contributions to land reclamation

- Become reference and supporting documents for related laws and regulations (i.e. Regulation on Land Reclamation)
Applications and social-economic benefits

2017年8月12日 央视新闻直播间、东方时空进行相关报道 Achievement on the news on Aug 12th, 2017

山西朔州•绿色发展、绿色生活、让绿水青山成为金山银山 Green development in Shuozhou, Shanxi


- The reclaimed land stands the tests of 9 droughts, 3 floods, 2 fires and 4 plagues of insects in 30 years.

- The method provides experience for local construction of green mining of ecological fragile area, and industrial transformation of resource based cities in 30 years.
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Thank you very much.
Welcome to China University of Geosciences and Pingshuo of China Coal.

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