

# Protection of Reservoir Water Quality Combining with Rocky Desertification Present Situation

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**Abstract.** Middle Route Project of S-N water diversion will be completed this year, and by that moment, the dream of a “stream of clear spring sent to Jingjin” will be come true. The water source of Middle Route Project of S-N water diversion-Danjiangkou water reservoir’s more than half area is in Xichuan town’s Nanyang City. To investigate and protect the environment situation around water source, we have gone deep into many mountains, soil sampling, stone sampling and make chemical laboratory analysis after plenty of preparation work in early stage. We come up with feasible plan about Xichuan area’s rocky desertification, to plant plants with higher survival life in the barren mountain with advanced ways, which can achieve water conservancy on one hand, and on the other hand, to prevent from water and soil loss so as to protect water quality of Dan Jiangkou reservoir.

## 1 Current situation and forming reasons of xichuan’s stony desertification

### 1.1 Basic situation of Xichuan’s stony desertification

Stony desertification is the abbreviation of rocky desertification, and is the extreme form of karst area’s land deterioration. As the stone desertification area’s water storage capacity is low, which can easily lead to drought, water exhaustion, woods decline and soil poor, stone desertification is also called “land cancer”.

Xichuan’s stony desertification spreads around Danjiangkou and drainage basins such as Dan Jiang river, Guan river, Qi river and Tao river,etc, 14 towns which covers about 0.96 million banbo. The annual soil erosion modulus is 41tons/hectare. The mountain rock of Xichuan rocky desertification is mainly limestone, and the soil is mainly ballast soil. As this area is washed by rain water all the year around, the bed rock exposed, gravel buildup, soil thin and woods rare, it is called vividly “black stony mountain” by local people. Our country has no uniform standards for division of stony desertification’s degree yet at present, so considering factors such as objective basis, value basis and theory basis, etc, we achieve the following distinguishing standards[1] in table (1), according to Xiong Kangning and Liping’s <<Remote sensing of Kasite’s stony desertification-GIS classis research—GIS>>. Following is pictures of all kinds of



**Fig.1** mild rocky desertification

rocky desertification taken during Xi Chuan investigation in fig.(1),fig.(2),fig.(3).

### 1.2 Formation cause of stony desertification

#### 1.2.1 Natural Factor

Xichuan belongs to the Southwest of Nanyang basin, and has many mountains ups and downs, peaks rising one after another, ravines crossbar, rock bared, bad water binding capacity, low vegetation coverage and serious water and soil loss, and it belongs to classic mountainous town of limestone mainly.



**Fig.2** moderate rocky desertification



**Fig.3** severe desertification

Normally, limestone’s main chemical composition is as following in table(2): We collected rocks in 22 places in seven towns in Xichuan, and the average content of CaO in the collected rocks is above 60%, which proves that the place we are investigating is carbonate rocky desertification beyond all question.

**Table1.** Index table of impure carbonate rock Karst area’s stony desertification degree division

| Strength grade                   | Bedrock exposure/% | Regolith/% | Gradient/° | Vegetation+bedrock/cm | Average soil thickness/cm | Agriculture use value                                |
|----------------------------------|--------------------|------------|------------|-----------------------|---------------------------|--|
| No obvious rocky desertification | <40                | >60        | <22        | >70                   | >20                       | Suitable for water conservancy                       |
| Potential rocky desertification  | >40                | <60        | >22        | 50~70                 | <20                       | Suitable for forestry and grassland farming          |
| Mild rocky desertification       | >60                | <30        | >25        | 35~50                 | <15                       | Critical suitable for forestry and grassland farming |
| Moderate rocky desertification   | >70                | <20        | >30        | 20~35                 | <10                       | Difficult to use land                                |

**Table2.** Chemical composition content of limestone(%) )

| Name of rock | Si O <sub>2</sub> | Ca O  | Fe <sub>2</sub> O <sub>3</sub> | Al <sub>2</sub> O <sub>3</sub> | M gO  | Mn O   | S O <sub>3</sub> | P <sub>2</sub> O <sub>5</sub> |
|--------------|-------------------|-------|--------------------------------|--------------------------------|-------|--------|------------------|-------------------------------|
| limestone    | 1.01              | 56.27 | 0.27                           | 0.27                           | 0.057 | 0.0065 | 0.009            | Trace amount                  |

Natural factors is the basic condition of rocky desertification's forming. The abundant carbonate in karst area has the features of easily leached and slow soil forming, which is the material basis of forming rocky desertification. High mountain, steep slope and concentrated rain prove erosion power and dissolution conditions for stony desertification.

Strong karst process promotes the forming and development of stony desertification [2]: the quicker corrosion speed not only corrode all of mother rock's soluble constituent, but also takes away most of the insoluble substance and reduce carbonate's soil-building ability.

Stony desertification is often spreaded over pure limestone area [3], and this is because the soluble matter substance not easily to be become in pure limestone is easily to lose, only some soil after weathering. Besides, under present climate conditions, it takes about 0.5 million years to form 1m thickness soil, while as in lack of soil and plants in

Stony desertification area, the karstification is weakened relatively, then the time of forming 1m thickness soil will be much more longer.

### 1.2.2 Hunan factors

The human factor is the main reason for the formation of rocky desertification land.

In the 1950s due to the construction of the Danjiangkou Reservoir, 543000 acres of land in Xichuan inundated(among this 285000 acres is farmland), relocation of 202,000 immigrants (including 127000 million after placement by the county). As mostly farmland were flooded, the after-by immigrants had to steep land clearing, deforestation, cultivation, grazing in order to maintain their livelihood , which leads to the destruction of vegetation, serious soil erosion and the mountain rocky desertification being intensified.

When we had investigation in Biaoichi Town, Jinhe, the elders in the local place told us that there were a large number of virgin forest and some trees had to be encircled by two people in the forties and fifties of last century. In those years of refining iron and steel, a large number of trees were felled for ironmaking, and the whole mountain was almost hacked. People's environmental awareness was very weak at that time, and reforestation projects was not carried out immediately. The mountain has been washed by rainwater through the year, which gives rise to the serious rocky desertification problem at present. Damage of rocky desertification Serious soil erosion, frequent natural disasters Xichuan rocky desertification region's forest ecosystems has been severely degraded, forest soil and water conservation capacity has been weakened and limestone bedrock was corroded and brushed by rain and surface water, and the water and soil loss is severe. With the intensifying of water and soil loss, it results in the loss of much of the land surface and a serious decline in productivity. In addition, due to the rocky desertification land vegetation coverage is very low[4], soil's ability to conserve water is poor, which intensify degree of drought in winter and spring. Water and soil loss leads to land desertification, rocky desertification seriously affects the ability of soil's capacity of water and soil conservation, and this vicious cycle has become one of the major factors in the induction of natural disasters in the region. "when there's rain there's flood, no rain namely drought " is the main feature of rocky desertification area[5].

## 2 Affect water quality of Danjiangkou Reservoir water source

Danjiangkou Reservoir watershed involves Danjiangkou City of Hubei Province, Yun County, Yunxi, Zhangwan etc and Xichuan, Dengzhou of Nanyang including all 16 towns in Xichuan.

According to the tasks indicators Nanyang Municipal Environmental Monitoring Station have been completed within the monitoring in 2013[6], now most of the rivers within Xichuan territory belong to II Grade water quality, some individual rivers belong to Grade III water quality. Namely, now most of the water quality of the river water diversion is in full compliance with the requirements. However, the soil test results show that most of the soil samples we got are acidic soils. The pH value of Large Shiqiao's three sampling locations[7] are as following table (3).

**Table3** Average ph value of soil sample in Yangying town DaShiqiao

| Sampling site | Dashiqiao Yangying adjacent foothills | Dashiqiao Yangying adjacent mountainside | Dashiqiao Yangying hilltop neighborhood |
|---------------|---------------------------------------|--|---|
| pH value      | 6.5                                   | 6.5                                      | 6.4                                     |

Elevation of these three borrow points respectively H = 176m, H = 204m, H = 281m. Getting ten soil samples within a certain range of each earth point to ensure that the measured results eliminate certain chance. To finish the Danjiangkou Reservoir water supply, its water level needs to reach an altitude of at least 170m, so all of the areas within Yangyin town adjacent mountain have huge threat to water quality of Danjiangkou Reservoir potentially.

Xichuan Danjiangkou reservoir has drainage area of 2616 square kilometers, and takes 56.9% of the total basin area. Rocky desertification within Xichuan caused serious soil erosion, a lot of soil and sand flow into Dan Jiangkou Reservoir, which on one hand leads to reservoir water turbidity and nitrogen exceeded; on the other hand, it causes reservoir sedimentation. Statistics show that for 20 years from 1960 to 1979, the total sediment of Danjiangkou reservoir area is

897.155 million cubic meters, with an average annual deposition of 44.86 million cubic meters, which has seriously affected the service life of the reservoir.

### 2.1 Affect people's production and life, economic development and social stability

As we have learned from the County Land Resources Bureau, Xichuan's arable land is not rich originally, and nearly 14 acres of Xichuan's arable land was submerged after the Danjiangkou reservoir was built and completing water diversion, which make the original not rich arable land become stretched.

This town losses 2.2 million tons of soil due to rocky desertification, water and soil loss on one hand leads to deficiency of large amounts of nitrogen, phosphorus and potassium nutrients, one the other hand exacerbates land barren, declines arable land and conflicts between people and land in the reservoir become more prominent. Currently, the county's average per person farming is less than 0.8 acres, of which more than 10,000 people less than 0.3 acres of arable land per capita; on the other hand, rocky desertification's water source is dried up during winter and spring, which not only affect agricultural irrigation water, but also cause difficulty in drinking water for people and animals. Up to now there are seven impoverished townships of the county, 60 poor villages, 85,000 poor people, of which 2.3 million can't even solve the basic food and clothing problem, and this have severely affected social stability.

## 3. Governance program of stony desertification

### 3.1 Existing prevention measures of Xichuan

First, intensify propaganda, close hillsides to facilitate afforestation. Take measures of closing hillsides to facilitate afforestation for areas of lighter degree. Slight rocky desertification can adopt moderate grazing.

Second, take moderate reforestation activities according to the existing land conditions of the mountains. For middle-degree rocky desertification areas, Xichuan will take large-scale afforestation activities from March to April each year, and most of them are arborvitae trees.

Third, explore the rescue plan of rocky desertification land actively. There's no complete programs for severe rocky desertification area at present yet. Policy, technology, finance, specific management modes, etc. are all constraints.

### 3.2 Put forward prevention measures for rocky desertification aiming at investigation conditions

#### 3.2.1 Prevention measures of mild stony desertification issues

To offer the problem of slightly rocky desertification appropriate policy guidance, then its development can be relatively easily to be controlled. First of all, the local forestry sector can continue to adhere to the basic policy of critical grazing farmland eliminate grazing. Large-scale farmers can be guided around town to develop aquaculture, and carried out large-scale farming. Administrations can carry out matchmaking between multiple households, so that a certain number of farmers to unite and establish cooperatives, introduce advanced management and technology, and make use of Xichuan's geographical advantages to create a group of local characteristics aquaculture industry.

Second, local forestry sector can carry our management innovation on the basis of the original policy. Slight rocky desertification mountain areas does not mean can't conserve any water source, but need a certain growing conditions. The famous Fussen Pharmacy in Henan Province has an annual output of nearly 400 million yuan, and Chinese medicine raw materials has very large gap. Growing herbs requires special mountain climate, Xichuan county

government is totally able to make policy concessions, reach certain agreement with Fussen Pharmacy, first try to grow moderately in a small range of Chinese herbal medicines, and then allow Fussen medicine for large-scale cultivation of needed medicines after obtaining some results in accordance with relevant laws and regulations, which is threefold thing. In this way, rocky desertification can be effectively prevented from developing into moderate desertification and severe rocky desertification, can create a considerable part of the profits for the company, can promote local rural labor force.

In the course of the investigation, we take back a lot of soil samples in the local rocky desertification mountain and make analysis. After laboratory analysis by Soil and Fertilizer Station of Nanyang City, the organic matter, nitrogen, and phosphorus contained in the soil are very considerable. As long as the climate is suitable, planting ordinary herbs is not a problem in general. For example, golden cypress, berberine, magnolia and plum are all very suitable for growing [9].

Xichuan's Slight rocky desertification area is 827000 hectares, which accounts for more than one-third of the total area of rocky desertification. If we make good use of all these woodlands, its economic profits and environmental effects can not be underestimated.

### *3.2.2 Solutions of moderate and severe rocky desertification problems*

Some of the severe rocky desertification areas are directly high mountains, some places are like slopes, and some are fundamentally barren stone ground. The problem we need to solve is how to make these rocky desertification areas own soil, and use what ways to conserve the soil. If we manage to solve these two problems, the problem of rocky desertification half will be settled half.

#### *3.2.2.1 Governance model should be innovated*

To change the situation of low survival rate of planted trees, it is necessary to abandon this backward cultivation methods, and forest planting can adopt the method of responsible woods for planting. Xichuan has many river network and the groundwater can completely be utilized, and they can directly drill a vertical shaft in the side which can solve water problem. Our country has made great achievements in the governance of rocky desertification, and gave birth to a large number of forestry companies living on dealing with stony desertification exclusively in the meantime of making achievements. They carry out desert tourism economy in the original rocky desertification area and has very good effect. Forestry can make contact with these companies achieving results, emulate the governance policies during desertification control, give appropriate concessions and jointly govern the rocky desertification problem relying on those companies' superior technology, personnel and financial strength.

#### *3.2.2.2 Specific measures of dealing with moderate and severe stony desertification*

In order to completely solve the rocky desertification problem, we must not let the bare bedrock exposed. In the research process, we saw a lot of arable land has been hoarding in one place. These earthworks was about 3-5 meters above the ground, with an average size of two football fields. Grass mats wove by straw are covering around all sides of the soil from bottom to the side to prevent from loss of soil. There are many earthworks like this piled in the total Xichuan, and by people's maintenance after transforming these soil to a specific location, we can not only prevent the soil from losing, but also keep it a certain fertility. In the future, these soil will be moved to relatively barren land area, which is the famous Xichuan fertilizing project.

Then why need to dig these soil? Now Danjiangkou

Reservoir water level is at an altitude of 142 meters, if store water, its water level will reach at least 176 meters, therefore, Xichuan has made immigration of nearly 200000 people. The digged and transferred soil is immigrants' arable land. Once the farmland is flooded by the reservoir, the water is bound to absorb soil nutrients, cause eutrophication of water bodies, especially exceeded nitrogen which will seriously affect water quality and safety and cause water turbidity; on the other hand, after so many soil is flooded, it will definitely cause a lot of sediment deposition in the reservoir area.

County government and relevant department can actively communicate with companies having successful treatment experience in stony desertification, invite professional forestry technician, soil and water conservation specialists, planting technicians, soil laboratory staff to form an expert team to the county for more deep, comprehensive and detailed research; these research can be used in the method of combining government and the relevant agricultural forestry companies who are interested. Thus, on one hand, the government can reduce some of the financial burden; on the other hand, related companies can get first-hand information on investigation and research, and the government and departments can both make the first judgment according to related research report.

The local government departments can provide a range of land, soil and other preferential policies when the agriculture and forestry companies take advantage of rocky desertification issue to do scale cultivation. Administrations can sign dedicated rocky desertification land use agreement with the agriculture and forestry company, and the agreement can clearly define that the agriculture and forestry company have to be engaged in economic activities related to rocky desertification treatment and both sides should implement according to the terms of the agreement.

In the first two years when the land was originally approved, the agriculture and forestry companies can quickly perform "experimental field" according to survey results. "Experimental field" can be carried out in layered manner.

The first step is to find ways to solve the problems of soil covering the bedrock on the rocky desertification mountain. It is obviously not practical to cover every place in the stony desertification area with uniform soil. The feasible solution is not to require covering every inch of rocky desertification bedrock with soil, but use some engineering measures - to establish a proper platform for accumulation of soil, so that the soil has a stable "foothold". In order to achieve better water and soil conservation, the tilt angle of the "starting point" must be different from the hillside. If the vertical distance between the two "footholds" keeps at about 10 meters, then the effect will be very good.

The second step is to solve the problem of selecting what plants to grow [9]. Grow plants of different species that can produce economies of scale in different zones, which in the present situation is one of the more viable options. We measured its soil pH is normal, not acidic [8]; the local climate in winter and spring is still very dry, so Xichuan's mountain area is not suitable for growing trees.

According to the agriculture and forestry staff, the output of pepper, walnuts, pomegranate is very commercially viable, but this method did not continue.

We adopt advanced management mode, and the introduction of companies can be a good solution to this problem. After research we found that the late economic effects of these crops do not show up, and the main reason is still a lack of water resources. After discussion, the final solution is that the agriculture and forestry companies build a large reservoir in the peak; then establish a comprehensive crop water irrigation system. In this regard, Israel has the world's leading advanced drip irrigation technology, and we can actively refer to their mature technical experience [10].

All in all, government support needs policies and companies rely on policies for financial investment; the local people can gain some income from this and are willing to take participation in, which can be said to be the secret of solving stony desertification problems.

## 4 Conclusion

Our country has made great achievements in the treatment of land rocky desertification, and the gradually emerging desert tourism and "comprehensive economic profit in desert" is just our successful experience in prevention and control of desertification. From these experiences, we can actively absorb and utilize in the treatment of rocky desertification. In summary, according to the successful treatment experience in land rocky desertification, we should do well in the following points for dealing with rocky desertification: rocky desertification can cause great impact on the water quality of Danjiangkou Reservoir, and it is also a very negative factor for the water level guarantee of the Danjiangkou Reservoir. To completely solve the problem, there must be in need of government's policy support, society's positive participation, raise awareness while dealing with rocky desertification and strengthening research; scientific verification, deep analysis; improving effectiveness of governance relying on science; improving the monitoring system and implementation of dynamic monitoring. Ensure the treatment to be carried out in stages and step by step, and only in this way, can the wish of a steady stream of clear spring to be conveyed to Beijing and Tianjin come true.

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