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Sand Control Engineering for Protecting the Salt Lake against Shifting Sand

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ABSTRACT

Most of the salt lakes lie in the arid deserts in the northwest of China, Inner Mongolia. Some have now been buried by shifting sand. Although the area of Jilantai Salt Lake is 120 km^2, at present only an area of 37 km^2 is useful for salt production. However, nearly one third of the salt mine (11.98 km^2) has already been buried by approximately 9,350,000 m^3 of sand. The quality of the salt is declining because of sand contamination, thus salt production is becoming more difficult and the cost of production is increasing. According to the forecast of some specialists, within 30 years the lake will be covered by a 0.5 m thick layer of shifting sand.

Sand control and windbreak engineering have been carried out since 1982 by salt workers. Fences have been constructed to enclose forest land to protect the original landform and to promote the growth of natural vegetation. The engineering included two kinds of biological and mechanical sand fixation and a new method has been explored in which highly mineralized water was used to control sands. For example, with the help of the moving spray method, a large area of sand was watered with a mineralized solution at a temperature of –17°C, so that the surface of the dunes froze hard like sand fixation by chemical means. After several years of control engineering, the area of vegetation around the lake is increasing. The environmental condition is improving, the speed of the shifting sand has slowed down and exploitation is prolonged.

INTRODUCTION

In northwest China, Inner Mongolia, there are more than 380 lakes which include salt, alkali and nitrate. The total area is 1,500 km^2. The total salt reserve is about 860 million t. Most of those lakes are located in desert and semi-desert zones and are being damaged by shifting sand which harms the production of salt. Accordingly, the control of the shifting sand was an extremely urgent problem. Since 1982, our saltworks has been cooperating with Professor Zhang K.B., of the Department of Desert Control, Inner Mongolia Forestry College, in carrying out this engineering in Jilantai. After 6 years' work, we found an efficient and practical way to control shifting sand.

EXPERIMENTAL AREA DESCRIPTION

Jilantai Salt Lake is located 39°40′N, 105°30′E and is a typical temperate interior desert region with a dry climate. The area has an average annual rainfall of 109.9 mm and average evaporation of 3023.7 mm. The area is windy and sandy. The western, northwestern and northeastern parts of the salt lake are surrounded by the Ulanbuhe Shamo desert. In general, the height of the dunes is 5 to 10 m. The frequency of blow to move sand (annual average speed is over 6 m/s) is 272 times in one year. Windy days (wind speed is over 17 m/s) are 58 days in one year. The maximum wind speed is 24 m/s. Main harmful direction of wind is northwest. The main soil is grey desert soil and other soils are: aeolian soil, saline and meadow soil. Desert and halic vegetation are the major component. The constituting species are:

Haloxylon ammodendron, Ammopiptanthus mongolicus, Reaumuria soongoria, Kalidium foliatum, Nitraria tangutorum and Psammochloa villisa and so on.

Before the 1960s, there were 70,000 ha of natural *H. ammodendron* around the salt lake, but they were almost destroyed in the early 1970s (Zhang, 1988). The shifting sand then increased and entered the salt lake at a rate of 33.27 m per year. According to an investigation in 1980, a 5.2 km^2 area of salt deposit or 14% of the whole area was covered by sand during the preceding 10 years. By 1983 it had increased to 29%, an area of 5.59 km^2, i.e. it had doubled during the 3 years. The sand accretion was 9.355 million m^3. At this rate of expansion, the entire Jilantai Salt Lake would have been covered by 0.5 m of sand in 30 years (Geng and Hu, 1989; Wan, 1989). However, from the beginning of the control engineering in 1983 until 1986, the rate of sand accretion on the salt lake had decreased more than 2-fold and only an area of 1.18 km^2 was enlarged. By 1987 the shifting sand had been controlled.

MAJOR TECHNICAL METHODS

Enclosure

The dunes were enclosed by fences and trees were planted. Fences were erected around the control area to protect the natural vegetation against damage by men and animals and to provide better environmental conditions for vegetation.

Supplemental planting

Trees were planted on the shifting dunes and bare land to maintain the original landform and natural vegetation. The combination of artificial and natural vegetation can form a complex forest structure of which can enhance the sand fixation effects.

Spray irrigation

Some mechanically-pumped wells were dug in the fenced plot of the experimental area to irrigate the artificial and natural vegetation in order to promote the growth and regeneration of vegetation. For economical and efficiency reasons, especially for complex desert conditions, some technical points were considered and some difficult problems were resolved in this engineering, such as arrangement and design of well site, well distance, well yield and water pipe line, types of pump and sprinkler head, size of spray nozzle, method of irrigation and so on. We decided to use a moving spray whose head and pipe can be moved conveniently. Slip knots are used between any two sections of pipe and the pipes can be easily assembled or disassembled in order to make the pipe line transport water in good condition without rusting knots.

Spray irrigation in winter

This is a new and practical way to control sand in this region. The coldest month is January in Jilantai, the mean monthly minimum temperature is –17°C. The key point of winter spraying is prevention of freezing around the pipe and sprinkler head so a rubber pipe was used. If the pipes froze, they could be beaten and the ice would crack and loosen. In addition, the sprinkler head has five nozzles with fixed spraying direction. When the temperature is at –24°C, the pipe cannot freeze due to the high speed of spraying.

Construction of clay barriers

Clay barriers were erected on the dunes around the salt lake to fix moving sand and trees were planted there.

Promoting a diversified economy

Various economic activities such as planting orchards and vegetable gardens, building fishponds, pig farms and chicken farms etc. were introduced. Intercropping of herbage and grain crops was also recommended in the orchards.

RESULTS AND CONCLUSIONS

By applying the above methods over an area of 22 km^2 of the experimental plot, some results such as recovery speed of vegetation, growth of vegetation and economic benefits were achieved.

1. The conservation of the original landform and natural vegetation made a good environment for recovery of vegetation and tree growth. Work on dune preparation was avoided, so a high cost was saved. The cost of dune preparation was calculated to be 14.3 times higher than that for direct planting without dune preparation. In addition, tree plantation on dune or bare land could form a mixed forest. The complex structure of trees was a good environment for vegetation growth and also to attain the goal of sand fixation ahead of time.

2. The moving pipe spray irrigation technique replaced other irrigation methods including flood irrigation, drip irrigation and infiltration irrigation in this area. These would have been quite difficult to organise in the desert and the irrigation area was small. The cost of spray irrigation was low; the total cost (including equipment) was 20% that of flood irrigation and 25% that of infiltration irrigation. Spraying gave better results than other methods, for example, in one experimental plot with 20% plant coverage after spraying 4 times in spring and summer, the coverage increased to 52.06% in September of the same year, but with drip or infiltration irrigation methods, the increment of vegetation coverage was low except for some heavily watered trees or shrubs.

3. Spraying in winter was carried out from last 10 days of December to mid-March of the next year during which period the average temperature was below –17°C. This solved many problems as follows:

TABLE 1

Rate of herb recovery

Species	Plot	Average height (cm)	Average crown cover (m^2)
Agriophyllum arenarium	A	36.2	5.17
	B	12.19	0.8
	C	3.8	0.06
Peganum harmala L.	A	18.3	0.34
	B	14.1	0.25
	C	8.0	0.24
Psammochloa villisa	A	94.3	
	B	71.6	
	C	50.6	
Phragmittes communis	A	86.4	
	B	32.6	
	C	5.01	

(a) Productivity and utilization of facilities was increased, even winter workers were able to be employed.

(b) There was an ice layer 26 cm thick on the surface after winter spraying, In the next spring the melted ice promoted the survival rate of trees (to 20%), relieved the stress on the water supply in spring and created conditions for enlarging the area of planting.

(c) The frozen land surface prevented a dune from moving during the winter period in the same way as chemical sand fixation.

(d) The leafing stage of trees was promoted to 3–5 days ahead of time.

4. Through the utilization of these methods for 3 years, great results such as regeneration of natural vegetation and increase of recovery were achieved (Zhang, 1983; Zhang and Zou, 1990) (see Tables 1–3).

Until 1990, shifting dune around the salt lake was fixed and no sands could enter the salt lake.

In addition, the combination of enclosure protection and artificial improvement measures helped

TABLE 2

Increasing of vegetation coverage in plots (%)

Period	Spray irrigation	Enclosure	Supplemental planting	Full-scale reforestation	Check plot
Before 1983	20	20	20	0.4	15
1983–9	52.06	35.75	26.0	8.54	13.04
1985–6	48.03	39.44	34.3	19.01	9.62
1986	54.0	41.6	45.0	27.5	6.89

TABLE 3

Plant growth in different plots

Species	Plot	Average height (cm)	Average crown (m)	Length of first year's branch (cm)	Density (number of tree/m^2
Nitraris targutorum	A	65.6	26.1	38.8	23
	B	53.7	17.5	28.1	16
	C	33.4	8.1	16.6	10
Ammopiptanthus mongolicus	A	102.8	2.10	15.7	0.20
	B	88.4	1.71	5.6	0.33
	C	80.0	1.40	5.2	0.11
Haloxylon ammodendron	A	157.7	3.21	62.2	0.002
	B	146.3	1.52	38.7	0.005
	C	70.8	0.23	17.3	0.0025

A: Spraying irrigation plot.
B: Closed forest plot.
C: Check plot.

natural vegetation recover rapidly. The effects of windbreak and sand fixation increased greatly and the load of wind decreased. Based on field measurements under the condition of wind velocity of 7–9 m/s, the load of near surface (<10 cm) is 0.038 g/min·cm^2 in the check plot and 0.0097 g/min·cm^2 in the enclosure plot, 3.9 times more in the check plot than in the enclosure plot (Wang, 1989; Mas, 1990). Supplemental planting to the natural vegetation decreased the area of reforestation and attained the effects of windbreak and sand fixation 2 years ahead of time. By the end of the control engineering (1987), no shifting sand damaged the salt lake. Throughout the project, especially spraying, the water table around the salt lake was raised by nearly 1 m and this had an indirect effect of refilling the bittern and promoting the water table for salt lake.

5. Through the control project for shifting dune, there was a suitable environment for diversified economy. Each year it produced 150,000 kg of vegetables, 23,000 kg of fruit and about 20,000 chickens, fish, eggs and pork, etc. which partly met the food needs of the salt workers. As to ecological benefits, the local microclimate had clearly been improved; shifting sand could no longer enter and cover the salt lake; moving sands disappeared from the streets of the town; trees flourished everywhere; the scent of flowers and fruits wafted in backyards and the local inhabitants have seen the coming of green scenery.

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