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THE MAIN METEOROLOGICAL FACTORS OF FORMATION AND DEVELOPMENT OF MIRE MEADOW OF QINGHAI LAKE DRAINAGE AREA

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ABSTRACT: Qinghai Lake is located in the northeastern Qinghai-Xizang(Tibet) Plateau. It is an especially big light saltwater lake. The mire meadow in Qinghai Lake drainage area is an eco-system which is affected by the eco-environment factors. Its formation, development and temporal and spatial distribution law are decided by a few main meteorological factors in the eco-environment to a certain extent. The main meteorological factors are ≥10℃ accumulated temperature, precipitation from May to September and annual humidity coefficient. The mathematical model of the mire-wetland rate and the main meteorological factors is given by multivariate linear regression in the paper.
KEY WORDS: Qinghai Lake drainage area, formation and development of mire, meteorological factors

I. INTRODUCTION

In the paper, the wetland in Qinghai Lake drainage area means the mire meadow in the region. Its formation and development are closely related with the humid environment of the area, while the law of its temporal and spatial distribution is decided by some main meteorological factors in the eco-environment to a certain extent. They are precipitation, accumulated temperature and annual humidity coefficient.

The mire meadow in Qinghai lake drainage area is formed in the cold and humid climate condition. The mire meadow is formed in the piedmont and alluvial fans, at the both sides of the rivers, or at the lakeside, and the areas where ground water is exposed, or surface water is accumulated at smooth depressions. According to MSS images and TM images in some regions

as well as color infrared aerial photographs, we obtained the distribution map of mire meadow in Qinghai Lake drainage area(Fig. 1) .

The past studies on the meteorological factors of Qinghai Lake drainage area are almost qualitative analysis. Referring to the past study results(Chen, 1995) , the quantitative analysis is adopted in the paper. The studies are not only important for expounding the mechanism of the formation and development of wetlands in Qinghai Lake drainage area, but also have practical values for rationally opening up and utilizing the wetlands in Qinghai lake drainage area.

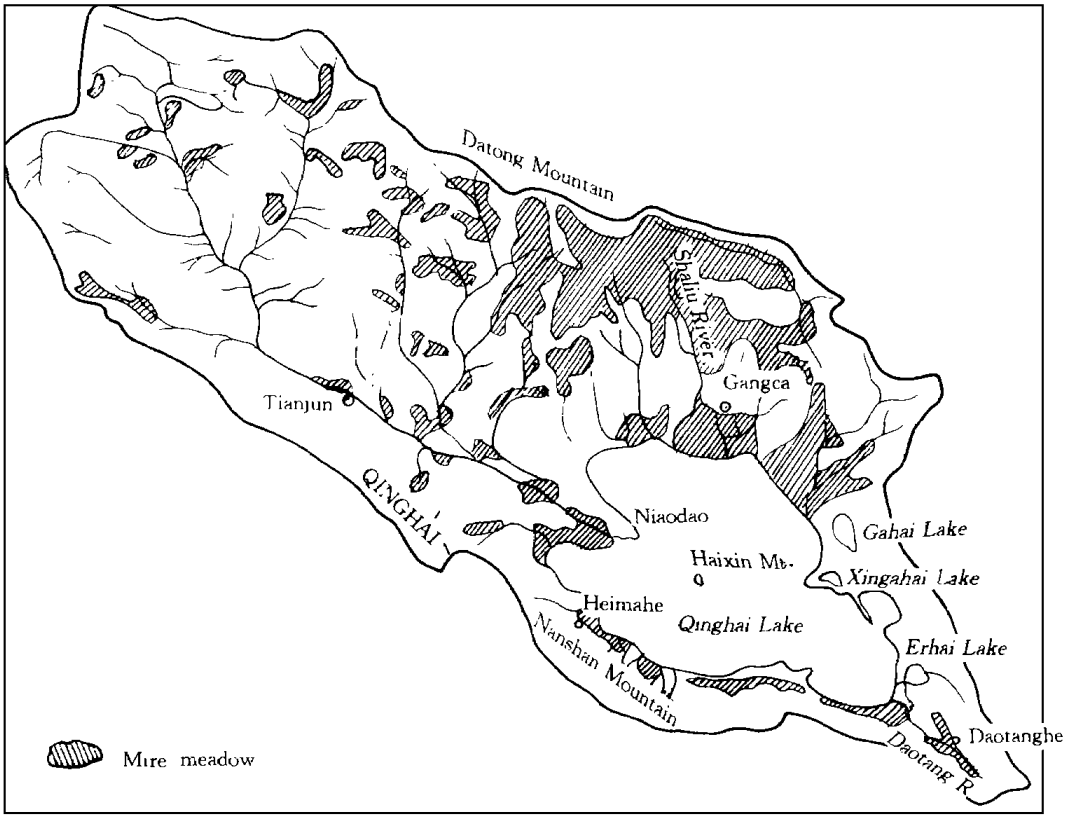

Fig. 1 Distribution of mire meadow wetlands in Qinghai Lake drainage area

II. THE BRIEF INTRODUCTION OF QINGHAI LAKE WETLAND

In the both views of ecology and economy, wetland is the most valuable eco-system with the highest products in China(Lu, 1990) . It should be protected, but this important natural resource is not protected in reality. By the statistical data, 40 percent of Chinese wetlands is damaged seriously, the wetland in Qinghai Lake area is one of them (Lu, 1990) .

Qinghai Lake is a huge plateau lake about which the world cares. It can regulate eco-system in the east part of Qinghai Province. Because it is between Qaidam desert and Huangshui river valley, the influence of the west desert climate to the east is alleviated and the east agri-

culture region is protected. If the water body was abating or vanishing, the east agriculture region should be damaged by the desert. Qinghai Lake is a fishing base and sightseeing spots in Qinghai. The region around Qinghai Lake produces carps of 4000– 5000 tons per year (Jin, 1995). There are 163 kinds of birds. By the statistical data, there are more than 100 000 birds in the bird-island. There are more than 36 kinds beasts. There are 53 categories of phytoplankton, 25 kinds of zooplankton, and 22 kinds of benthon in the lake. Because it has rich biodiversity, Qinghai Lake have been listed into the main international wetland list, so is good for protecting the wetland in Qinghai lake drainage area. The wasteland around the lake was opened up with extensive cultivation, then given up soon for grazing. The fishing and hunting are too excessive. Recently, some rivers flowing into the lake are polluted. Although Qinghai Lake Nature Reserve was set up in 1975 and the bird- island administration of Qinghai Lake Nature Reserve was set up in 1984, the protection is not efficient.

The mire meadow in Qinghai Lake drainage area is one component of Qinghai Lake wetland. Because of excessive grazing, it is damaged. Using the investigation data for many years, we studied this wetland type——mire meadow in the paper.

III. ENVIRONMENT SURVEY

Being situated in the northeast part of the Qinghai-Xizang Plateau, where Haibei Autonomous Prefecture is bounded by Hainan Autonomous prefecture, Qinghai Lake is the largest lake in China. Qinghai lake drainage area lies between 36°15' N – 38°20' N and 97°50' E– 101°20' E. Qinghai lake lies between 36°32' N – 37°15' N and 99°36' E– 100°47' E. It is 109 km long from west to east and 65 km wide from north to south, and perimeter 360 km. In 1988, it remained at 3195.59 m a.s.l, with an area of 4304.5 km^2 and volume of 73.88 billion m^3. The average water depth is 16m and the deepest 27 m. In the eastern side of the lakes, there are Gahai, Xingahai, and Erhai Lake, among which Gahai Lake is the largest one with an area about 48 km^2. There are Haixinshan and Sankuaishi (Guchashan) islands in the lake. Qinghai lake belongs to neotectonics fault lake. It is a light salt water lake and mountains surround it. So it becomes an enclosed inland drainage area. The main rivers are Buh, Shaliu, Hairag, Ganjig, Lima, and Daotanghe rivers.

Qinghai Lake basin is high in northwest and low in southeast. The main geomorphic types from low to high are lakeside plain, alluvial and diluvial fan, low mountain hill and high mountain, and wind-drift sand landform in the northeast basin. Qinghai Lake drainage area has obvious plateau continental climatic characteristics, which means cold and windy. The annual sunshine duration is more than 3000 hours. The average annual temperature is 0.3– 1.1℃, and average precipitation is 384.6 mm, while evaporation is 1378.7 mm. The direction of wind is almost northwest, the average annual windy day is 76.8 days.

The wetland mainly lies at northwest part of Qinghai Lake drainage area, especially gets together at northern shore of Qinghai Lake (Fig. 1)

IV. THE FORMATION AND DEVELOPMENT OF MIRE MEADOW AND THE CATEGORY OF COMMUNITY

The mire meadow belongs to intrazonal vegetation. The hygrophyte and perennial plants are the main vegetation types. The main mire meadow vegetation is *Blysmus sinocompressus*, *Scirpus distigmaticus and Kobresia schoenoides*. Because it is very cold in the vegetation distribution area, there is a frozen earth layer under the ground so that the water in the soil cannot permeate. In the process of the thawing, the water content in the soil layer increases and the soil is very wet. There is accumulated water in the earth surface all year so that the mire meadow has been formed and developed.

The mire meadow plant community types in Qinghai Lake drainage area are as follows (Chen, 1992):

1) *Kobresia schoenoides* community is distributed at 3500– 4200 m a. s. l. in northwest Qinghai Lake where it is flat river sources and both banks of the rivers are very low. These rivers are Buh, Shadu and Hairag rivers. The distribution area of the type is the largest and its elevation is the highest.

2) *Carex stenophylloides* community is distributed at 3200– 3500 m a. s. l. in the lowlying area besides the rivers or the area where underground water is overflowing.

3) *Blysmus sinocompressus* community is distributed at 3198– 3400 m a. s. l. in the low land where it is in the front of alluvial and diluvial fans and the underground water is overflowing, or in the river delta area. At the same time, the odd one is distributed in the flat area of the col of the high mountain where the mountain slope runoff gets together. The soil water is supersaturated or there is stagnant on water. The community is also common in the flat rivulet area. It is a dominant luxuriant plant. Sometimes there are tracts of pure Blysmus sinocompressus community.

4) *Scirpus distigmaticus* community is distributed at 3198– 3250 m a. s. l. in the both sides of the rivulets of the lakeside around the lake. Its distribution area is small. It is a dominant luxuriant plant.

5) The miscellaneous grass community is the mire meadow near the lake. Triglochin palustre is the advantage community. The variation range of its covering rate is big, usually 25% and 85%.

V. CLIMATE WORSENING, LAKE LEVEL DECLINE ACCELERATING, AND ECO-ENVIRONMENT DETERIORATED

By the present available data, the lake surface was about 8200 km^2 in the heyday, twice of today's. The lake level has been fluctuating, but the general trend is continuous decline (Zhou, 1992), so that the lake is getting smaller and smaller. According to the interpretation to the aero– photos and data by Remote Sensing Station of Qinghai Province the lake surface was

4583.9 km^2 in 1956, 4450.5 km^2 in 1972 and 4304.5 km^2 in 1986. From 1956 to 1986, the lake had been cut down by 279.4 km^2, with a reducing velocity of 9.3 km^2/a, among which it had reduced 134.4 km^2, with a velocity of 8.3 km/a from 1956 to 1972, and reduced 146 km^2, with a velocity of 10.4 km^2/a from 1972 to 1986. The lake level remained at 3196.94 m a.s.l. in 1986, with a declining velocity of 10.53 cm/a and water reducing volume of 0.46–0.49 billion tons.

By the surveying data of Qinghai Province General Hydrometric Station, it is also known that the lake level was 3195.55 m a.s.l in 1959, 3193.59 m a.s.l in 1988, with a reducing velocity of 9.87 cm/a. From 1959 to 1972, the lake level declined 1.08 m, with a velocity of 8.3cm/a, and from 1972 to 1986, declined 1.88 m, 11.75 cm/a.

By the above mentioned data, it can be found that the declining velocity of Qinghai lake level after 1972 is faster than that before 1972. The main source of Qinghai Lake water is precipitation. The continuous decline of the level shows that the income of the lake water is less than its expenditure, which is caused by the arid and windy climate. According to the data of Gangcha County Meteorology Observatory Station, the mean annual precipitation in the 1970s was 5.2 mm less than that from 1958 to 1980, and the precipitation from 1976 to 1980 was 28.3mm less than the average in the 1970s. In the meantime the mean annual evaporation in the 1970s increased 36.3 mm compared with that from 1958 to 1980.

VI. THE SELECTION OF THE MAIN METEOROLOGICAL FACTOR INDEXES OF FORMATION AND DEVELOPMENT OF MIRE MEADOW

On the basis of qualitative analysis, the selected main meteorological factors should be those which directly restricted the formation and development of the mire meadow. The wetland rate is selected to represent the quantity index of the formation and development of the wetland environment in Qinghai Lake. The wetland rate can show the synthetical action of the meteorological factors on the formation and development of the wetland environment. First, the mire wetland formation is decided by hydrological condition, and then thermal condition. The low temperature is good for the development of the mire meadow. The mire meadow of Qinghai Lake drainage area is the outcome of cold and wet climate. According to the common indexes of meteorological factors of the formation of the ordinary wetlands and data now available in Qinghai Lake drainage area, three variables are chosen, they are the precipitation from May to September, annual humidity coefficient, and $\geqslant$10 ℃ accumulated temperature.

VII. THE MIRE WETLAND RATE AND ITS MATHEMATICAL MODEL

According to $\geqslant$10 ℃ accumulated temperature, precipitation from May to September and annual humidity coefficient of the main meteorological station in the mire meadow distribution area in Qinghai Lake drainage area and nearby regions, such as Tianjun, Haiyan, Jiangxigou,

Gonghe, in 30 years(1960– 1985), the mathematical model of the main meteorological factors of the formation and development of wetland environment in Qinghai Lake drainage area are obtained.

$$Y = 1.1154 - 0.0022X_1 - 0.3402X_2 + 6.78 \times 10^{-6}X_3$$

where Y is mire wetland rate, X_1 is the precipitation from May to September, X_2 is annual humidity coefficient, X_3 is ≥10℃ accumulated temperature. Because of F> F0.01 on the 0.01 level in Table 1 of the analysis of variation, the mire wetland rate is linearly related to the main meteorological factors. It shows that the mire wetland rate in Qinghai Lake drainage area is restricted by the precipitation from May to September, the annual humidity coefficient and ≥10℃ accumulated temperature.

In Table 2, the simple correlation coefficient of ≥10℃ accumulated temperature is – 0.7364, is the highest; while those of precipitation from May to September and the annual humidity coefficient are lower, they are 0.6235 and 0.4564 respectively. That of ≥10℃ accumulated temperature is minus, it means that the higher temperature damages the condition of the development of the wetland, in other words, that means that it restrains and retards the formation and development of the mire meadow environment in Qinghai Lake drainage area. The simple correlation coefficients of the precipitation from May to September and the annual humidity coefficient are positive. These two factors are the dominant ones. Because the mire meadow of Qinghai Lake drainage area is a natural synthetical body and the product of the integrative effect of the main meteorological factors, the simple correlation coefficient cannot express the essential relations between the main meteorological factors and the mire wetland rate.

Table 1 Analysis of variance

Source of variance	Square sum of discrepancy	Degree of freedom	Average square sum of discrepancy	F rate
Regression	1.84×10^6	3	6.13×10^6	
Residual	1.18×10^6	20	5.96×10^4	10.3
Total	3.02×10^4	23		

In Table 2, the multiple correlation coefficient of the precipitation from May to September and the annual humidity coefficient to the mire wetland rate is 0.9211, that of the precipitation from May to September and the accumulated temperature to the rate is 0.9694, that of the annual humidity coefficient and ≥10℃ accumulated temperature to the rate is 0.8998. The three multiple correlation coefficients are positive. This means that the associa-

Table 2 Simple and multiple correlation coefficient

Simple Correlation Coefficient	Multiple correlation coefficient
0.6235 (X_1 to Y)	0.9211 (X_1, X_2 to Y)
0.4564 (X_2 to Y)	0.9694 (X_1, X_3 to Y)
– 0.7364 (X_3 to Y)	0.8998 (X_2, X_3 to Y)

tion of any two factors is more useful than a single factor to the formation and development of the wetland environment in Qinghai Lake drainage area.

The distribution of the precipitation in Qinghai Lake drainage area is not even, concentrated from May to September, which makes up 80% of the annual precipitation. The temperature is going up quickly from May. The hydrothermal condition coordinate harmoniously. ≥10℃ accumulated temperature is suitable for the mire meadow growth and soil formation.

The mire meadow in Qinghai Lake drainage area is at 3200– 4200 m a. s. l with cold weather. There is a frozen earth impermeable stratum formed for many years and there are many ice crystals melt in the process of thawing. The liquid water content increases in the soil. The lower part of frozen earth impermeable stratum prevents the melted water from permeating. The precipitation gets together in the soil. The accumulated water is formed in the surface of the earth. The helophytes and hygrophytes grow thickly. Because the aeration and permeating of the soil is not good, the gleization is formed gradually, and the mire wetland rate is high. The mathematical model of the mire wetland and main meteorological factors given by multivariate linear regression not only explains the reason of the formation and development of mire meadow in Qinghai Lake drainage area in the qualitative sense, but also provides comparative scale from the quantitative aspect. Moreover, the model can also forecast the unknown wetland rate.

VIII. CONCLUSION

The mathematical model of the mire meadow wetland rate in Qinghai Lake drainage area environment and the main meteorological factors of the formation and development of the mire meadow wetland is given by multivariate linear regression. The research results show that the application of the model is very convenient. The abundant precipitation and the bigger annual humidity coefficient in the growth season supply the essential prerequisite for the formation of the mire meadow in Qinghai Lake drainage area. The low temperature is also good for the formation and development of the mire meadow. The association of the main meteorological faetors is more important for its formation and development.

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