COUNTER-MEASURE AND INFLUENCE OF THE SEA SALT PRODUCTION ACCORDING TO THE TREND OF CLIMATIC VARIATION

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Abstract: According to the data of temperature, precipitation, and evaporation in Tianjin Changlu Haijing Group Co. Ltd. Meteorological station from 1954 to 2003, the climate of Tanggu area is analyzed statistically: the temperature of Tanggu area for 50 years appears to be ascending; especially during the decade years, the air temperature went up obviously, the precipitation decreased. Meanwhile, how to make use of the climatic resources and face the influence of climatic variation for the sea salt production are analyzed.

Key Words: Climatic Variation; Sea Salt Production; Precipitation; temperature

INTRODUCTION

Nowadays, the sustainable development is a major issue in the world that most people are paying attention to. Climatic variation has an imp-
ortant forward-looking role on the sustainable development. Climatic variation has already drawn people's broad attention. [1]

Tianjin Changlu Haijing Group Co. Ltd, located at Bo-Hai Bay, is the classical mainland monsoon climate area with these following climate characteristics: cold winter with less rain-snow; droughty spring with much wind-sand; hot summer with much precipitation; cool autumn with very nice sunshine. Sea salt production relies on natural evaporation, concentrated sea water to make saturated brine be crystallized to produce salt, that's why the climatic variation has a massive effect on sea salt production. To upgrade the strain capacity of sea salt production and make better use of climate resource, the effect of climatic variation on sea salt production and the future counter-measure must be analyzed in order to keep the stable production and high quantity of sea salt.

SOURCE DESCRIPTION

Since the Tianjin Changlu Haijing Group Co. Ltd. Meteorological Station put into use to do the professional weather forecasting and monitoring service, a lot of valuable information has been accumulated. According to the climate information of Tanggu Salt Plant Meteorological Station, combining the characteristics of sea salt production and starting from the climate conditions that influence the sea salt production, This article analyzed the characteristics and changes of the climate in the past 50 years, which will

help to guide the sea salt production and make full use of climate resources.

Seasons: Spring（March- May）, Summer（June- August）, Autumn（September- November）, Winter（December- February）。

WEATHER FEATURES

Sea salt production mostly relies on light and heat to make crude salt be crystallized and separated out by evaporation, so sea salt production has a very close link with the weather, and mastering the feature of climate change can have a guiding and helping role on sea salt production. Sea salt production is very seasonal, so reasonably planning the production is very important. Sea salt production is separated into 4 stages: spring, summer, autumn and winter. Spring and autumn with low relative humidity, high temperature, more evaporation, and less precipitation is the main season of sea salt production; summer has high relative humidity, high temperature, more evaporation, but very high precipitation, which is not very good for sea salt production; therefore, summer is mostly for the plastic tarpaulin of the precipitation and flood prevention; winter, with low temperature and less evaporation, is also not very good for sea salt production, which is mostly for the maintenance and improvement of the salt pan. [2] 。

The change of temperature and precipitation is the main factor of climatic variation; the amount of evaporation is an important indicator of sea salt production.

The next is to analyze the information of temperature, precipitation, and amount of evaporation, which all influence sea salt production. It will be helpful to discuss the regularity of climate change in the past 50 years and sea salt production strategy suitable for the climate change.

Temperature

1) Seasonal change and annual change of average temperature of the whole year

The data of average temperature in Tanggu area in the last 50 years are described in Table 1.

From Table 1 it can be seen that: from the 1960s to the 1970s the temperature is kind of low; since the 80s, the temperature is going up. As for the seasonal climate change, winter has the biggest variation range and summer next, but the rising rate is different. Rising rate in winter is 0.210 ℃/10 year; and 0.117 ℃/10 years in summer. The average rising rate in winter is bigger than that in summer. From Table it also can be seen the temperature change in winter and summer in different years has a very noticeable difference. In the 70s and 80s, the temperature in winter clearly goes up, so the rise of average temperature of the whole year is mainly because of the warming of winter. From the 80s to the 90s, the temperature of summer clearly goes up, so the rise of average temperature of the whole year is mainly because of the contribution of summer. During the 90s, the annual average temperature in both winter and summer is higher than before. Overall, the temperature rising in winter is bigger than that in summer. Especially in the pass ten years (1994-2003) the temperature in spring, summer, and autumn are always going up, with spring and summer the most noticeable. The annual average temperature variation has a tendency of rising. By linear fitting, it can be calculated the increase rate of annual average temperature in Tanggu in the pass 50 years is 0.29 ℃/10year; the increasing speed is even faster than that in the whole China, which is 0.04℃/10year. [3]

Table 1 Average Temperature/10 years from 1954 to 2003, Tang-gu District (Units: ℃)

Year	Annual	Spring	Summer	Autumn	Winter
1994-2003	13.3	13.4	26.0	14.1	-0.7
1961-1970	12.1	12.1	23.3	13.9	-4.4
1971-1980	12.2	12.4	21.6	14.1	-1.1
1981-1990	12.6	12.8	24.4	14.1	-1.9
1991-2000	13.2	12.4	25.9	13.6	-0.6
1954-2003	12.5	12.5	25.5	13.9	-1.9

2) Extreme Temperature Change

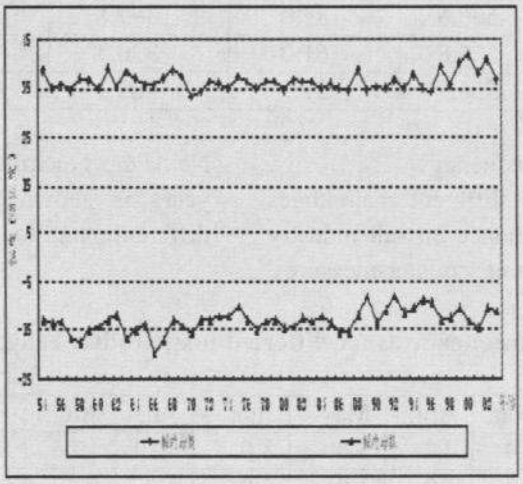

Fig.1 The Changing Chart of Extreme Temperature during the year 1954~2003

From figure 1: the highest extreme temperature and the lowest one both goes up, especially, the lowest extreme temperature of winter increases the most obviously. The highest extreme temperature of the whole year fluctuates between 33.1℃ (1970) to 41.9 ℃ (2000), lowest temperature between -19.7℃(1966) to-8.1℃ (1992). The lowest extreme temperature is relevantly high during the year 1988~1996, and warm winter appears; in the recent 10 years (1994-2003), the highest extreme temperature is 39.6℃(1997), 40.0℃(1999), 41.9℃ (2000), 40.8℃ (2002). The highest extreme temperature/year is clearly higher than the average value of the highest extreme temperature.

Precipitation

1) Seasonal Change of Average Precipitation

The precipitation data of Tanggu District in the last 50 years are described by group in Table 2.

From Table 2 it can be seen that: from the 80s to present, the precipitation has a downtrend, the biggest influence on the precipitation comes from summer and autumn next. Through linear fitting, the average decreasing rate of precipitation in the pass 50 years goes down to 17.06mm/10 years. Annual precipitation goes down all in all, but the actual precipitation situations in different times are different, which can be separated into the following sections:

The 60s was the peak time of precipitation, with three big flood-years: 1964(1037.2 mm), 1966 (890.9mm), and 1969 (912.9 mm).

From 70s to 80s, the annual precipitation went up slowly.

The precipitation in the 1990s was the least in the recent 50 years (the difference of average value is about 40.1 mm). Especially

in the past ten years, the precipitation decreases much seriously (Average value difference is about 82.1 mm). Only in year 1995, 1998, 2003, the precipitation slightly exceeded the average value in recent 50 years. In year 2002 the annual average precipitation is only 314.8 mm, which is the second least in the history; in the autumn of 2003, the average precipitation is only 201.2 mm, October (114.8 mm), 10^{th} ~12^{th} October (113.4 m) are both the highest in the history.

Table 2 Average Precipitation/10 years from 1954—2003, Tanggu District (Unit: mm)

Year	Annual	Spring	Summer	Autumn	Winter
1994-2003	484.8	56.5	321.4	95.2	10.7
1961-1970	628.8	55.9	489.9	73.6	9.4
1971-1980	587.4	56.4	434.6	90.4	6.0
1981-1990	606.5	82.0	377.8	134.4	12.3
1991-2000	526.8	61.0	330.3	125.9	9.6
1954-2003	566.9	59.7	409.1	85.6	12.4

2) Precipitation Frequency

Precipitation with different magnitudes will have different influence on salt industry and will cause different counter-measures. Next, the precipitation situation in recent 50 years is shown in Table 3 according to different magnitudes.

Table 3 Precipitation frequency as for different magnitudes, Tanggu District (Unit: Times)

Month	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Year
≥0.1mm	3.4	4.7	5.6	8.0	12.1	10.6	5.9	4.8	66
≥5.0mm	0.4	1.2	1.8	2.9	6.3	5.4	2.4	1.4	23
≥10.0mm	0.1	0.6	1.2	2.0	4.9	4.1	1.6	0.7	15
≥50.0mm	0.0	0.0	0.0	0.2	0.9	0.8	0.1	0.0	2

From Table 3 it can be seen that: according to the production flow of the sea salt, if the precipitation amount exceeds 5mm, the plastic tarpaulin is necessary. Large amount of precipitation are mainly in June, July, August and September, accounting for above 70%. Big precipitation changing rate is a typical climate feature in this area.

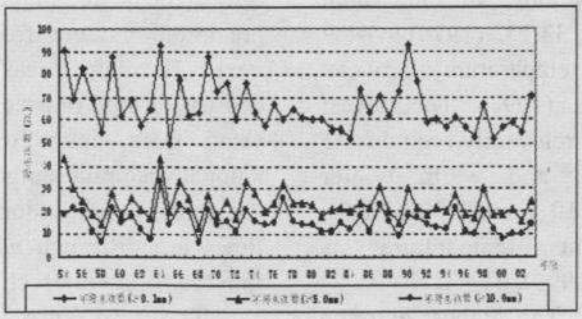

Fig. 2 The Changes of precipitation frequency, 1954~2003

The Precipitation frequency with the precipitation ≥ 0.1mm is between 50 times (1965) and 93 times (1964, 1990), with average value of 66 times; The Precipitation frequency with the precipitation ≥ 5.0 mm is between 13 times (1968) and 43 times (1964), with average value of 23 times; The Precipitation frequency with the precipitation ≥ 10 mm fluctuates between 7 times (1958, 1968) and 33 times (1964), with average value of 15 times; The Precipitation frequency with the precipitation ≥ 50.0 mm is

between 5 times (1966, 1969, 1984) and 0 time (1957, 1963, 1979, 1989, 1996, 2002); and there are no precipitation ≥100.0mm from 1988 to 2003.

From Fig.2 and Table 3, it can be seen that: the annual precipitation amount and annual precipitation frequency with 4 magnitudes almost have the similar changing tendency, which tends to become smaller.

3) Days of the Thunderstorm

Thunderstorm usually comes suddenly, with a serious destruction; table 4 is the statistics of thunderstorm days in recent 50 years.

Table 4 Thunderstorm Days every 10 year from1954 to 2003, Tang-gu (Unit: Day)

Year	1961-1970	1971-1980	1981-1990	1991-2000	1994-2003	1954-2003
Average	23.2	25.0	29.4	29.6	26.9	26.8

From Table 4 it can be seen: during 50 years, there are 1360 thunderstorm days in all, and the average value is 26.8 day/year; thunderstorm day varies between 14 days (1967) and 44 days (1959), and the average number of thunderstorm days every ten years increases; especiall-
y in the 80s and the 90s the thunderstorm day numbers is the most; and the thunderstorm day number in past ten years are almost the same as the annual average thunderstorm day number. The earliest thunderstorm appeared at March 11th, 1992, and the latest one appeared at November 6th 1989.

The Amount of Evaporation

The amount of evaporation is a very important indicator of sea salt production, the curve below reflects the change of evaporation amount in recent 50 years.

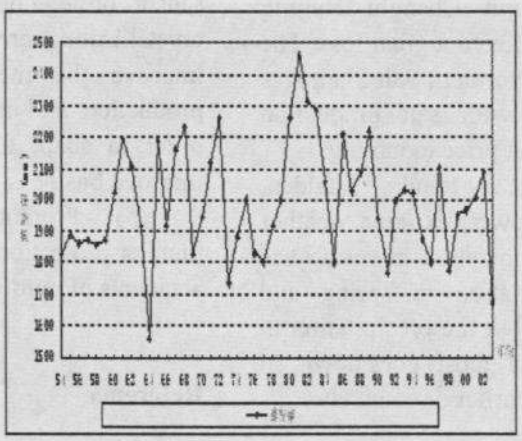

Fig 3 The change curve of evaporation amount during the year 1954~2003

From figure 3 it can be seen that: evaporation amount per year is varying between 1562.2 mm (1964) to 2459.4 mm (1981); the average value of 50 years is 1991.1 mm. Since the 80s, the evaporation amount has been clearly going down.

clearly going up.

(2) Temperature has obviously increased since the 1980s, especially the 90s, the extent is bigger; that is mostly because spring and summer are getting warmer, temperature in summer goes up very fast, the highest extreme temperature has reached an extreme value in history.

(3) Annual precipitation in Tanggu goes down as a whole, especially in the 90s.

THE TREND & EFFECT OF CLIMATE CHANGE

According to the statistic data of climate change of Tianjin Changlu Haijing Group Co. Ltd from the year 1954 to 2003, such conclusions are made that:

(1) The average temperature, highest & lowest extreme temperature in Tanggu is

Precipitation ≥5.0mm are mostly in July and August, and next is June and September; since the 80s, precipitation in spring and autumn mounts, but the precipitation in flood season drops, and sudden and destructive dangerous weather is also getting more.

In Tanggu, temperature is going up, especially noticeable in the past 10 years. Because of warming climate, the precipitation distribution and the frequency of flood and drought will be changed, with all kinds of abnormal weather brought. The sea level will also raise, storm surge become more serious, the same as the flood threat [1]. Annual highest extreme temperature is 39.6℃(1997), 40.0℃(1999)、41.9℃(2000)、40.8℃(2002), constantly breaking the historical records; On August 23rd 1991, because of the external wind of typhoon and the astronomical spring tide, Tianjin Changlu Haijing Group Co. Ltd occurred dyke breaching, suffering a great loss; On October 10~12th 2003, because of an extra torrential rain (113.4 mm), as well as the storm tide, Tianjin Changlu Haijing Group Co. Ltd also suffered a great loss. The sea salt production of Northern Salt Plant was seriously influenced, with salt production decreased and crude salt price mounting.

Climate change trend: sudden, destructive (thundershower) extreme weather has become more; temperature in spring has clearly risen; precipitation in spring and autumn has went up,; but the precipitation in flood season's (July to August) goes down, so flood season may end earlier or come late.

COUNTER-MEASURE OF SEA SALT PRODUCTION

(1) Aiming at the trend that sudden, destructive(thundershower) extreme weather becomes more, some emergency mechanism should be built to upgrade the capacity of information gathering and processing, uplift the forecasting capacity of sudden, destructive weather, improve the forecasting ability of climate change and provide evidence for leaders and development department.

(2) Strengthen the defense project construction of sea dike; coordinate the construction of seashore road; reinforce the dikes which have not reached the standard to deal with the impact of sea-level rising and increase the resistance ability of storm.

(3) According to the trend of climate change, make full use of favorable weather conditions and climate resource; in accordance with the characteristics of sea salt production process, reasonably arrange the production, and appropriately extend the spring and autumn period. Carry out crystallization process all the year round; the spring salt harvesting period, is brought forward, and the autumn salt harvesting period is delayed in order to make full of evaporation amount.

(4) Seizing the favorable opportunity that salt industry market is getting better, and combining the rise of the desalination industry, technological transformation of beach field should be strengthened. Aiming to increase the effective single yield and emphasizing the reserve capacity of medium / sensor brine, company should increase the crystallization area with plastic tarpaulin to improve the mechanization level of salt production and improve labor efficiency in order to adapt Climate change and further improve business benefits.

(5) Promote the construction of thunder-protection facilities; prevent accidents of outdoor workers from happening.

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