Research on the Improvement of Ecological Development of Salt-alkali Land in Tianjin

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Abstract. This paper studies the ecological development and improvement measures of the two important saline-alkali land in Dongli Lake Resort in Dongli District and Sino-Singapore Eco-city in Binhai New Area of Tianjin, and puts forward the harm caused by saline-alkali land to the ecological environment. It also provides suggestions for ecological development and improvement of saline-alkali land.

1. Introduction
As the largest coastal city in the north, Tianjin is adjacent to the east of Bohai Sea. The area of saline-alkali land accounts for more than half of the total land area of Tianjin, which poses great challenges to the green development of Tianjin. In order to build an ecologically livable Tianjin city, it is necessary to improve this large saline-alkali land and transform it into ecological land for better development.

2. Tianjin saline land
2.1. Tianjin natural conditions
Although Tianjin is a coastal city, its downtown area is not directly facing the sea. The main coastal areas include Dagang District, Dongli District, Hangu District and Tianjin Port. The sea area is about 3,000 square kilometers. Tianjin is geographically located on the west coast of the Pacific Ocean. With the help of the Bohai Economic Circle, it is an important seaport that connecting the inland and overseas countries. The landforms are high in the north and low in the south, most of land are plains. Due to the influence of sea water, there are many salt flats and the geology is salty clay.

2.2. Formation of saline-alkali land
Saline-alkali land refers to soil salinization is too high. Generally, the content of salt in the soil surface layer and the degree of the alkalization exceed a certain standard, which is called saline-alkali land. The soil in this land is seriously deficient in nutrients and the plants are almost unable to grow normally. The cause of the formation of saline-alkali land in Tianjin is mainly natural factors. Like the coastal areas where the altitude is not high, it is immersed in seawater all the year round and continuously retreats into the sea to form a saline-alkali land. In addition, Tianjin is located in the north of China, which belongs to the North Temperate Zone. It is affected by the monsoon and the marine climate. The spring is dry, rainy and windy, and the summer rains are heavy and concentrated. It is prone to “returning salt” and “desalting”. “Returning salt” refers to the evaporation of surface water caused by the dry climate in spring, and the accumulation of salt in groundwater on the surface of the soil. “Desalting” refers to the
large amount of soluble salt that penetrates into the lower surface of the earth's surface with rainwater during the summer rainy season.

2.3. Hazard of saline-alkali land
Saline-alkali land has seriously affected the development of Tianjin's circular economy and ecological sustainable development. However, as a kind of land resource, if the saline-alkali land can be ecologically developed, the stability of Tianjin's ecosystem can be improved and it can become an important reserve land resource. Tianjin's saline-alkali land is concentrated in economic development zones and industrial agglomerations that affecting Tianjin's agricultural and industrial development. This soil has low content of organic matter, poor nutrient content, and severe loss of nitrogen and phosphorus. The soil has a higher pH value and a higher calcium carbonate content, and the trace elements in the soil lose their effectiveness to varying degrees. Its physical properties and structure are poor, there are only a few non-capillary pores, and there is a lack of good preservation ability. The high concentration of soil solution in saline-alkali soil and high osmotic pressure will cause crops to lack the ability to absorb water. In short, the plants and microorganisms on the saline-alkali soil are not able to grow and develop normally.

3. Tianjin saline-alkali land ecological development and improvement measures
The Dongli Lake Resort in Dongli District and the Sino-Singapore Eco-city in Binhai New Area are typical examples of the ecological development of saline-alkali land. However, the saline-alkali land in each region is different, so it should be treated according to local conditions. Table 4-1 summarizes the regional situation of Dongli Lake Resort and Sino-Singapore Eco-city.

3.1. Regional comparison

| Region                  | Sino-Singapore Eco-city                                      | Dongli Lake                                           |
|-------------------------|-------------------------------------------------------------|-------------------------------------------------------|
| Vegetation conditions   | Special halophytes such as Suaeda salsa, Tamarix, etc.      | The vegetation is mainly swamp vegetation, dry hay reeds, Suaeda and other salt-bearing meadow vegetation communities. |
| Topography              | Alluvial, low sea plains, depressions, ground elevations 1~3 m, more salt flats, salt marshes and wetland landscapes. | The height of the section is 3.1-3.5 m, and the terrain is lower than the surrounding area. It is affected by the high water level in the lake all the year round, and it is easy to collect rainwater. |
| Soil conditions         | Soil drought, water shortage, soil silt, composed of coastal saline soil and salinized moist soil, clay, silt clay loam and silt loam. | The soil belongs to chloride salinized tidal soil, it’s sticky and compact. The soil capillary water rises fast, easy to return to salt, easy to suffer from drought, and is highly vulnerable to salt and waterlogging; The soil texture is mainly heavy soil and clay, so the soil volume is significant, generally 1.3-1.5 g•cm\(^{-3}\). |
| Surface water and groundwater | The shallow groundwater level is about 1m, and the salinity is 4g/L. The groundwater mainly receives atmospheric precipitation and surface water infiltration and seawater side seepage recharge. | All natural water bodies in the area belong to salt water, and the degree of mineralization is relatively high, mostly belonging to strong salinity water. The salinity is generally 10 ~ 30g/L, the average is 16.7g/L; Groundwater burial is shallow, 20 ~ 30 cm in the rainy season, 40 ~ 50 cm in the dry season. |
3.2. Soil rational indicators in various regions
Lv Lefu and others selected the sample soil of the Sino-Singapore Eco-city and analyzed the soil-related physical and chemical indicators as follows:

| Index | PH value | Water soluble salt (mg/kg) | Na⁺ (mg/kg) | K⁺ (mg/kg) | Ca²⁺ (mg/kg) | Mg²⁺ (mg/kg) | HCO₃⁻ (mg/kg) | CO₃²⁻ (mg/kg) | Cl⁻ (mg/kg) | SO₄²⁻ (mg/kg) |
|-------|---------|---------------------------|-------------|------------|-------------|-------------|---------------|---------------|-------------|---------------|
| Data parameter | 8.31 | 6303.88 | 1794.89 | 116.41 | 204.72 | 146.06 | 302.35 | 11.25 | 2860.90 | 867.29 |

Zhang Xing analysed the current status of Dongli Lake soil. The relevant data are as follows:

| Index | PH value | Na⁺ (mmol/100 mg) | Ca²⁺ (mmol/100 mg) | Mg²⁺ (mmol/100 mg) | HCO₃⁻ (mmol/100 mg) | Cl⁻ (mmol/100 mg) | SO₄²⁻ (mmol/100 mg) | Organic matter content |
|-------|---------|------------------|------------------|------------------|------------------|------------------|------------------|---------------------|
| Data parameter | 8.38 | 0.35~9.17 | 0.05~0.35 | 0.04~0.67 | 0.39~1.28 | 0.17~7.13 | 0.05~1.79 | <1.5% |

It can be seen that the pH value in both areas is high, and the content of salt ions is also high. Such as Na⁺, Cl⁻ and Mg²⁺ can inhibit the absorption of nutrients by plants. The content of potassium in the soil of Sino-Singapore Eco-city is also rich, mainly because the alluvial parent material of coastal salt soil is rich in potassium. By studying the relevant data, the soil is deficient in trace elements such as manganese, zinc and iron, so the soil organic matter content is low.

3.3. Improvement measures for ecological development of saline-alkali land in various regions

3.3.1. Sino-Singapore Eco-City. The soil salinization in Binhai New Area is very serious. As a silt coast, its saline-alkali land accounts for more than 90% of the total area of Binhai New Area. Sino-Singapore Eco-City is located in Binhai New Area, close to Bohai Bay. This harmonious community created by China and Singapore has become “the happiest eco-city in China in 2018”. The soil of the Sino-Singapore Eco-City is affected by natural factors and man-made factors, such as climate and artificial dredging.

Soil salinization has always hindered the ecological development of the eco-city. For areas with low salinity, organic fertilizer is applied to increase the organic matter in the soil. In the moderate salinization area, some improved facilities for salt separation and salt washing are provided. For example, the dark channel dark pipes are used to drain and drain the salt, and the partitions are provided to prevent infiltration. Although in areas with severe salinization, the vegetation is not easy to survive. It is also possible to plant some skunk and eucalyptus trees to improve the saline-alkali land into an ecological green space for ecological development. At the same time, using land mulching technology to reduce soil water evaporation, so as to prevent “anti-salt” phenomenon.

The precipitation in Binhai New Area is small and uneven. We should also pay attention to maintaining irrigation while supplementing the water of green plants while controlling effective drainage. Improve irrigation methods, improve soil properties in multiple directions, pay attention to the separation of irrigation system and drainage system, and do not use drainage to irrigate. In order to improve the efficiency of soil improvement, using variety of substances to improve soil permeability, such as mixing 4:1 soil and river sand. The application of phosphogypsum is also a way to improve soil structure. The groundwater is relatively high, but the silt can be effectively used to improve the water environment. So use the bay mud to fill the low-lying land, raise the ground and lower the water table.
3.3.2. Dongli Lake. Dongli Lake is located in the northeast of Dongli District, connecting the urban area and Binhai New Area. It has a flat terrain and abundant water resources. As a successful case of wetland park construction, the improvement measures of the Dongli Lake saline-alkali land are mainly biological improvement, that is, planting appropriate salt-tolerant plants or halophytes. For example, there are trees such as acacia and mulberry, and shrubs such as Chinese rose, medlar and ivy. Alfalfa and sesbania are planted in the areas to be developed. Aquatic plants in Dongli Lake are water lilies, etc.

Huzhangzhuang Village is next to Dongli Lake, the soil in this village is rich in potassium. So the villagers use this saline-alkali land to grow grapes, and the grapes are very sweet. There are a lot of vineyards here and there are all kinds of vegetables and fruits to pick the greenhouse, both for picking and sightseeing.

In addition to the waters that have accumulated water all year round, the groundwater burial in the Dongli Lake area is generally very shallower, which causes the groundwater salt to be easily converted into soil water and salt. Therefore, in Dongli Lake, the improvement of saline-alkali land should first control the drainage, so that the drainage can be smoothed out during the rainy season. In addition to the drainage, it is necessary to "storage rain", so that the rainwater can dissolve the chloride in the soil, and pay attention to "interception" on the saline-alkali land that has been greened and improved to prevent re-salting.

For clay soil, sand spreading is adopted. At the same time, the soil salt is adjusted by means of fertilization and soil modification, and appropriate organic fertilizer is applied to carry out chemical improvement to lower the pH value of the soil.

4. Conclusion

Whether it is the Sino-Singapore Eco-city in Binhai New Area or the Vanke Town Resort in Dongli Lake, the ecological improvement of these two saline-alkali areas can be said to have achieved results, and it is worth learning from other parts of China in the treatment of saline-alkali land. However, the maintenance of the ecological development of saline-alkali land will not stop. Whether it is biochemical measures or physical measures or agricultural measures, various measures only improve the local environment of soil salinization. In the long-term improvement, how to stabilize the conservation and ecological management of green plants is very important.

In the future improvement of saline-alkali land, we should also explore more cost-effective and convenient improvement measures and improve the governance technology of ecological development. According to local conditions, develop resources, use ornamental salt plant festivals and brackish water to save cost of treatment, enrich regional development, combine the ecological development of saline-alkali land with the establishment of wetland parks, and create a good eco-city and resort.
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