The Application of Constructed Wetlands in Ecological Construction of Coastal Industrial Agglomeration

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Abstract. This paper takes constructed wetlands as the research object, analyses the position characteristics of land reclamation area where modern coastal industrial agglomerating in ecological pattern, points out that the lack of ecological buffer is a key problem that causes the negative ecological and environmental impact of industrial development on coastal areas. This paper expounds the importance of the sustainable development of coastal industrial agglomeration, puts forward that two key points of constructing the stable ecological pattern of land and sea are pollution reduction and ecological reconstruction; also points out that constructed wetland is of great value and significance in constructing ecological buffer in coastal industrial gathering area through analysing the important function of constructed wetland in pollution reduction and ecological reconstruction. Taking the typical constructed wetland project in China as a case, in the end of the paper, the effects of constructed wetland on marine ecological and environmental protection are further analysed.

1. Introduction

Industry gathering to the coast is a developing trend of industrialization, informatization, ocean exploitation and economic globalization. The modern industrial clusters have shifted from inland to coastal areas, widely distributed in coastal areas and even in reclaimed land areas. However, due to the lack of ecological buffer, the development of coastal industrial zones make the natural environment of coastal areas change, the regional environmental quality has deteriorated gradually and the regional environmental capacity is insufficient now.

The key points of building a stable ecological pattern is pollution reduction and ecological reconstruction. The modern coastal industrial gathering area represented by land reclamation area needs to construct a new ecological buffer zone as an ecological barrier for land-sourced pollution discharge into the sea.

Constructed wetland can achieve pollution reduction effect through plant absorption, microbial metabolism, also substrate adsorption and precipitation, etc. The construction of wetland has strong application value in pollution reduction, water and soil conservation, water conservation, bird attraction, biodiversity maintenance and ecological construction in industrial areas.

Taking constructed wetlands in Tianjin Lingang industrial zone and Caofeidian industrial zone as examples, this paper analyzes the important role of constructed wetlands in ecological construction of industrial zone from the aspects of pollution reduction and ecological environment optimization.
2. The location characteristics and development concept of modern coastal industrial zone

2.1 Environmental constraints of coastal industrial zones

No matter advanced or newly industrialized countries, the resources for development mainly come from land. But the non-renewable resources on the land are nearly exhausted. The ocean is rich in resources, including seabed mineral resources, marine biological resources, seawater chemical resources, marine power resources, so people turn to the ocean for more resources for industrial development. Industry gathering to the coast is a developing trend of industrialization, informatization, ocean exploitation and economic globalization. The marine economy development is an important choice to ease the pressure on China's resources and environment. The modern industrial clusters have shifted from inland to coastal areas, widely distributed in coastal areas and even in reclaimed land areas.

From the perspective of regional development conditions, the coastal industrial cluster is located in the coastal area, with convenient transportation and low water transport costs. At the same time, it is far away from population gathering areas, which is conducive to industrial development.

From the perspective of ecological protection, taking sewage as an example, sewage that reaches discharging standard from traditional inland industrial areas will be discharged into rivers, wetlands, lakes, estuaries, coastal wetlands, and finally into the sea after being diluted and purified by above mentioned ecosystem.

However, at present most of the sewage in the coastal industrial zones is treated as follows: Firstly the sewage will be pretreated by sewage pretreatment facilities which built by enterprises in the parks respectively, then the sewage that reaches the influent requirement will be discharged into the park's centralized sewage treatment plant, finally directly discharge into the sea. The treatment system in the built parks has indicated the lack of ecosystem purification process.

With the rapid gathering and development of coastal industrial areas, the marine ecological environment is under great pressure and influence. The capacity of resources, ecology and environment in China's coastal waters is really limited, and the deterioration of marine ecological environment caused by human activities is increasingly prominent, which has seriously affected the sustainable development of coastal areas.

With the development of coastal industrial areas, the natural environment in coastal areas has changed. The regional environmental quality has deteriorated gradually and the regional environmental capacity is not optimistic anymore. In the subsequent development process, environmental protection and ecological construction should be further strengthened.

2.2 Development concept of coastal industry

Building an ecological civilization, promoting green development and improving the quality of the ecological environment have gradually become the top-level requirements of the state. How to construct marine ecological civilization and realize sustainable development in coastal waters is an important issue in many coastal areas.

The development of high pollution and high water consumption industries in coastal areas brings great pressure to water pollution prevention and ecological environment protection. The pollution of coastal waters in China is becoming more and more serious and the pollution scope of coastal waters is expanding rapidly.

Based on the background of ecological civilization, the key points of building a stable ecological pattern are pollution reduction and ecological reconstruction. The modern coastal industrial gathering area represented by land reclamation area needs to construct a new ecological buffer zone as an ecological barrier for land-sourced pollution discharge into the sea.

3. The application value of constructed wetland in coastal industrial gathering areas

3.1 Advantages of constructed wetlands in pollution reduction and ecological reconstruction
Constructed wetland, namely with artificial built pools or groove filled with a certain depth of soil or layer, planting vascular plants or aquatic plants with strong root system. Constructed wetland can achieve the effect of pollution reduction through plant absorption, microbial metabolism, substrate adsorption and precipitation, etc. Its construction has strong application value in the deep purification of industrial sewage and ecological construction.

Constructed wetland has the characteristics of good purification effect, simple process equipment, convenient operation, maintenance and management, low energy consumption, strong adaptability to sewage load change, low engineering infrastructure and operation cost, biological safety of effluent, significant ecological environmental benefits, and resource recovery of wastewater.

3.2 The value of constructed wetlands in developing ecological barriers in coastal industrial areas
For industrial clusters, the residual low-concentration pollutants in the sewage which reaches effluent quality can be deeply adsorbed and degraded by building a micro-ecosystem in constructed wetlands. At the same time, constructed wetland has a higher tolerance range to salinity, such as the tail water of petrochemical industry and paper industry.

By utilizing the natural conditions of the industrial zone and satisfying the purification function, the wetland treatment system can be designed with the ecological landscape such as water surface and vegetation arrangement, so as to play a more efficient role in ecological barrier value in the industrial gathering area.

Constructed wetlands, as a means of ecological restoration in industrial areas, have certain significance for regional ecological reconstruction. In addition to the function of pollution digestion, wetland treatment system contributes positively to soil and water conservation, water conservation, bird attraction and biodiversity maintenance. Meanwhile constructed wetland is actually an ecological barrier on the route that industrial sewage flows from land to sea area, under the mode of reclaiming land, it establishes an artificial ecological buffer area between the new land and sea.

4. Typical cases study of the constructed wetlands application in coastal industrial areas
In recent years, the research and application of constructed wetland has spread widely. Typical examples of constructed wetland treatment technology include: constructed wetland of Tianjin Lingang industrial park, of Tianjin Nangang industrial park and of Caofeidian industrial park, etc.

The sewage treatment processes of Tianjin Nangang and Caofeidian are both in the form of "enterprise pretreatment + sewage treatment plant in the park + constructed wetland + deep sea discharge". The sewage treatment process of Lingang industrial zone is in the form of "enterprise pretreatment + sewage treatment + reclaimed water treatment + constructed wetland", which means the sewage can be stored inside the wetland instead of discharge into deep sea, mainly because of the relatively small amount of sewage and the sufficient balance of evaporation.

The constructed wetlands of Caofeidian industrial zone and Tianjin Lingang industrial zone are taken as examples to analyze the pollution reduction and ecological barrier effect on coastal industrial zones.

4.1 Constructed wetland of Tianjin Lingang industrial zone
According to the related data, Tianjin Lingang industrial zone adopts the "surface flow–subsurface flow" combined constructed wetland. The constructed wetland occupies 63.25ha and has a total water volume of 17,500 m³/d.

The project has been running stably and curbing a large number of pollutants discharged into the coastal waters in order to ensure the environmental quality of the landscape water in the region and improve the water quality of the coastal waters.

By comparing the inflow and outflow water quality indexes of wetland system, the effect of wetland treatment can be obtained, which is shown in Table 1. After reaching the scale of 17,500 m³/d, a considerable amount of pollutants can be reduced every year, as follows: COD 349t; BOD₅ 159t; SS 159t; NH₃-N 116t; TP 7.94t.
Table 1. The effect of wetland treatment of Tianjin Lingang.

| Water quality indexes | Treatment effect (Removal rate) % |
|-----------------------|----------------------------------|
| 1 SS                  | 71                               |
| 2 BODs                | 71                               |
| 3 COD                 | 52                               |
| 4 NH$_3$N             | 69                               |
| 5 TP                  | 71                               |

In addition to its unique advantages in pollution reduction, the wetland in Tianjin Lingang industrial zone has played an irreplaceable role in conserving water resources and creating a good regional ecological environment. Tianjin Lingang ecological wetland has been built into a coastal species habitat in large ecological industrial zone, creating a rich biodiversity landscape.

4.2 Constructed wetlands of Caofeidian industrial zone

Caofeidian industrial zone adopts the "surface flow–subsurface flow" combined constructed wetland. The constructed wetland occupies 15.71ha and the designed water volume is 40000 m$^3$/d.

By comparing the inflow and outflow water quality indexes of wetland system, the designed effect of wetland treatment can be obtained, which is shown in Table 2.

Table 2. The effect of wetland treatment of Caofeidian.

| Water quality indexes | Treatment effect (Removal rate) % |
|-----------------------|----------------------------------|
| 1 SS                  | 40                               |
| 2 TN                  | 20                               |
| 3 COD                 | 20                               |
| 4 Petroleum           | 80                               |
| 5 Phenol              | 60                               |

Caofeidian constructed wetland project can improve the efficient recycling of water resources, promote the biodiversity and enhance the comprehensive environmental quality in the chemical
industrial park, in order to maintain the ecological security of the industrial zone and promote the stability of the ecosystem.

5. Conclusion
Modern industrial clusters have shifted from inland to coastal areas, and are widely distributed in coastal areas and even at land-reclamation areas. However, the lack of ecological buffer causes the deterioration of regional environmental quality. This paper takes constructed wetlands in Tianjin Lingang and Caofeidian industrial zone as examples, illustrates the important functions in pollution reduction and ecological reconstruction in industrial agglomeration zone from the perspective of sewage treatment effect and ecological function.

To sum up, constructed wetland is of great value and significance in constructing ecological buffer zone in coastal industrial gathering area. The increasingly serious sewage problem and the increasingly mature research of constructed wetlands will inevitably bring about the extensive application of constructed wetlands. Subsequently, the majority of scientific research workers can carry out in-depth research relying on the constructed wetlands in industrial parks, further improve the treatment effect of constructed wetlands on different kinds of sewage and promote its popularization and application.

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