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Multi-function Research on Wetland Center for Chemical Industrial Park Water Reuse

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Abstract: Widely application of CWs (Constructed Wetlands) in domestic wastewater treatment of China is developing wetlands into a multi-function wetland system. Wetland center in CAMIP (Changshu Advanced Materials Industrial Park) (Suzhou, Jiangsu Province, China) successfully improved tail water quality to level IV of Environment Quality Standards for Surface Water (GB3838-2002) by the combination of different CW steps and achieved water reuse in CAMIP for industrial purpose. Different from traditional tail water advanced treatment, wetland center is designed under the principle of combining landscape and ecological treatment technology. Since this center started running, the removal rate of TN (Total Nitrogen), NH_3-N, TP (Total Phosphorus) and COD (Chemical Oxygen Demand) reaches 87%, 91%, 44% and 60% respectively. Also, 2,038,000 m^3 industrial water reuse in 2015 and 2016 was achieved; emission reduction on COD, NH_3-N and TN reached 100 t, 7.2 t and 15.2 t; an ecological garden that combines ecological wastewater treatment, wetland landscape, habitat renovation and educational functions was created.

Key words: Ecological wastewater treatment, wetland landscape, ecological restoration, ecological education.

1. Introduction

According to statistics, the industrial water consumption of ten thousand Yuan output value in China is 103 m^3, and this number in the USA and Japan is 9 m^3 and 6 m^3 respectively [1]. From ancient times water has been reused in China, and even the excreta is collected for other uses [2, 3]. During 18th and 19th century, it was common to reuse irrigation water in Europe and North America [4]. Later, in most developing countries, the sewage water treatment technologies were used to prevent water pollution in the beginning, but later these became sewage water discharging points [5].

There is a wastewater treatment plant built inside CAMIP (Changshu Advanced Materials Industrial Park). The wastewater from the companies is pre-treated before discharging to the sewage pipe network. The water is treated at the treatment plant to meet the discharge limits and then discharged to the Yangtze River [6]. The outflow water quality of the treatment plant should meet < Discharge Standard of Main Water Pollutants for Municipal Wastewater Treatment Plant & Key Industries of Taihu Area (DB32/1072-2007) > and Level I-A in < Discharge Standard of Pollutants for Municipal Wastewater Treatment Plant (GB18918-2002) >, and the water quality only meets Level V of Environment Quality Standards for Surface Water (GB3838-2002). It has caused some huge impacts to the water quality in the Yangtze River and the downstream area.

Therefore, a wetland center is built inside the CAMIP to further treat the outflow water from the treatment plant. When the water meets Level IV of Environment Quality Standards for Surface Water (GB3838-2002), it is reused by the companies via the water plant in the industrial park. In this paper, two aspects of the multi-function effects of the wetland center for industrial park wastewater reuse will be explained, which are treatment function and ecological landscape.

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2. Treatment Function of the Project

2.1 Process Flow

The inflow of the wetland center is the tail water from the industrial park wastewater treatment plant. The compounds that can be easily biodegraded have already been removed, leaving the compounds that are difficult to treat. Besides, the salinity is high and the chlorine concentration is commonly around 800 mg/L. Based on this, the ecological wetland unit system is applied in the wetland center, which is an optimized combined wetland system that can treat different waste water pollutants, in order to guarantee the elimination of the compounds which are complicated and hard to remove. Based on the condition that the content of the pollutants is relatively low, the total area of the filters was designed as 30,000 m^2.

The process flow of the wetland center is shown in Fig. 1. The effluent from the industrial wastewater treatment plant is pumped into the buffer tank. Then, with 20 distribution cells, the water is distributed to 20 corresponding vertical flow wetland units intermittently. The outflow from the vertical flow wetland will then enter the ecological pond by gravity. Later, water will enter the surface flow wetland and then flow to the saturated flow wetland by gravity. The effluent from the saturated flow wetland will then be transferred to the storage tank of the industrial water plant, treated and sent to the companies for reuse.

2.2 Treatment Efficiency

Four stages of ecological wetland were designed at the wetland center, and their functions are as follows.

The first stage is vertical flow wetland. An intermittent loading way is used in the vertical flow wetland. It can improve the re-oxygenation and is good at oxidation and nitrification. The second stage is the ecological pond. There is a deep water area inside the ecological pond, which can be effectively used for phosphorus precipitation. The third stage is surface flow wetland, which ensures the re-oxygenation of water from the deep water area. Emergent plants planted here will help the further precipitation of suspended solids. The fourth stage is saturated flow wetland. This type of wetland is the best in denitrification. The plants inside

Fig. 1 The process flow of the ecological wetland center in CAMIP.

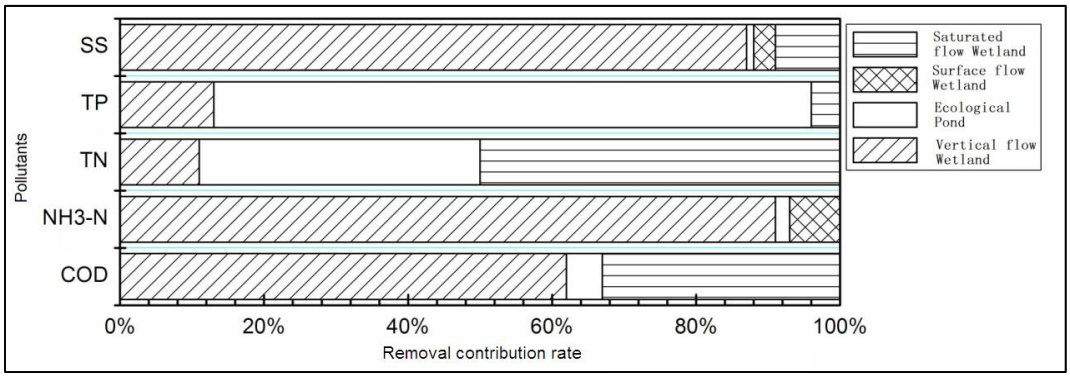


Fig. 2 The removal contribution rate of each wetland.

the wetland can provide extra carbon source, improve the efficiency of nitrogen removal and reduce the content of total nitrogen. The removal rate of each stage is indicated in Fig. 2.

It can be seen in Fig. 2, that most pollutants can be efficiently removed even for the high salinity tail water. Vertical flow wetland has an advantage of removing SS (Suspendid Solid matter), NH_3-N and COD (Chemical Oxygen Demand) and the removal rate are 87%, 91% and 62% respectively. The ecological pond can remove TP (Total Phosphorus) efficiently and the removal rate is 83%. Saturated flow wetland can remove 50% of TN (Total Nitrogen).

2.3 Treatment Stability

According to the water quality statistics of the wetland center in 2015-2016 (Fig. 3), the content of the pollutants in inflow fluctuated within a certain range for the whole year, especially for NH_3-N and TN. However, the outflow quality is stable and even during the winter, when the temperature is low and the plants wither, the treatment is still maintained at a good level. This indicates that the wetland center is able to cope with the inflow water quality of high salinity water and the change of weather or temperature.

2.4 Project Benefits

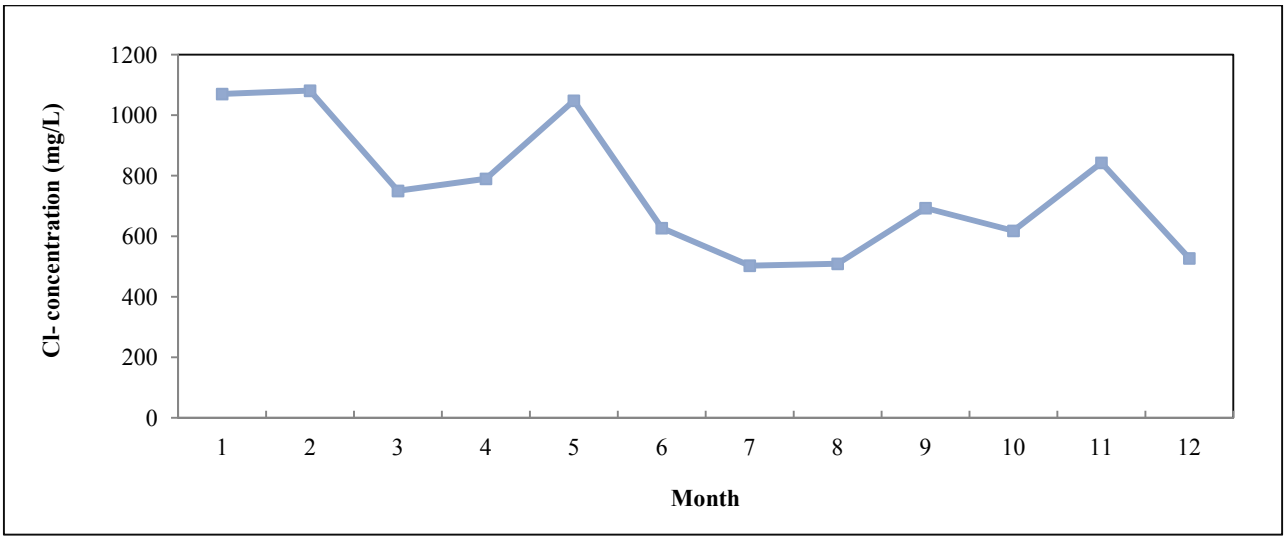
2.4.1 Ecological Benefit

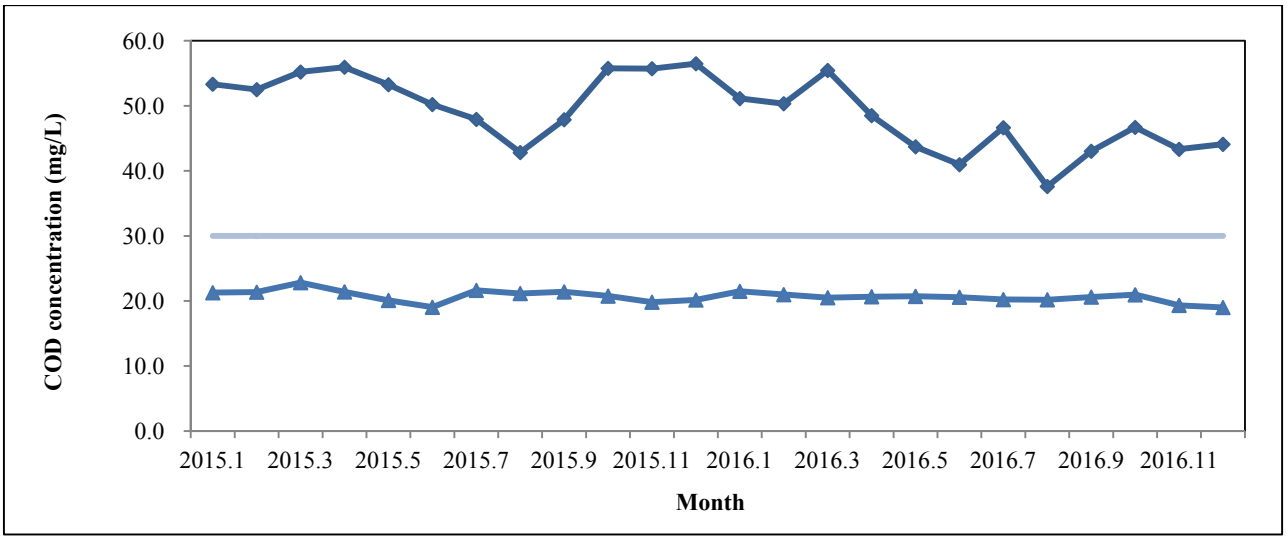
Filter materials, wetland plants and organisms are the three main elements of constructed wetland, and together they form the environment of wetland. The species of flora community in the wetland center is rich and diverse, which attracts birds and reptiles to migrate here, and creates a good habitat environment for biodiversity protection. Furthermore, it can store the water resources and regulate local microclimate [7]. Animals, plants and organisms together constitute a stable ecological complex, which contributes to preserve the ecological balance of the area and provides a platform for ecological science and ecological education at the same time.

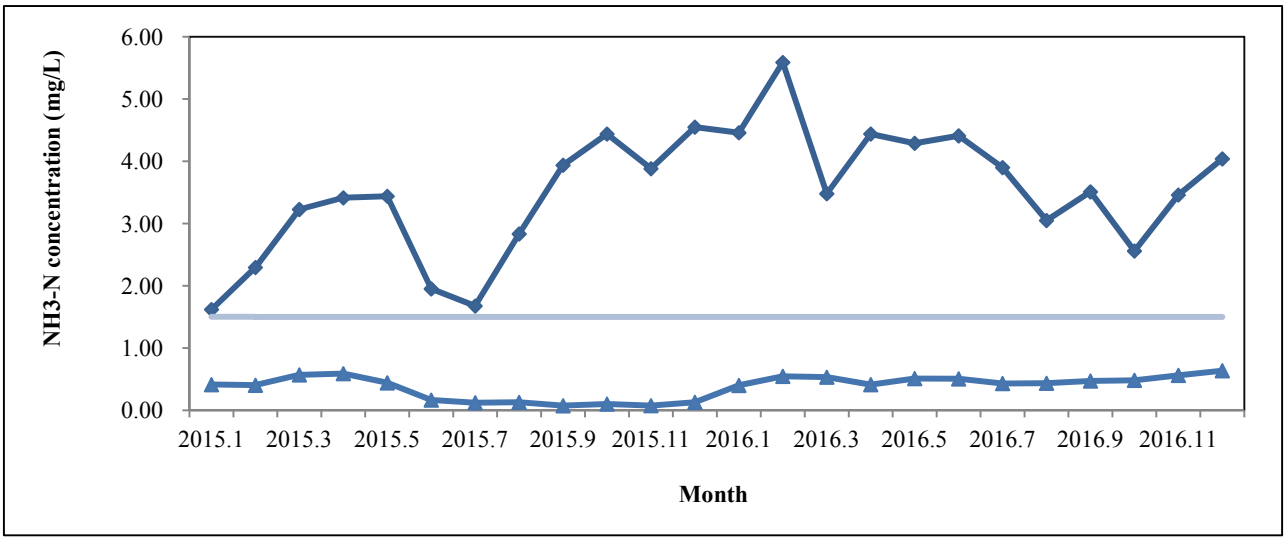
2.4.2 Economic Benefits

In this project, solar energy technology was used. In total, 360 pieces of 220 Wp Polycrystalline Assembly were installed. There is one 50 KW and one 30 KW inverter, 5 DC lightning protection boxes and one AC distribution cabinet. From 18th January 2016, the solar station started to connect grid and to generate electricity. Totally 82,365 kilowatt hours were generated in 2016. The generated power was used to operate the wetland center and the rest was sent to the grid.

As the project has started to operate, it contributes to the emission reduction of the industrial park. During 2015 and 2016, 100 t of COD, 7.2 t of NH_3-N and 15.2 t of TN were prevented from being emitted to the Yangtze River. This project is one of the key projects in Changshu ‘12th Five-Year Plan’, and when it is in operation, it helps to build a ‘Zero Emission Trend demonstration Industrial Park’ for the province [8, 9].


Cl- concentration (mg/L)
1200
1000
800
600
400
200
0
1
2
3
4
5
6
7
8
9
10
11
12
Month


COD concentration (mg/L)
60.0
50.0
40.0
30.0
20.0
10.0
0.0
2015.1
2015.3
2015.5
2015.7
2015.9
2015.11
2016.1
2016.3
2016.5
2016.7
2016.9
2016.11
Month


NH3-N concentration (mg/L)
6.00
5.00
4.00
3.00
2.00
1.00
0.00
2015.1
2015.3
2015.5
2015.7
2015.9
2015.11
2016.1
2016.3
2016.5
2016.7
2016.9
2016.11
Month

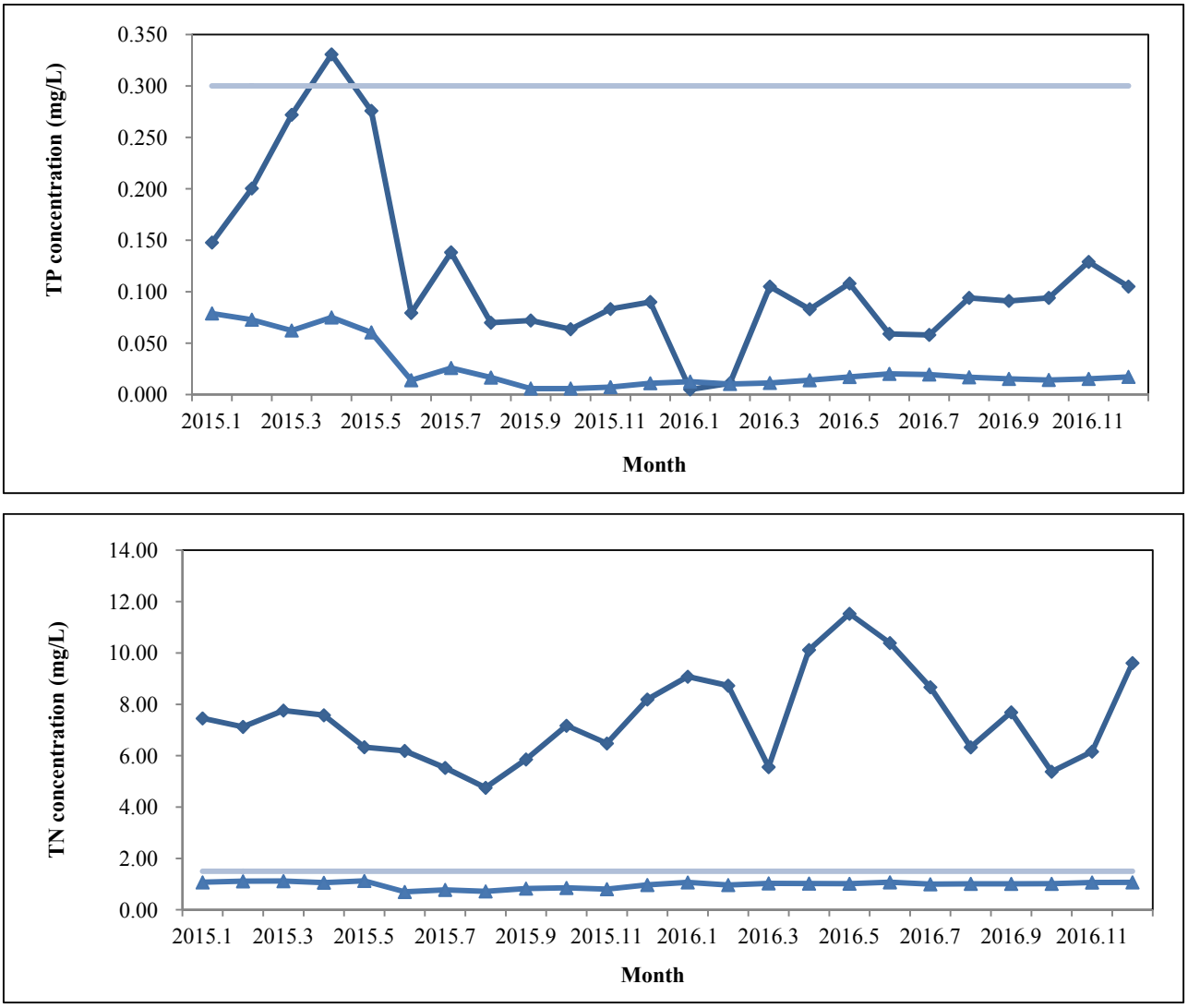


Fig. 3 2015-2016 inflow and outflow water quality of the wetland center, including Cl^-, COD, NH_3-N, TP and TN concentration (The diamonds show the water quality of the inflow and the triangles show that of outflow. The blue straight lines show the water quality standard for IV class water.).

3. Project Landscape Function

This project makes reference to classical Chinese garden style and then lays out the water body and landscape in the industrial park. Under the premise that the water loading rate, the hydraulic retention time and the optimized space usage is ensured, the unit wetland was used as a module to build different wetland formations. By designing and arranging unit formation, space structure, communication organization and plants configuration, an ecological landscape effect was created, which can be combined with wetland technology to serve as ecological supply for the industrial park and build a wetland landscape that offers both ecological and landscape benefits [10].

3.1 Unit Formation

Buffer tank is the highest point of the five units, which is located at the northern center. It is also the best viewing platform in the wetland center and one can overlook all other four units from here.

There are 20 filter beds in the formation of three-stage concentric sector structure in the vertical flow wetland part, which is the main view section of the wetland center. Plants of these 20 wetland units have different height and coverage, which forms a

Fig. 4 Technology and landscape layout.

multi-level, high and low density co-existing, ups and downs varying, implicit and good-looking landscape and creates an unlimited open or narrow viewing within a limited landscape range.

For the ecological pond and the surface flow wetland, the narrow area in the west and south was used to set up water flowing surface and floating island with plants, to create a flowing scene. Saturated flow wetland is the second viewing point apart from vertical flow wetland. Different from the vertical flow wetland, clear and clean water and landscape can be seen in saturated flow wetland. The main body was built with bamboo supporting frame and stone cages, which creates natural and continuous meandering water channels in a shape of '丰' (a Chinese character means abundant and rich). It can ensure the retention time as well as create a landscape that associate activity and inertia.

3.2 Space Structure

The area where the project located is a valley plain area and a few of shallow water bodies can be found here. The design of the overall space structure learnt from the classical Chinese garden style of 'opening, developing, transiting and closing'. It starts from the buffer tank, develops at the vertical flow wetland, then transits at the ecological pond and surface flow wetland, and finally closes at the saturated flow wetland, which forms a Chinese garden style space that is continuous for a whole, rich in space changing, combining activity and inertia and expressing the concept of 'hiding while revealing, revealing while hiding'. Water is the soul of this project. To prevent the space from being fragmented, all the landscapes were arranged like flowing water and based on the original land shape and created a dynamic space that changes but still unifies as a whole [11].

3.3 Communication Organization

The communication organization uses walking system mainly to avoid damages to the wetland units. The main road surrounds the vertical flow wetland and creates a round circle. The pavement materials are mainly permeable bricks. Rainwater runoff can directly discharge to saturated flow wetland and surface flow wetland. The vertical flow wetland in the middle serves as a giant reservoir so that the wetland center can hold all the water when the precipitation rate is high.

3.4 Plants Configuration

The plants configuration is based on the aquatic plants that are capable to treat water and is targeted at protecting local plants and create a natural, wild and ecological effect. According to the function demand of each wetland unit and landscape, plants are arranged in three categories, which are pure aquatic plants, aquatic plant communities and herbaceous plants.

During the plants configuration, the greening is also maintained according to the landscape. The terrain of the project in the industrial park has been modified and mountain forest and grass slope are introduced to the landscape design, which demonstrates the local country land style and natural characteristics. Many wide meadows with ups and downs are set in the park, which provides a richer landscape level and space and realizes a real integration of ecology and landscape.

4. Conclusion

The complement of wetland center in CAMIP can on one hand reduce the amount of wastewater that is discharged to the Yangtze River, protect the water environment of Yangtze River, Wangyu River and Tai Lake and preserve the water resource for the downstream areas. On the other hand, it combines landscape design and water treatment wetland and creates water and scenes in an industrial park, which provides a new idea for industrial parks with low pollution and ecological development. It highlights the harmonious and ecological relationship between the industrial development, flora and animals in an industrial park, which can be used to promote the construction of an ecological industrial park.

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