《The Construction and Restoration Effect of Heituwa Wetland System on YongDing River in BeiJing》

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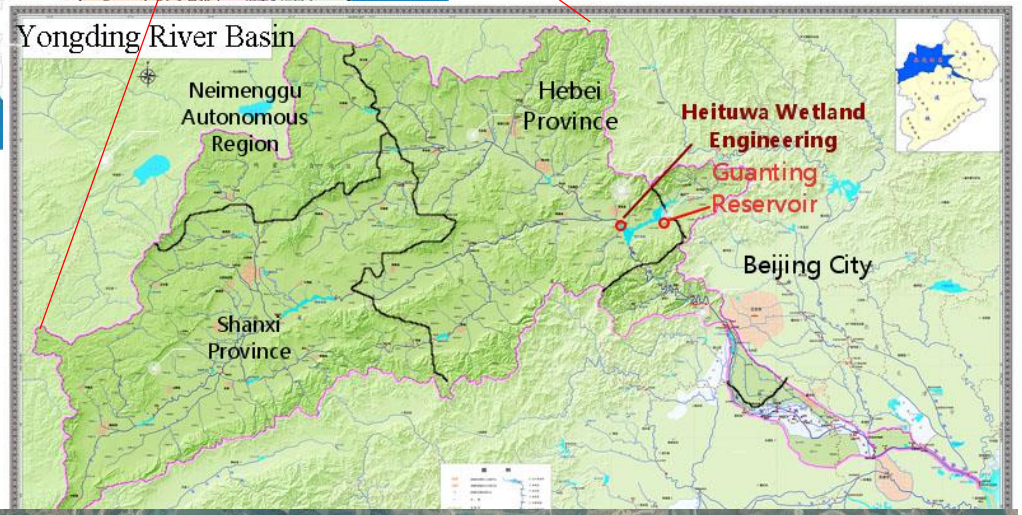
1. Research Background

- Guanting Reservoir is an important water source for industrial, agricultural production and daily life in the west of Beijing.。
- Guanting Reservoir is a type IV-V water body, and some time individual indexes are inferior type V. The main pollutants are organic matter and nitrogen compounds, and the water quality reaches eutrophication level.

The deterioration of water quality has destroyed the original natural ecosystem of Yongding River. It is urgent to restore the water supply function of Guanting Reservoir to Beijing.

Yongding River Basin



2. Construction of Hetuwa Wetland Engineering

In view of the fact that the main pollution source of Guanting Reservoir was Yongding River water, which accounted for 92% of the total sewage，Heituwa Wetland Engineering was constructed at the entrance of Yongding River to the reservoir, to reduce the pollution and improve the water quality of Guanting Reservoir.

Engineering Site Selection

Heituwa Wetland System Engineering is located near the entrance of Yongding River of Guanting Reservoir.

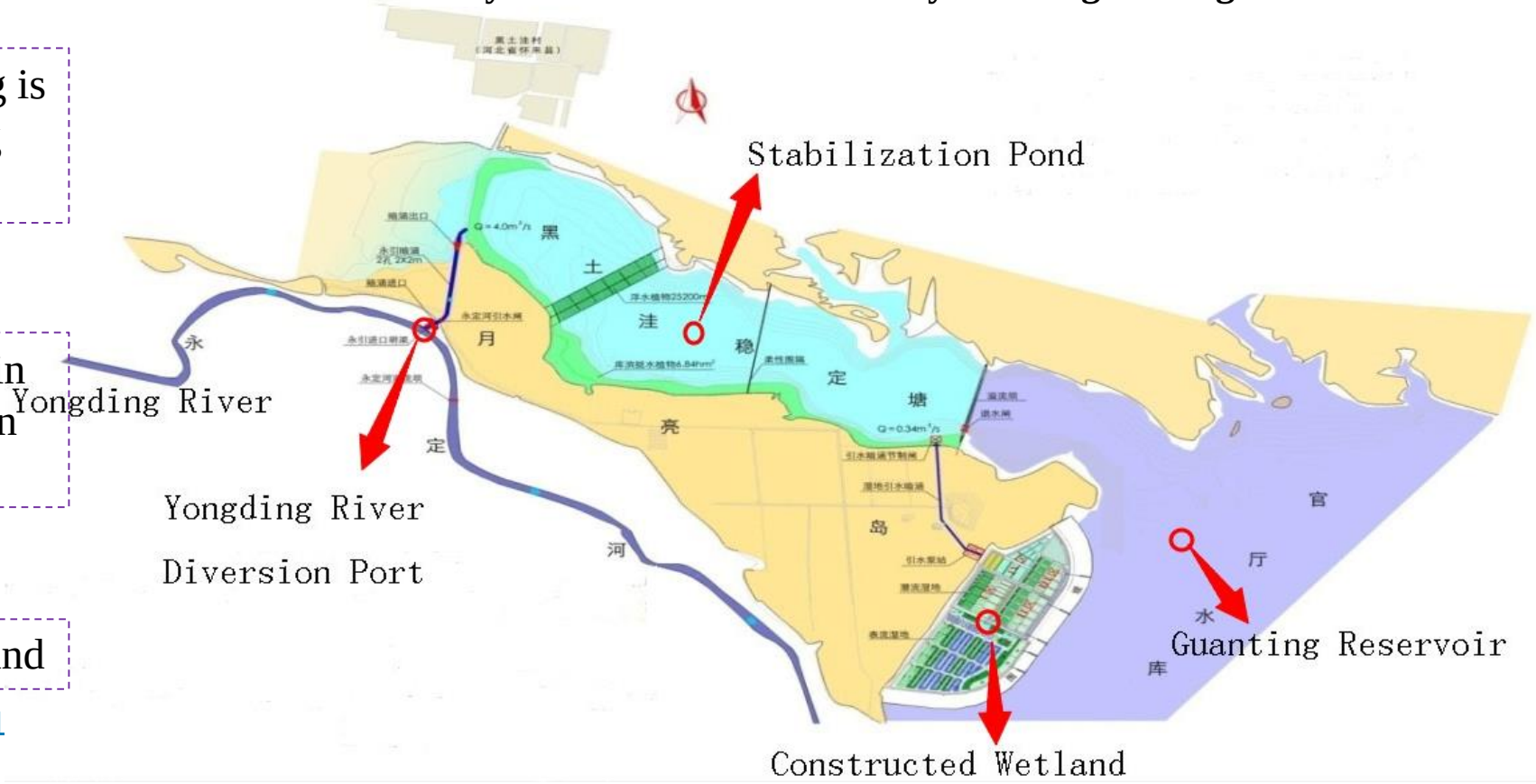
Construction Time

The engineering started construction in September 2003 and was completed in April 2004.

Overall Process Plan

Stabilization pond+Constructed wetland

General layout of Heituwa Wetland System Engineering



2. Construction of Hetuwa Wetland Engineering

Stabilization Pond

- The water surface area is 840,000 m^2 . hydraulic load 0.41$m^3/(m^2*d)$.
- **Plant Disposition**: Arbor belt, shrub belt, tapir plant belt and submerged plant community were set up around stabilization pond according to elevation.
- The stabilization pond was divided into **three functional zones** along the longitudinal direction by diaphragm: **sediment deposition zone**, **phytoplankton zone** and **anaerobic purification zone**.

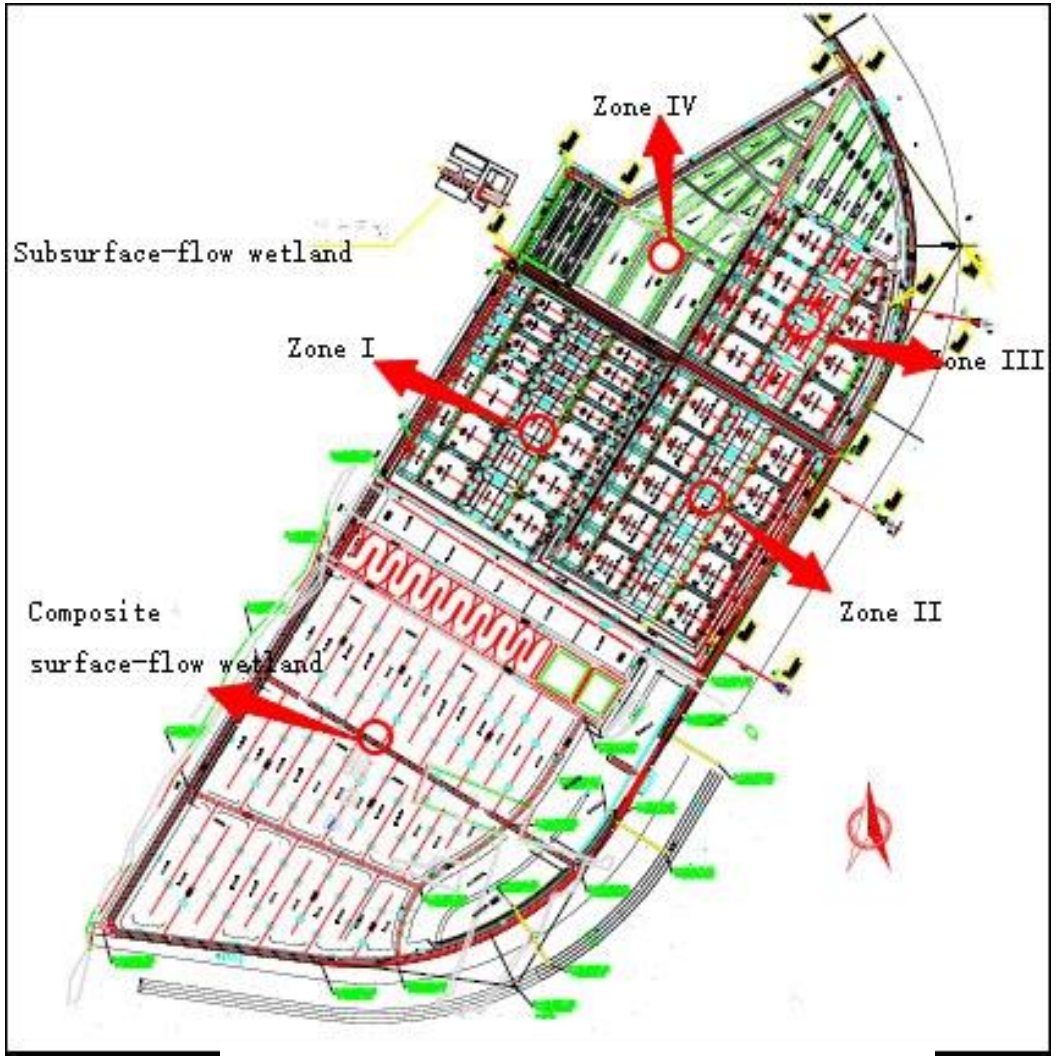
2. Construction of Hetuwa Wetland Engineering

Constructed Wetland

- The constructed wetland was consisted of **subsurface-flow wetland** (area of 7.3 hm^2)and **composite surface-flow wetland**(9.3 hm^2).

- Composite surface-flow wetland was composed of S-shaped biological ditch, biological pond and end-stage infiltration system.The water treatment capacit was 0.2 m^3/s.

- The subsurface-flow wetland was divided into **four zones**.The water treatment capacit was 0.2～0.6 m^3/s.
- Zone I-III was uniformly distributed by two rows of underground canals, and the technological process of each area was basically the same.
- There were **6 test units** in each zone, and each wetland unit was connected in parallel. The water flowed from the distributor canal into **the emergent aquatic plant pond**, **the first-class plant gravel bed**, **the aquatic pond**, **the second-class plant gravel bed** and **the sand filter** in turn.



Overall plan of constructed wetland

2. Construction of Hetuwa Wetland Engineering

Operation of wetlands in 2005

Operation of wetlands in 2009

3. Study on Purification Effect of Wetland System

Test Method

Monitoring Section

- Four monitoring sections are mainly laid along the route: wetland system intlet, stabilization pond outlet, constructed wetland inlet and wetland system outlet.
- In addition, there were monitoring sections of wetland inflow and effluent in each wetland unit.

Monitoring Time and Frequency

Monitoring frequency was once a month.

Selection of monitoring data for 2008-2015.

Monitoring Indicators and Analysis Method

Monitoring Indicators	Analysis Method
biochemical oxygen demand after 5 days（**BOD_5**）	《Water quality-Determination of biochemical oxygen demand after 5 days（BOD_5）for dilution and seeding method》(HJ 505-2009)
permanganate index（**COD_{Mn}**）	《Water quality-Determination of permanganate index》(GB 11892-1989)
nitrate nitrogen (**NO_3-N**)	《Water quality-Determination of nitrate-nitrogen-Ultraviolet spectrophotometry》(HJ/T 346-2007)
ammonia nitrogen (**NH_3-N**)	《Water quality-Determination of ammonia nitrogen-Nessler's reagent spectrophotometry》(HJ 535-2009)
total nitrogen (**TN**)	《Water quality-Determination of total nitrogen-Alkaline potassium persulfate digestion UV spectrophotometric method》(HJ 636-2012)
total phosphorus (**TP**)	《Water quality-Determination of total phosphorus- Ammonium molybdate spectrophotometric method》(GB 11893-1989)
soluble orthophosphate (**orth-P**)	Water and Wastewater Monitoring and Analysis Method (Fourth Edition) (Supplementary Edition)

3. Study on Purification Effect of Wetland System

Overall Purification Effect of Wetland System

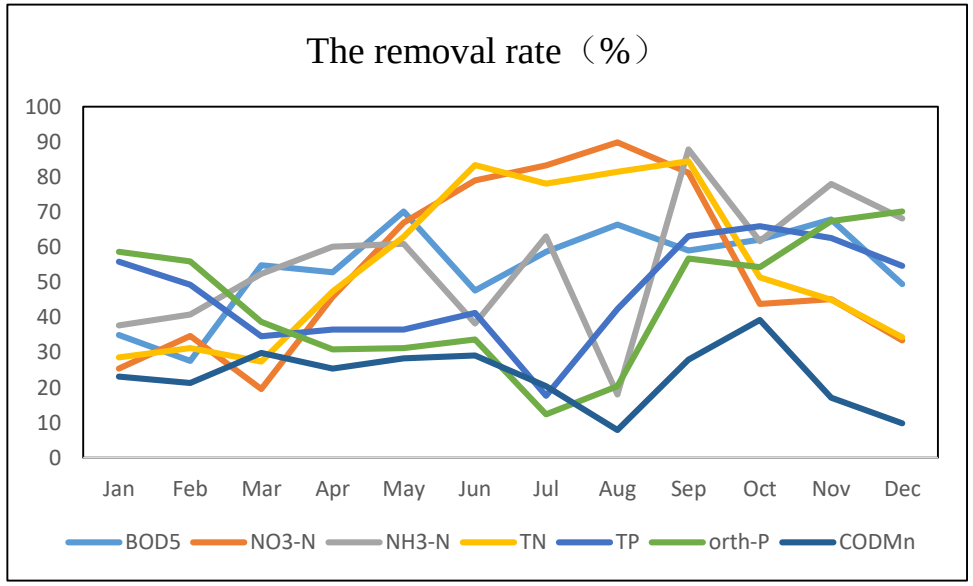
- On the whole, Heituwa Wetland System had a certain removal rate for BOD_5, NO_3-N, NH_3-N, TN, TP, orth-P and COD_{Mn}, with an average removal rate of 54%, 54%, 56%, 55%, 47%, 44% and 23%.

Indicators	BOD_5	NO_3-N	NH_3-N	TN	TP	orth-P	COD_{Mn}
average removal rate/%	54	54	56	55	47	44	23

- It can be seen from the figure that the removal rate of various chemical indicators in wetland system fluctuated with the seasonal changes.

- **From January to March:** the removal rate of pollutants was relatively low.
- **From April to September:** the removal rate of pollutants showed an upward trend.,
- **From September to December:** the removal rate of pollutants decreased as a whole.

➢ Wetland has better effect on pollutant removal in warm period than in cold period.



overall purification effect of wetland system

3. Study on Purification Effect of Wetland System

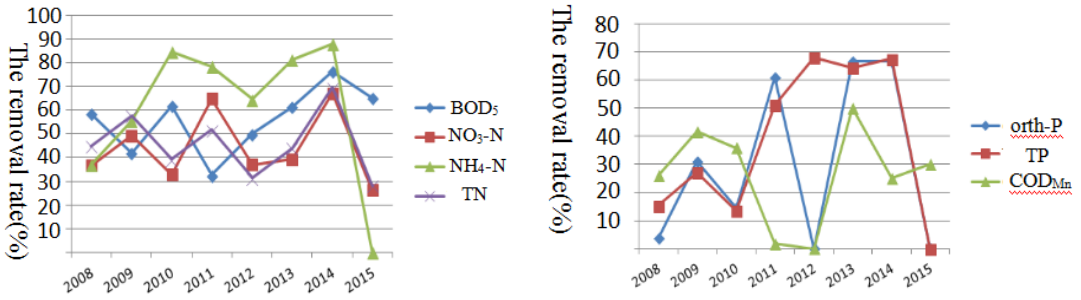
Annual Change of Purification Effect of Wetland System

□Chart display： from 2008 to 2015, the removal rate of each chemical indicator of the wetland system had no obvious change trend

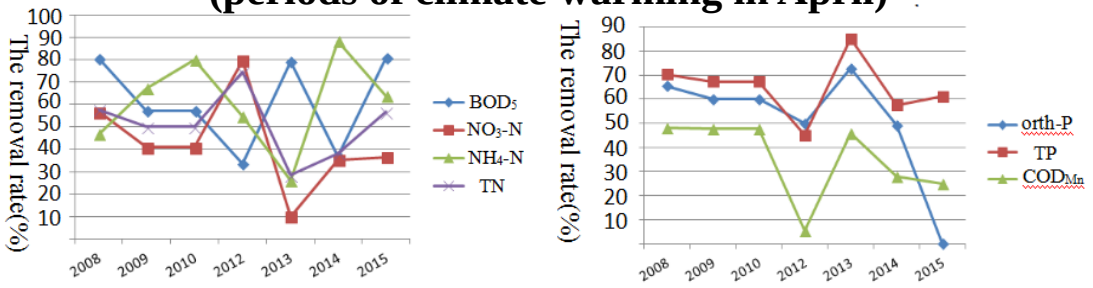
□The removal rate in October was significantly higher than that in April.

➢**April**： The removal rates of BOD_5, NO_3-N, T-N and NH_3-N are basically stable from 2008 to 2014 while the other three indicators waved greatly.

➢**October**： BOD_5, NO_3-N, T-N and NH_3-N all showed high removal efficiency, while the other three indicators were basically stable.



Annual variation of wetland system removal efficiency (periods of climate warming in April)



Annual variation of wetland system removal efficiency (periods of climate cooling in October)

3. Study on Purification Effect of Wetland System

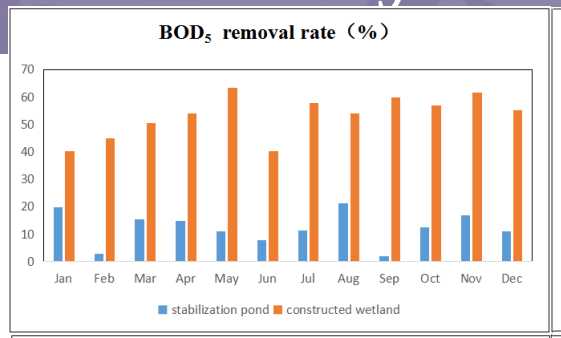
Comparison of Purification Effect Between Stabilization Pond and Constructed Wetland

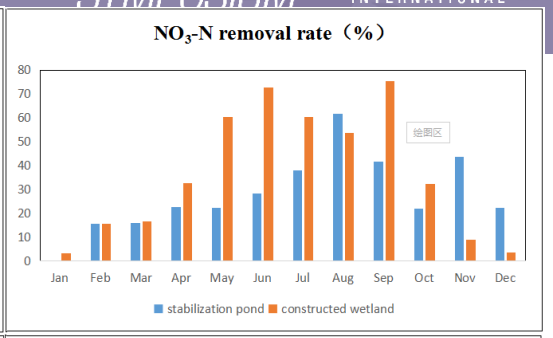
comparison of purification effect between stabilization pond and constructed wetland

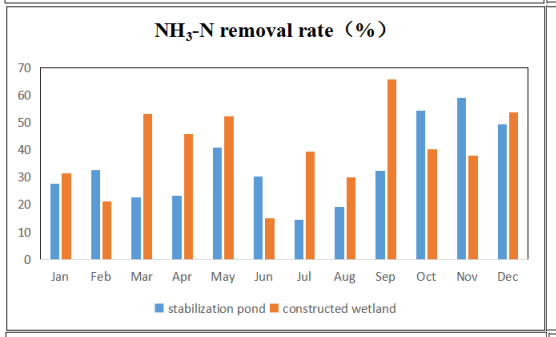
The Study Area	Indicators	BOD_5	NO_3-N	NH_3-N	TN	TP	orth-P	COD_{Mn}
stabilization pond	average removal rate/%	12	28	34	30	37	50	8
constructed wetland	average removal rate/%	53	36	41	37	19	12	24

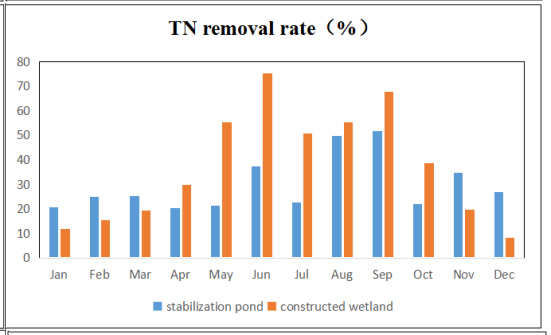
The removal efficiency of chemical indicators in stabilization ponds and constructed wetlands differs greatly:

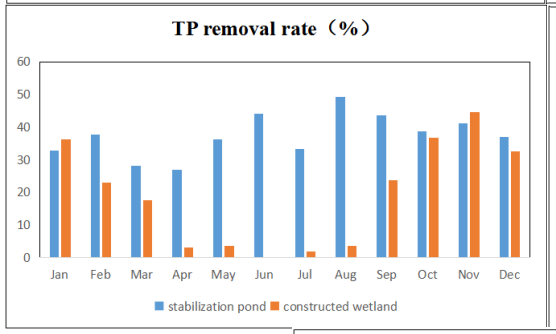
- The effect of **stabilization pond** on **orth-P and T-P** removal is better than that of COD_{Mn} and BOD_5 removal.；
- The removal efficiency of **BOD_5 and N** by **constructed wetland** is better than that of P. The removal efficiency of chemical indexes by Constructed Wetland varies greatly with month.。

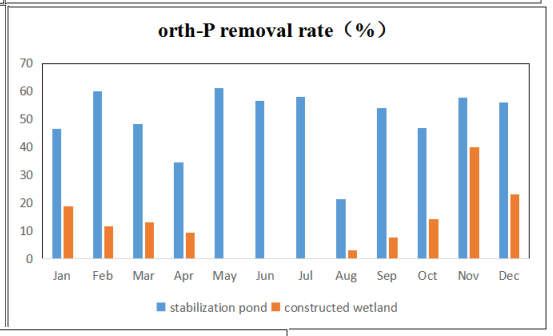


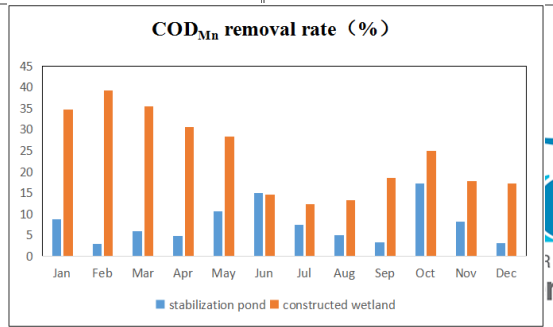










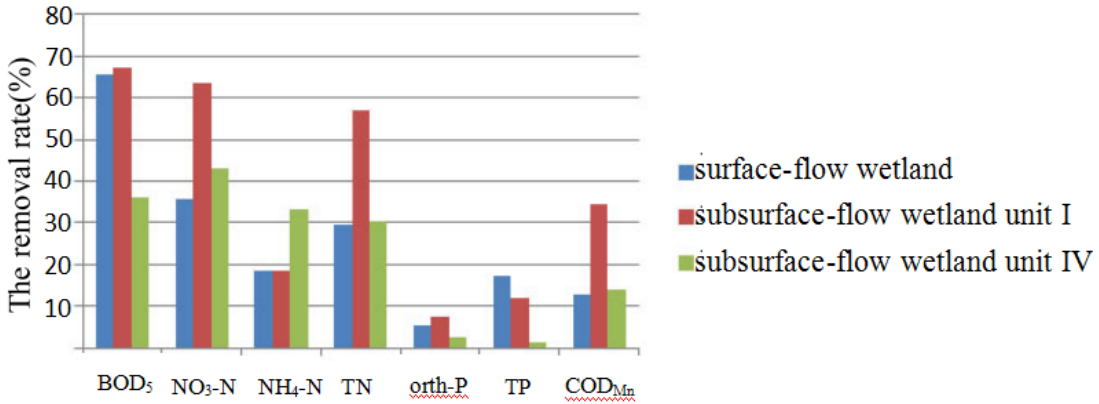


3. Study on Purification Effect of Wetland System

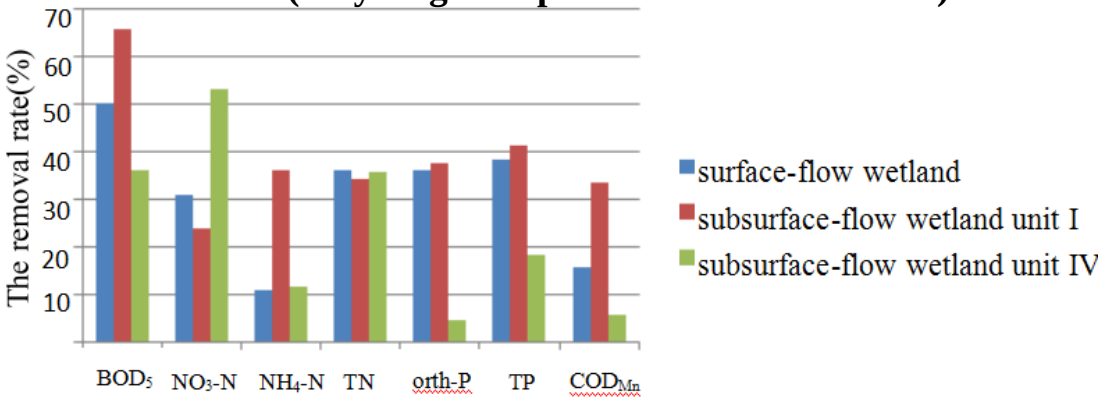
Comparison of Purification Effect Between Surface-flow Wetland and Subsurface-flow Wetland in Different Zones

The results show that :

- the removal effect of **BOD_5**, **orth-P** and **COD_{Mn}** in **zone I of subsurface-flow wetland** was better than that in zone IV of subsurface-flow wetland and surface-flow wetland.
- Subsurface-flow wetland area IV and surface-flow wetland had different removal effect on chemical indicators due to different climates.



Purification effect comparison of different zones of the constructed wetland (May--high temperature and more water)



Purification effect comparison of different zones of the constructed wetland (October--low temperature and less water)

4. Conclusion

◆ Overall Purification Effect of Wetland System

- Heituwa Wetland System had obvious purification effect on the incoming water of Yongding River. The average removal rates of BOD_5, NO_3-N, NH_3-N, TN, TP, orth-P and COD_{Mn} were 54.31%, 54.01%, 55.57%, 54.63%, 46.69%, 44.21% and 23.32%, respectively.
- The removal rate of chemical indicators in wetland system fluctuated with the season, and the effect was better in warm period than in cold period.

◆ Annual Change of Purification Effect of Wetland System

- From 2008 to 2015, the removal rate of each chemical indicator in wetland system had no obvious change trend, and the removal effect was relatively stable. The removal rates of BOD_5, NO_3-N, NH_3-N, TN, orth-P, TP and COD_{Mn} were significantly higher in October than in April.

4. Conclusion

◆ Comparison of Purification Effect Between Stabilization Pond and Constructed Wetland

- There was a significant difference in the removal effect of various chemical indicators between the stabilization pond and the constructed wetland. The constructed wetland showed better removal effect on BOD_5, NO_3-N, NH_3-N and TN, while stabilization pond showed better removal effect on TP and orth-P.

◆ Comparison of Purification Effect Between Surface-flow Wetland and Subsurface-flow Wetland in Different Zones

- The removal effect of BOD_5, orth-P and COD_{Mn} in zone I of subsurface-flow wetland was better than that in zone IV of subsurface-flow wetland and surface-flow wetland. Subsurface-flow wetland zone IV and surface-flow wetland had different removal effect on chemical indicators due to different climates.

4. Conclusion

◆ Environmental Benefit and Demonstration Meaning:

- Heituwa Wetland is of great significance for intercepting sewage and improving water quality of Guanting Reservoir.
- At the same time, as a typical wetland system in North China, it is also a technical exploration to construct wetland system in low-temperature areas of North China to treat river micro-polluted water. It can provide experience for the construction and operation management of constructed wetlands for purifying river water in North China.

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