

# Applications of high efficient vertical flow constructed wetland for the treatment and reuse of domestic sewage in residential community

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## Abstract

Domestic sewage treatment for new developing residential community areas is becoming more and more popular in terms of ecology, high quality, reuse and cost effective. Therefore, a holistic methodology for water management with low cost and reliable technology should be introduced and developed. The high efficient vertical flow constructed wetland (HEVFCW) has been developed and established by Shenzhen Academy of Environmental Science to improve the removal efficiency of organic matter, N, P and suspended solid. Moreover, HEVFCW has been applied in domestic sewage and lake water treatment in residential community in China. Results revealed that this system can achieve a high pollutant removal efficiency of SS, COD, BOD<sub>5</sub>, NH<sub>4</sub>-N, TP with removal rate of 40–93.5%, 87–91.4%, 89.1–98.7%, 72.3–82.2%, 93.4–97.3% under hydraulic load rate of 0.33–1.0 m/d. Effluent concentration could all meet the discharge regulation limits for reuse of recycling water for urban in China.

**Keywords** Vertical flow constructed wetland, Residential community, Wastewater treatment

## Introduction

HEVFCW, which is researched and developed by Shenzhen Academy of Environment and Science, is a high efficient ecological technology for pollution abatement. With unique structure, flow pattern, small occupation and long-term operation, this technology further develops the traditional constructed wetland process. Because of its such advantages as advanced process, reliable technology, high

efficiency and energy saving, easy in operation, low cost and landscape environment improvement, this technology has been applied in treatment and reuse of domestic sewage and landscape lake water in residential community.

## Methods

HEVFW had been applied in treatment and reuse of domestic sewage and landscape lake water circulating purification in residential community.

Treatment of domestic sewage system(Fig.1) consisted of two parts: pre-treatment system and constructed wetland system. The pre-treatment system includes three parts: hydrolysis acidification pool, contact oxidation tank and sedimentation settler. The Hydraulic Retention Time(HRT) are all 3h in the hydrolysis acidification pool and in the contact oxidation tank. The Bio film was hung in the tanks with 3m high. The air / water ratio was 3:1 in the contact oxidation tank. The reaction time in the sedimentation tank was 30 minutes.

No pre-treatment is needed in lake water circulating system (Fig. 2). The hydraulic capacity in the wetland is about  $1\text{m}^3/\text{m}^2\text{d}$ . Lake water is pumped up into the constructed wetland. Effluent from the constructed wetland flows back into the landscape lake and is thereby re-circulated.

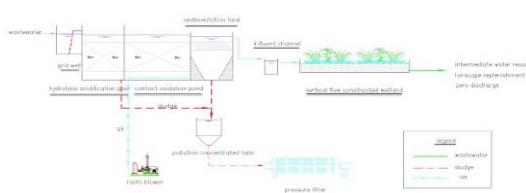


Fig. 1 CWs for domestic sewage treatment

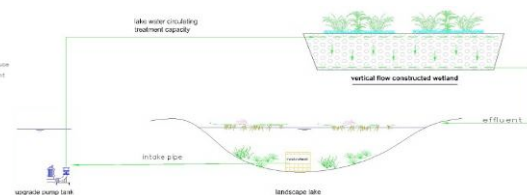


Fig. 2 CWs for lake water circulating treatment

## Results and discussion

Over the last 15 years, HEVFCW system had been successfully applied in community wastewater treatment projects in more than 20 cities in China.

Major design parameters of HEVFCW project is shown in Table 1:

*Table 1. Major design parameters of HEVFCW systems applied in China.*

	<b>Tiger Apartment CW</b>	<b>Gemdale CW</b>	<b>Vanke City CW</b>
Start of operation	10/2005	3/2006	5/2006
Design wastewater treatment capacity(m <sup>3</sup> /d)	30	5000	500
Type of influent	Domestic sewage	Domestic sewage	Lake water
Pretreatment	①+② <sup>(*)</sup>	①+②+③ <sup>(*)</sup>	None <sup>(*)</sup>
HEVFCW area(m <sup>2</sup> )	90	10000	500
HLR(m/d)	0.33	0.5	1.0
HRT(h)	43.2	34.5	11.5
Filtration material(size in mm)	Sand,Gravel (1-40,layer laying)	Sand,Gravel (1-40,layer laying)	Sand,Gravel (1-40,layer laying)
Function of effluent	Greening water	Greening water	Lake water circulating

<sup>(\*)</sup>①:Hydrolysis acidification pool,②: Contact oxidation tank,③: Sedimentation tank

Treatment capacity of the constructed wetland system for sewage purification in Tiger Apartment is 30m<sup>3</sup>/d. The effluent water is reused for watering the lawn irrigation of the area. In November 2006, USGBC awarded Tiger apartment LEED silver. Treatment effect is shown in Table 2:

*Table 2 Treatment effect of Tiger Apartment constructed wetland system for domestic wastewater*

<b>Index</b>	<b>SS(mg/L)</b>	<b>COD(mg/L)</b>	<b>BOD<sub>5</sub>(mg/L)</b>	<b>NH<sub>4</sub>-N(mg/L)</b>	<b>TP(mg/L)</b>
Influent quality	78	176	86	32.8	3.07
Effluent quality	5	15	2	7.4	0.08
Regulation limits <sup>a</sup>	--	--	20	20	--
Removal efficiency (%)	93.5	91.4	97.6	77.4	97.3

<sup>a</sup> Water quality standard for urban miscellaneous water consumption (GB/T18920-2002) urban greening standard.

Gemdale Lihucheng is located in Guangzhou city. This community occupies a large

area but there is no municipal drainage service. To protect the aquatic ecosystem of the lake in the area , a constructed wetland system was built for the treatment and reuse of the domestic sewage water. The system consists of 20 dispersed constructed wetlands. The total treatment capacity is 5000m<sup>3</sup>/d. All the effluent water is reused for watering the lawn irrigation of the area and replenishing the lake. Treatment results of this systems are as follows (Table 3):

*Table 3 Treatment effect of Gemdale constructed wetland system for domestic wastewater*

<b>Index</b>	<b>SS(mg/L)</b>	<b>COD(mg/L)</b>	<b>BOD<sub>5</sub>(mg/L)</b>	<b>NH<sub>4</sub>-N(mg/L)</b>	<b>TP(mg/L)</b>
Influent quality	95	200	88.6	21.7	2.2
Effluent quality	14	26	1.1	6	0.1
Regulation limits <sup>b</sup>	20	40	20	10	0.5
Removal efficiency (%)	85.3	87	98.7	72.3	95.4

<sup>b</sup>Pollutant emission limit value for wastewater (DB44/26-2001) Grade I standard.



The Landscape of Gemdale Lihucheng Constructed Wetland



Vanke City Constructed Wetland in Shenzhen, China

Vanke City is a residential community. There is a 10000m<sup>2</sup> landscape lake in the community. We designed and built the constructed wetland for lake water circulating purification for treatment of the collected rainwater. 500m<sup>3</sup>/d lake water flows through

constructed wetland and then returns to the lake. Treatment effects of this system is shown in (Table 4). Five years running showed that system had good removal effects of SS, COD, BOD<sub>5</sub>, NH<sub>4</sub>-N, TP. The effluents could stably meet the IV criteria specified in the *Environmental Quality Standards for Surface Water* (GB 3838-2002).

*Table 4 Treatment effect of Vanke City constructed wetland system for lake water*

<b>Index</b>	<b>SS(mg/L)</b>	<b>COD(mg/L)</b>	<b>NH<sub>4</sub>-N(mg/L)</b>	<b>TP(mg/L)</b>
Influent quality	10	17	0.45	0.29
Effluent quality	6	16	0.08	0.02
Regulation limits <sup>c</sup>	--	30	1.5	0.1
Removal efficiency (%)	40	--	82.2	93.4

<sup>c</sup>Environmental Quality Standards for Surface Water (GB 3838-2002) Grade IV standard.

## Conclusions

Results from the application of the HEVFCW revealed that this new HEVFCW with the pre-treatment system can achieve a high pollutant removal efficiency of SS, COD, BOD<sub>5</sub>, NH<sub>4</sub>-N and TP with removal rate of 40-93.5%, 87-91.4%, 97.6-98.7%, 72.3-82.2%, 93.4-97.3% under hydraulic load of 0.33-1.0 m/d. Effluent concentration could all meet the discharge regulation limits for reuse of recycling water for urban in China.