

# Spatial distribution of ORP and its correlation with microbial population in a novel horizontal subsurface flow constructed wetland

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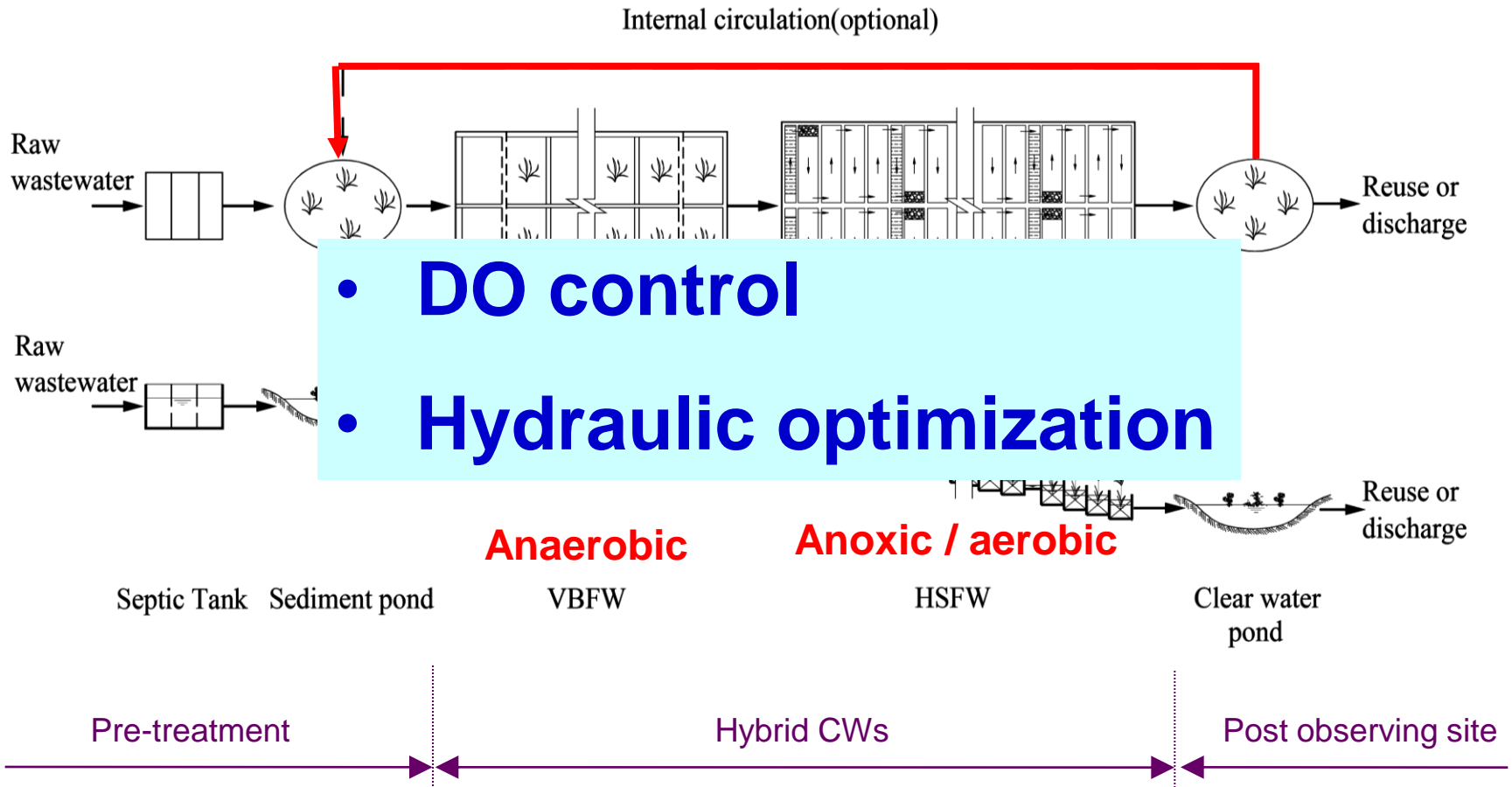
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- **Introduction**
- **The Constructed Wetland and research methods**
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# Introduction

- Constructed Wetland (CW) : environmental friendly, cost effective for wastewater treatment; good potential for Decentralized system and reuse.
- Microbial activity is primarily responsible for the removal of carbon and nitrogen in CWs
- Microbial process is usually limited by relative low Dissolved Oxygen (DO) concentration level
- **A new hybrid constructed wetland system was designed trying to improve the Oxygen Transfer Rate from air to water in a natural way.**

# The Hybrid CW: VBFW+HSFW system



# Vertical Baffled Flow Wetland (VBFW)





# Horizontal Subsurface Flow Wetland (HSFW)



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# Pilot system

2005 - 2006, in  
Chongqing University;





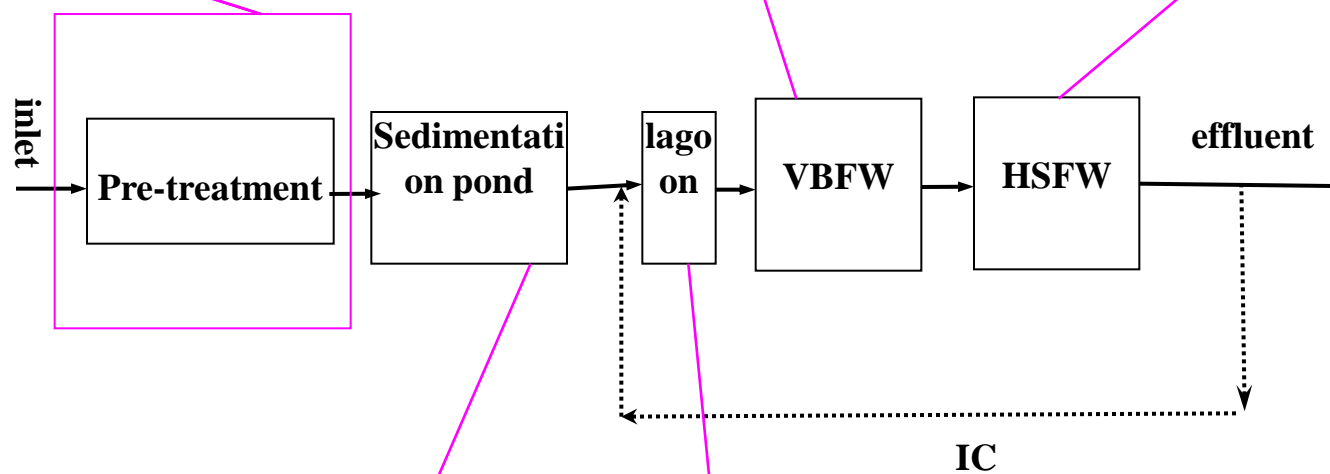
# Full-scale system\_Lugu Lake



- **Designed treatment capacity: 1000 m<sup>3</sup>/d;**
- **Technology: VBFW+HSFW**
- **Scenic site and High plateau;**
- **Nov. 2007 - present**









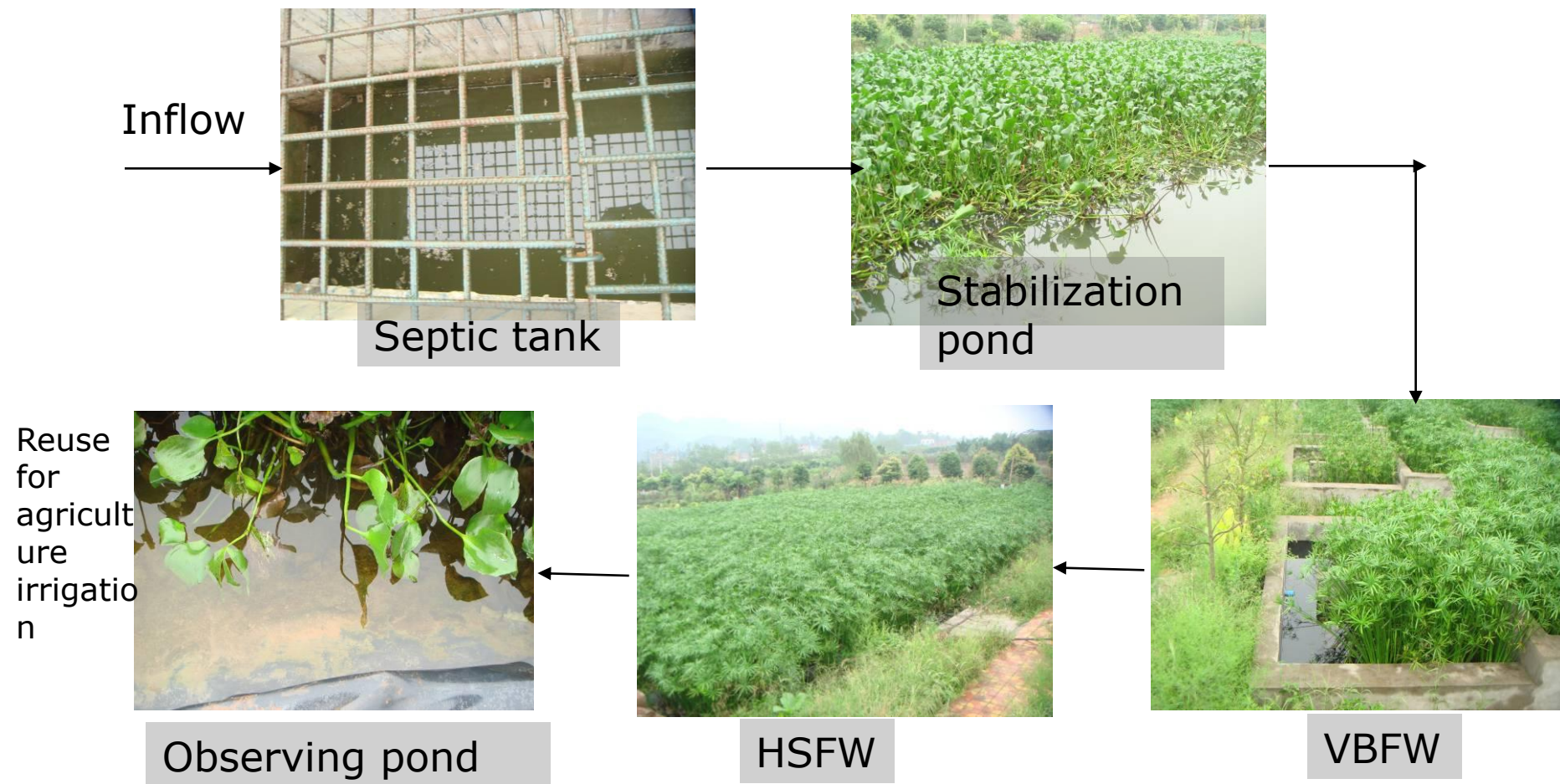
# Full-scale system\_Baishiyi

- **Designed treatment capacity: 500 m<sup>3</sup>/d;**
- **Full-capacity operation**
- **Small community**
- **Technology: VBFW+HSFW**
- **April 2008 - present**





# Full-scale system\_Baishiyi





# Full-scale system\_ Wulong Fairy Mountain

- **Designed treatment capacity: 1200 m<sup>3</sup>/d;**
- **1/5 in operation**
- **Mountainous site, high altitude**
- **Technology: VBFW+HSFW**
- **Nov. 2008 - present**



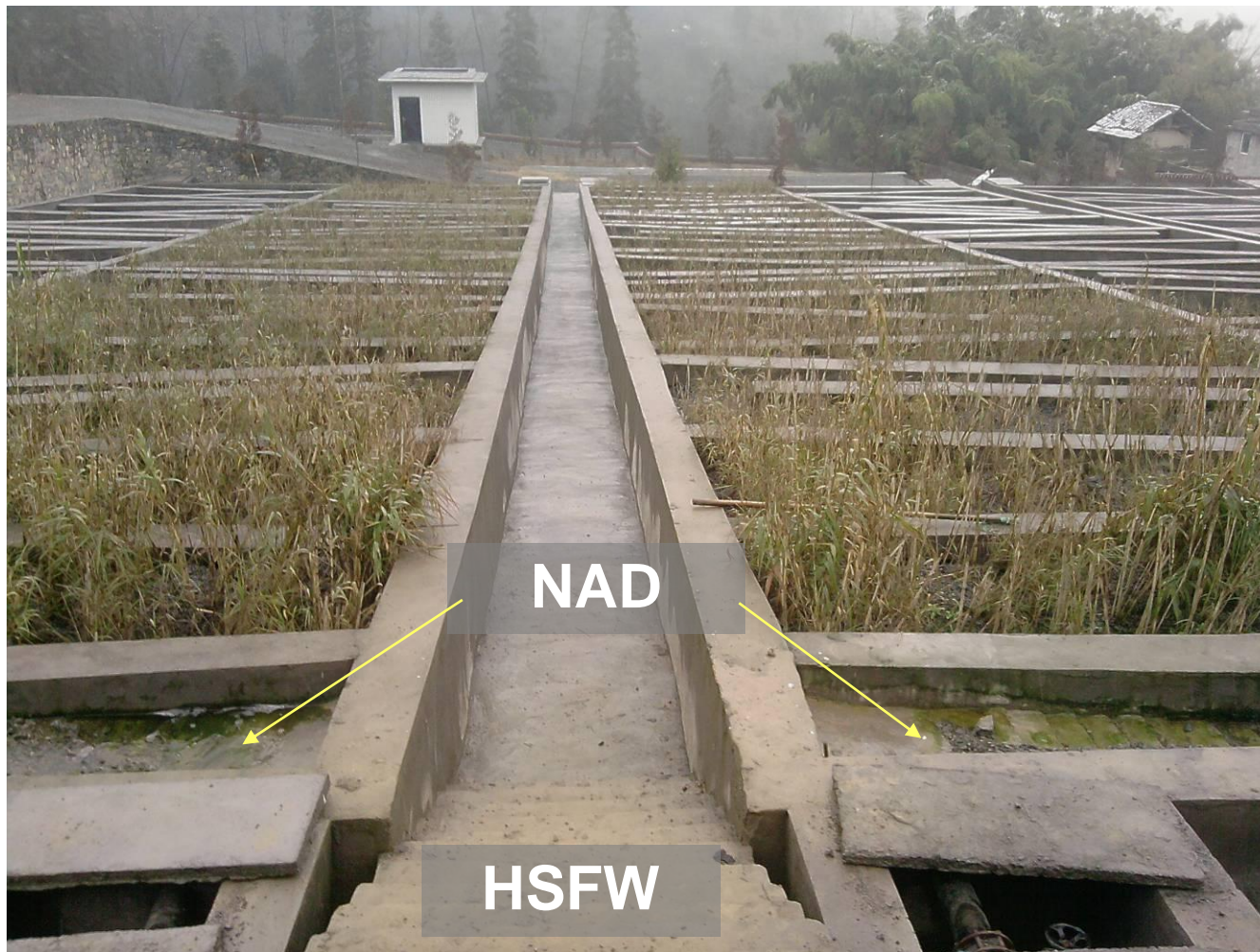
Valve wells for drying the VBFW and preventing from clogging



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Chongqing University



# Full-scale system\_Wulong Fairy Mountain



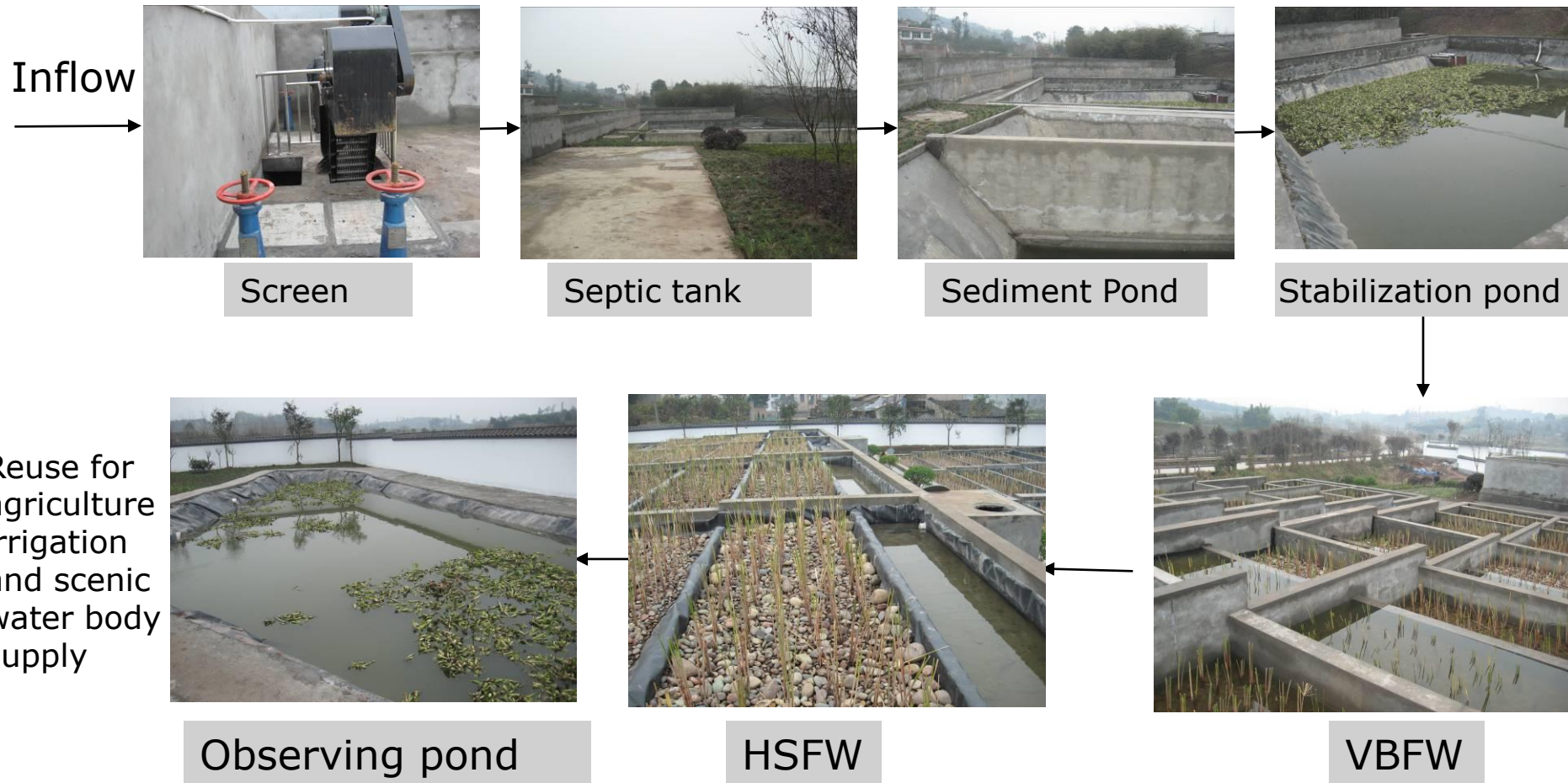
# Full-scale system\_ Qinghe Agro-park



- **Designed treatment capacity: 1500 m<sup>3</sup>/d;**
- **Small community**
- **Technology: VBFW+HSFW**
- **Begin with Jan. 2011**



# Full-scale system\_ Qinghe Agro-park



# Full-scale systems

	LuGu lake CW	Baishiyi CW	Wulong Fairy Mountain CW
Start of operation	11/2007	4/2008	11/2008
Type of site	Scenic site High plateau; altitude: around 2190m;	Small community Non-mountainous site altitude: around 180m;	Town in natural conservation area; Mountainous site; Altitude: around 1200m.
Design wastewater treatment capacity (m <sup>3</sup> /d)	1000(4000 P. E.)	500 (2000 P. E.)	1200(7000 P. E.)
Vegetated beds area (m <sup>2</sup> )	Total: 3716; VBFW: 433; HSFW: 3283;	Total: 1172; VBFW: 192; HSFW: 980;	Total: 3306; VBFW: 1010; HSFW: 2296;
Specific area (m <sup>2</sup> m <sup>-3</sup> d)	3.72	2.34	2.76
Surface HLR (cm/d)	26.9	42.7	36.3
HRT (h)	44	31	45
Filtration material (size in mm)	Gravel (3-20, decrease step by step)	Gravel (3-20, decrease step by step)	Gravel (3-20, decrease step by step)
Plants	<i>Phragmites</i>	<i>Cyperus alternifolius</i>	<i>Cyperus alternifolius</i>
Internal circulation	Operated in winter	Non operated	Operated in winter and holiday season



# Full-scale systems

Parameter	LuGu lake CW			Badiyiyuan-Bayixian CW			Wulong Fairy Mountain CW			Average Eff. (%)
	Influent <sup>a</sup>	Effluent <sup>a</sup>	Eff. (%)	Influent <sup>a</sup>	Effluent <sup>a</sup>	Eff. (%)	Influent <sup>a</sup>	Effluent <sup>a</sup>	Eff. (%)	
T/°C	10.8	--	--	22.3	--	--	18.4	--	--	
pH	7.2	--	--	6.2	--	--	6.0	--	--	
COD (mg/l)	132	2							83.6	85.7
SS (mg/l)	93	3							99.0	96.8
NH <sub>4</sub> -N (mg/l)	10.8	2							71.7	80.5
TN (mg/l)	--	--							76.1	76.1
TP (mg/l)	2.9	0.1							68.1	76.5

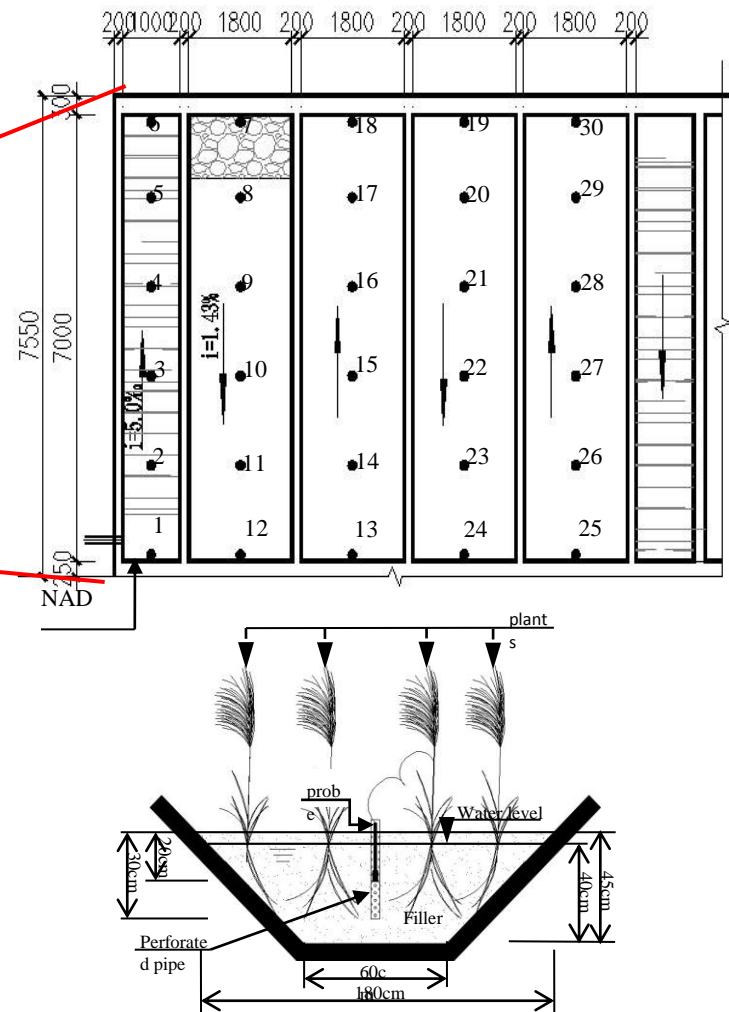
**This research tries to evaluate the performance of HSFW on DO increasing and its effect on microbial process.**

<sup>a</sup> Concentrations expressed in mg/l, Mean data (minimum–maximum)

<sup>b</sup> National discharge standard of pollutants for municipal wastewater treatment plants, China, Grade 1, Class B (GB 18918, 2002).

<sup>c</sup> Value in parenthesis is the limit with ambient temperature higher than 12°C.

# Material and methods

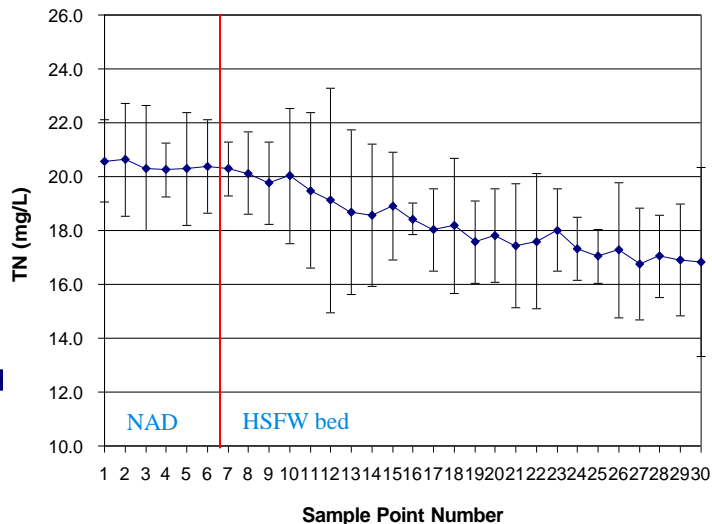
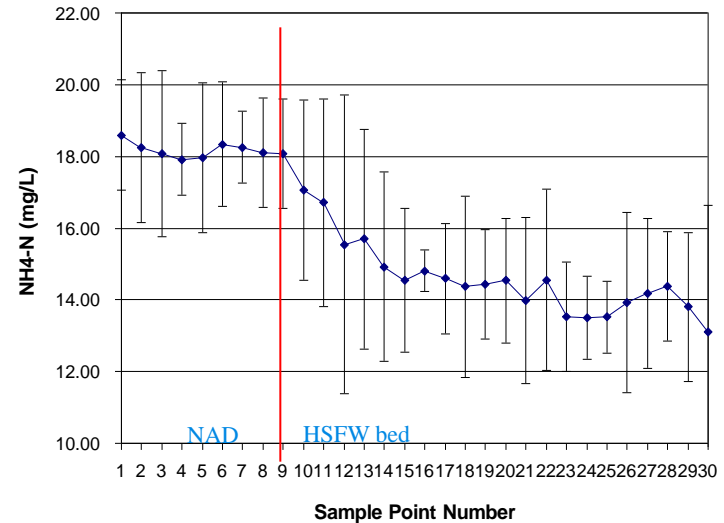
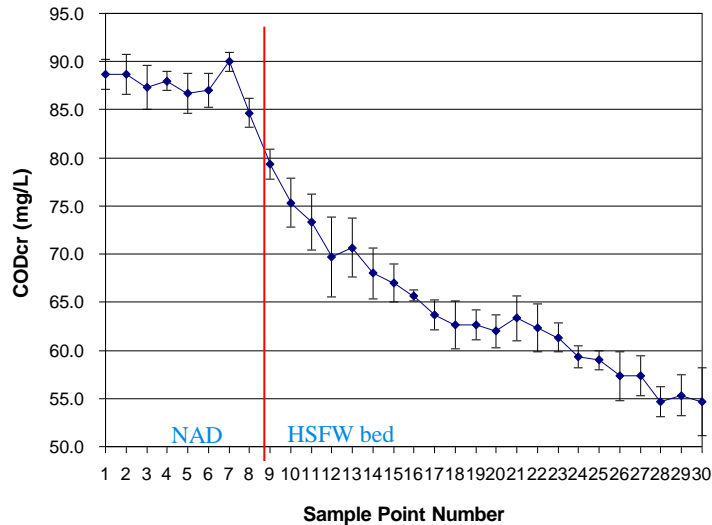




# Material and methods

- COD<sub>cr</sub>, TN, NH<sub>4</sub>-N, G<sub>COD</sub>, G<sub>TN</sub>, G<sub>NH4-N</sub> (the gradient of the parameters along the flow path in CW)
- DO, ORP,
- Specific Oxygen Uptake Rate (SOUR) of the sludge
- Microbial Population Density (MPD) of the sludge – indicated by the amount of phospholipids with simplified PLFA.
- Pearson Product Correlation Coefficients (r) for correlation analysis

# Results and discussion



## Concentration profiles of COD and Nitrogen

CODcr, NH<sub>4</sub>-N, and TN reduced from  $88.7 \pm 1.53 \text{ mg.l}^{-1}$ ,  $18.60 \pm 1.30 \text{ mg.l}^{-1}$ ,  $20.58 \pm 0.63 \text{ mg.l}^{-1}$  to

$54.7 \pm 3.51 \text{ mg.l}^{-1}$ ,  $13.11 \pm 0.58 \text{ mg.l}^{-1}$ ,  $16.83 \pm 1.34 \text{ mg.l}^{-1}$

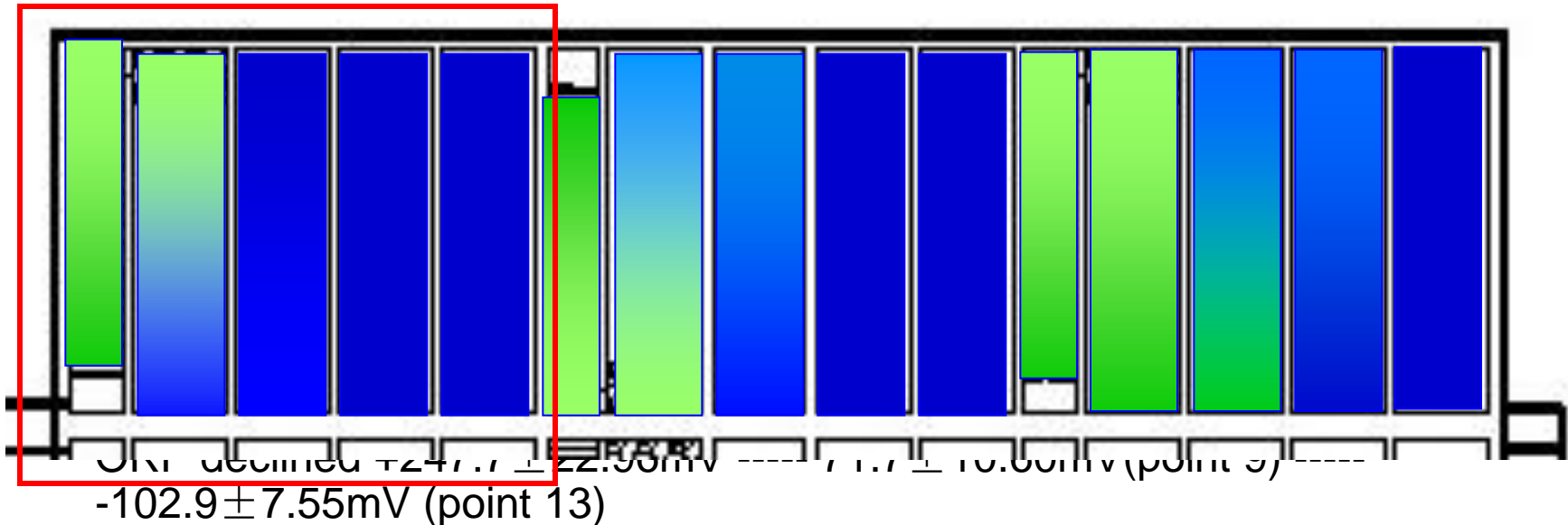
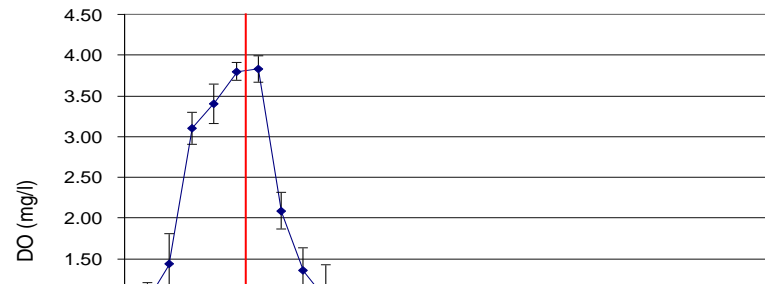
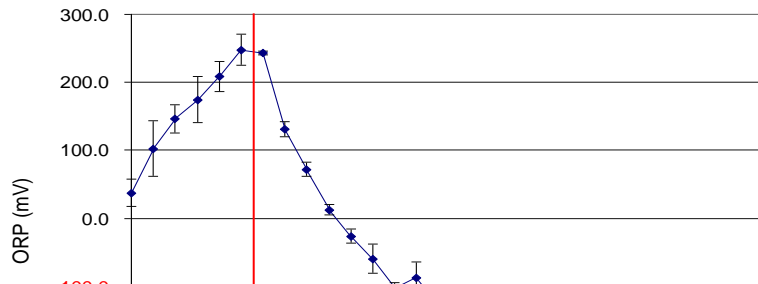
respectively within the studied section of HSFW





# Results and discussion

## Profile of ORP and DO



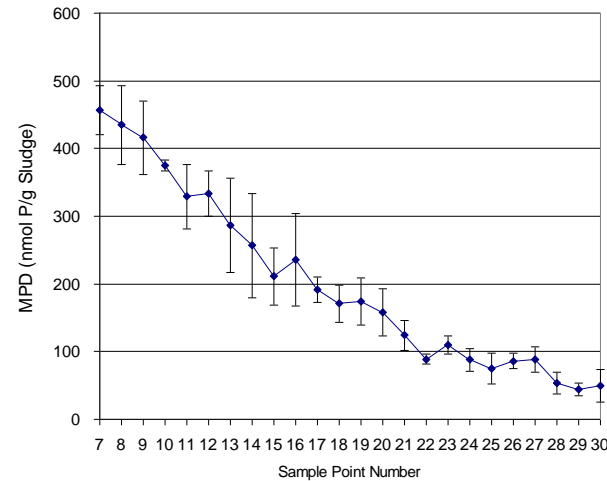
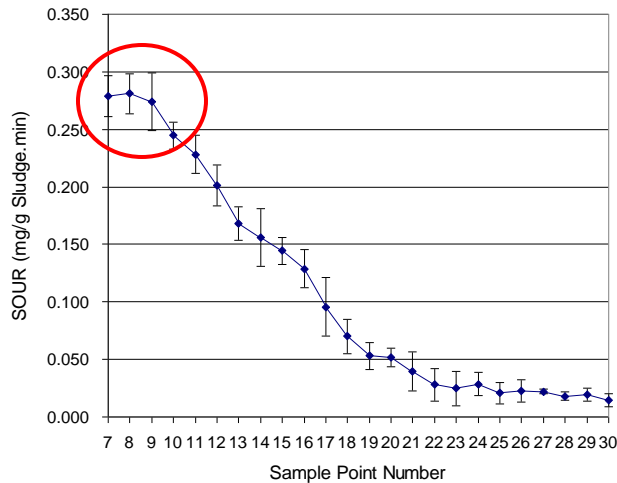
-102.9 ± 7.55mV (point 13)

an aerobic zone 3.5m long (0.5 hour)

an anoxic zone of 3.5m long (0.5 hour). the remaining HSFW bed is dominated in anaerobic condition.

# Results and discussion

## Profile of MPD and SOUR in HSFW bed



MPD and SOUR decreased dramatically from  $457 \pm 36.12$  nmol P/g sludge and  $0.279 \pm 0.018$  mg  $O_2$ /(g sludge.min) at point 7 to  $19 \pm 24.06$  nmol P/g sludge and  $0.015 \pm 0.006$  mg  $O_2$ /(g sludge.min) respectively at point 30.

At the beginning of HSFW bed (from point 7 to Point 10), the SOUR value shows typical aerobic bio-film growing on the gravel surface.



# Results and discussion

## Correlationship analysis

r	COD	NH <sub>4</sub> -N	TN	ORP	DO	SOUR	G <sub>COD</sub> *	G <sub>NH4-N</sub> *	G <sub>TN</sub> *	G <sub>ORP</sub> *	G <sub>DO</sub> *
SOUR	0.945	0.944	0.970	0.922	0.650	--	0.805	0.513	0.307	0.807	0.714
MPD	0.964	0.944	0.970	0.926	0.680	<u>0.986</u>	0.776	0.466	0.330	0.776	0.700
<u>ORP</u>	<u>0.955</u>	<u>0.942</u>	<u>0.920</u>	--	<u>0.875</u>	<u>0.922</u>	<u>0.915</u>	<u>0.460</u>	<u>0.235</u>	--	--
DO	0.744	0.715	0.658	0.875	--	0.650	0.825	0.114	0.062	--	--

- MPD and SOUR have very obvious positive correlativity with  $r = 0.986$
- ORP has more positive correlations with chemical and microbial parameters compared with DO. ORP is a more reasonable parameter to indicate aerobic or anaerobic environment in CWs.
- The spatial distributions of Microbial Population and microbial activity intensity are closely related to the redox condition in HSFW bed;
- Biological degradation of organic matters still dominates the microbial process in the studied section of HSFW bed.

# Conclusions

- A seven-meter-long NAD in the novel horizontal subsurface flow constructed wetland can improve the DO concentration in wetland bed creating an aerobic zone of around 3.5m long with HRT of 0.5 hour and an anoxic zone of around 3.5m long.
- The increased DO concentration can enhance aerobic microbial process and accelerate biodegradation of COD and  $\text{NH}_4\text{-N}$  consequently.
- The high correlation coefficients between ORP and the parameters of microbial activity ( $r_{\text{ORP-MPD}} = 0.922$  and  $r_{\text{ORP-SOUP}} = 0.926$ ) indicate that microbial activity intensity are greatly influenced by the redox condition in HSFWS bed.
- In the studied section of HSFWS bed, bacterial activities for biological degradation of organic matters are still the main microbial process, which exhaust most of the oxygen in water phase.



# THANKS FOR YOUR ATTENTION



研究学术 造就人才 佑启乡邦 振导社会

人类之文野，国家之理乱，悉以人才为其主要之因。必人才日出，然后事业日新；  
必事业日新，然后生机永畅。世界所以进化无疆，国家所以长存不敝，胥赖于此。

——1929年《重庆大学筹备会成立宣言》、《重庆大学宣言》摘录