Applied Research of Strengthened Ecological Floating Bed in the Purification of Urban Landscape Water

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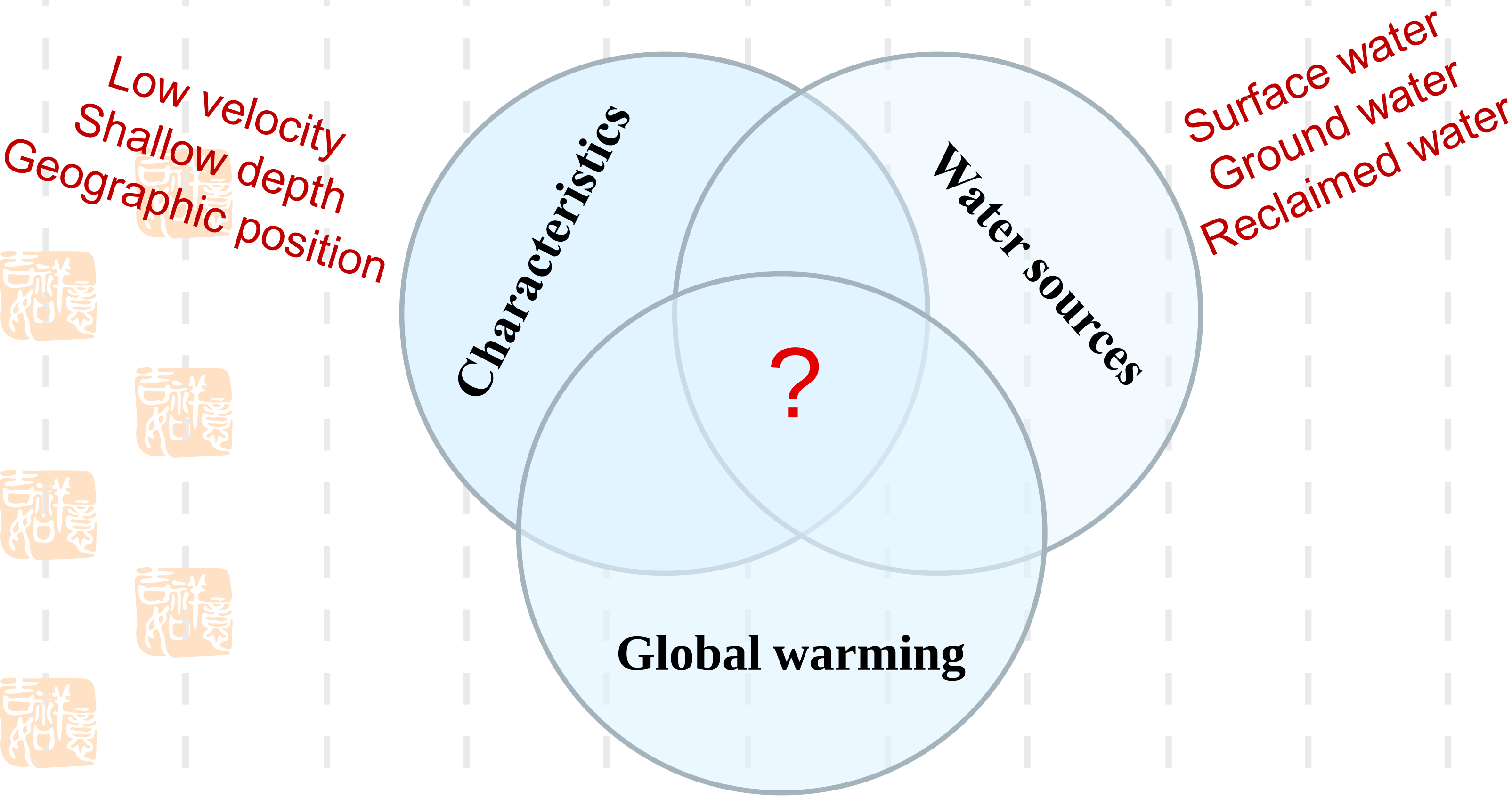
Urban Landscape Water in Xi’an

- **“571028” project from Xi'an Water Affairs Bureau in August of 2012.**
- **5 channel waters, 7 wetlands, 10 rivers, 28 lakes.**



Current Situation

Methods to control the landscape water quality

- **Physical methods: diversion dilution, sediment dredging, sediment coverage**
- **Chemical methods: chemical alga-killing, flocculation precipitation, remediation of stabilization and solidification**
- **Biological methods: remediation through aquatic animals, aquatic plants, and microorganisms**

Green, Economical, Efficient, combined technology

Ecological Floating Bed(FB)

- a new artificial wetland technology
- play an important role in greening, and beautifying the environment besides purifying water bodies
- highly efficient in removing nitrogen (N) and phosphorus (P) from water
- prevent the outbreak of algae during high-temperature season

Some concerns about FB

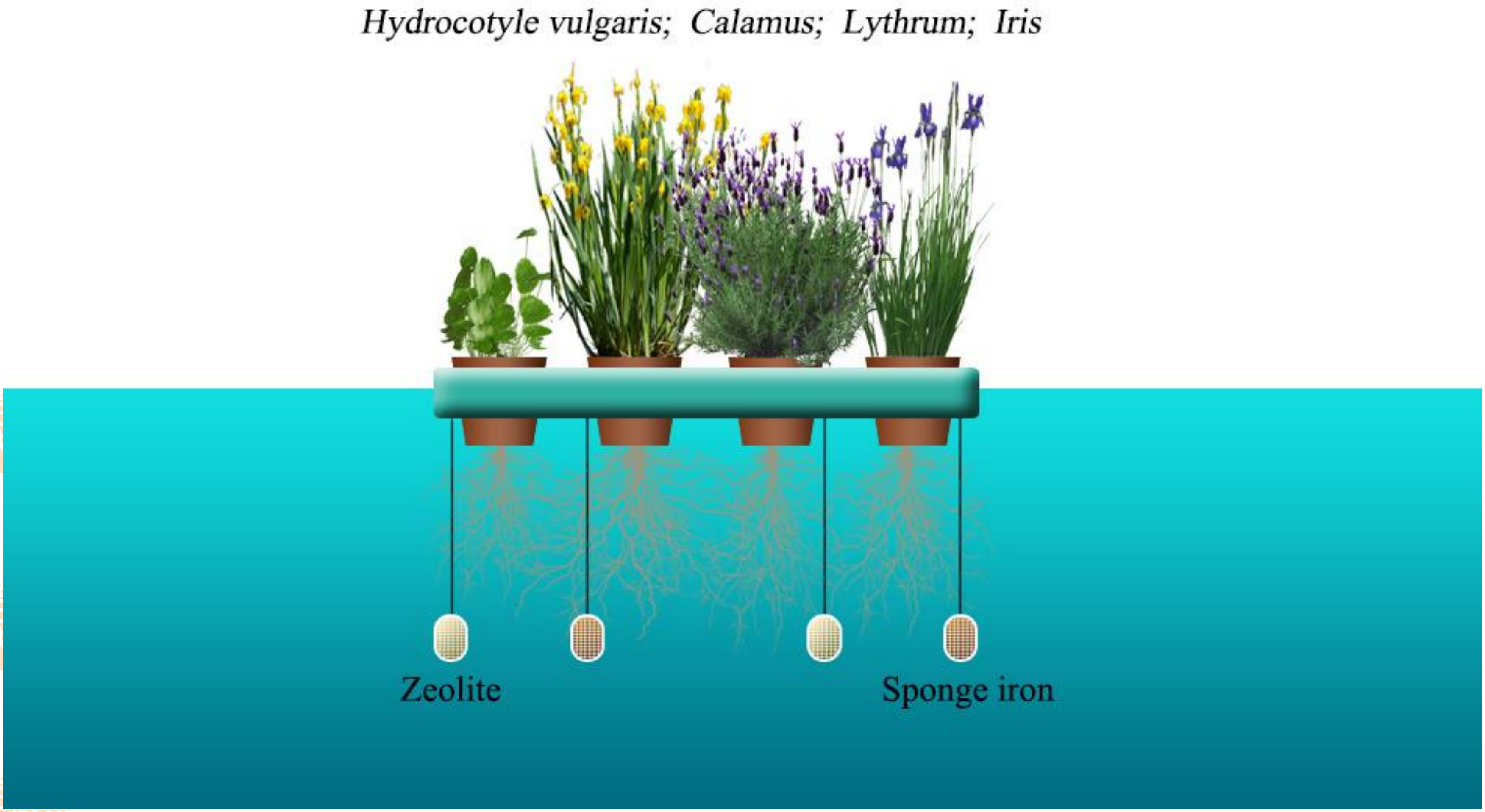
- Winter?
- Contribution of plants in FB
- Harvest of Plant in FB
- Resource of Plant in FB

Purposes of Our Research

- **Setup Strengthened Ecological Floating Bed(SFB) with filler added to cope with the winter.**
- **Monitor the removal efficiency and analyze the removal mechanism of SFB.**
- **Explore the optimal time for plant harvest and the proper way for plant resource.**

Strengthened Ecological Floating Bed

Schematic diagram



Field experiment

- An artificial lake in Xingqing Park
- A total area of 326 m^2 and an effective water depth of 0.65 m
- Water source: reclaimed water
- Period: July of 2016 to Sep of 2017

Four plants

- **Four native plants, namely, *calamus, iris, lythrum, and Hydrocotyle vulgaris* were vegetated in FB and SFB.**
- **The planting density in both zones was 10 plants per m^2, thereby leading to a plant coverage of the water areas of approximately 45%.**

Shaanxi Garden Center in Xi'an

Two fillers

- Both zeolite and sponge iron in SFB were suspended 25 cm below the water surface in nylon bags with 2 mm mesh.
- Dosages used in SFBZ were 1.6 kg zeolite per m^3 water and 2.0 kg sponge iron per m^3 water.

zeolite

sponge iron

Reclaimed Water as only Water Source

Tab.1 Replenishment quantity of reclaimed water

replenishment quantity (m^3)	Ⅰ 1th day	Ⅱ 23th day	Ⅲ 36th day	Ⅳ 52th day	Ⅴ 74th day	Ⅵ 111th day	Ⅶ 149th day
CZ	15.8	15.4	15.0	16.1	15.7	15.5	16.0
FBZ	16.2	15.9	15.7	16.3	16.2	16.1	16.8
SFBZ	16.9	16.5	16.3	16.8	16.6	17.0	17.4

Tab. 2 Water quality parameters of recharged water (reclaimed water)

Index	TN（mg/L）	NH_4^+-N（mg/L）	NO_3^--N (mg/L)	NO_2^--N（mg/L）	TP (mg/L)	PO_4^{3-}-P（mg/L）	Chl-a（ug/L）	Algal density（cells/mL）	Turbidity（NTU）
Maximum	10.23	4.10	5.52	0.67	0.92	0.84	8.25	28200	38.25
Minimum	4.36	1.29	1.93	0.03	0.38	0.31	1.06	7777	16.21
Average	7.81	2.78	3.36	0.23	0.73	0.46	4.38	13560	26.91

Sampling and analysis

water

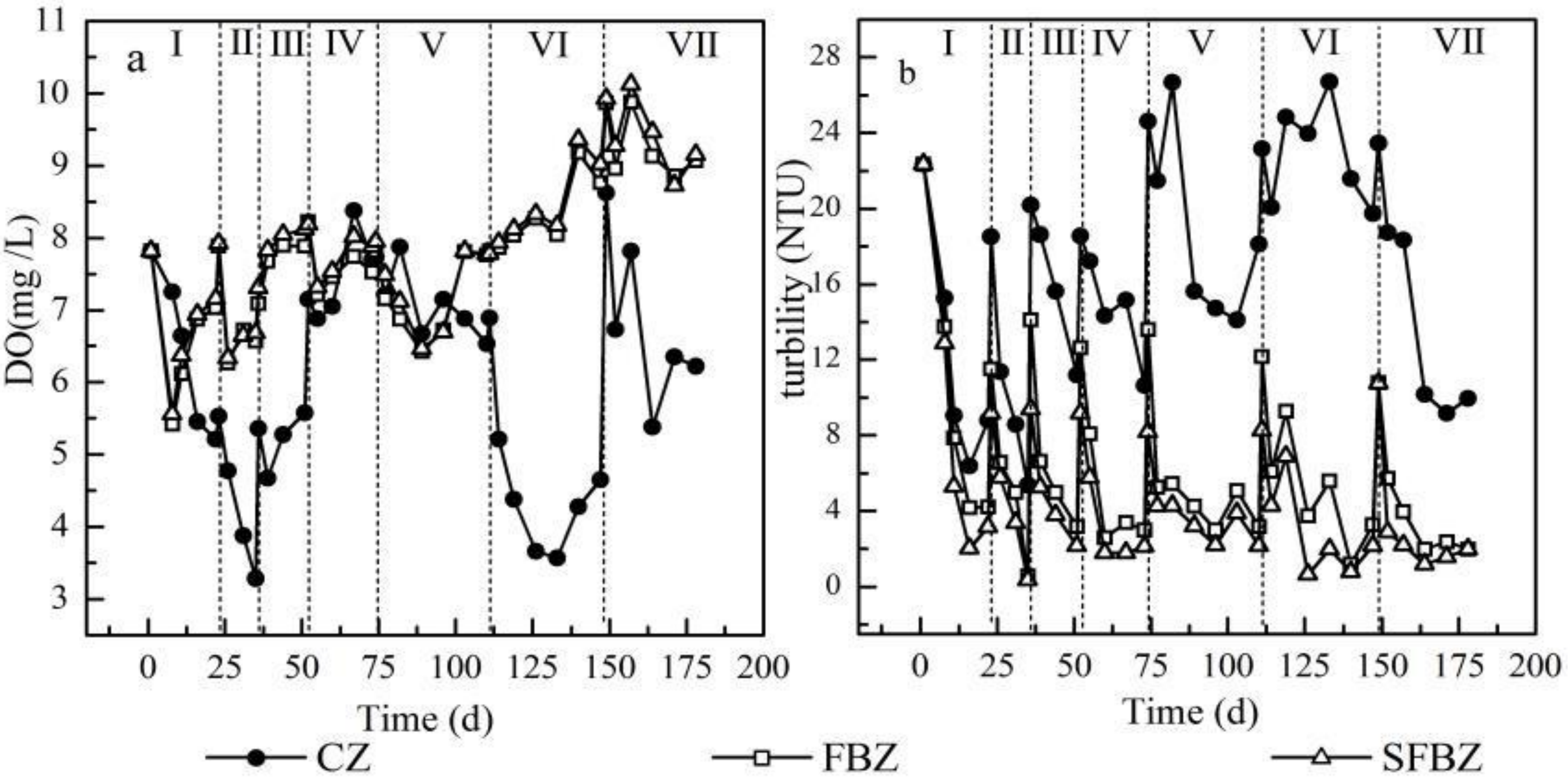
- Five sampling points (in the center and four corners) were set for each experimental area. The water sample used for each zone was obtained by mixing the water samples from the five different points, which were collected at 25 cm below each water surface. Water samples were collected at 9:00 a.m. every 5 days.
- Temperature (T) and dissolved oxygen (DO) were monitored on-site.

plant

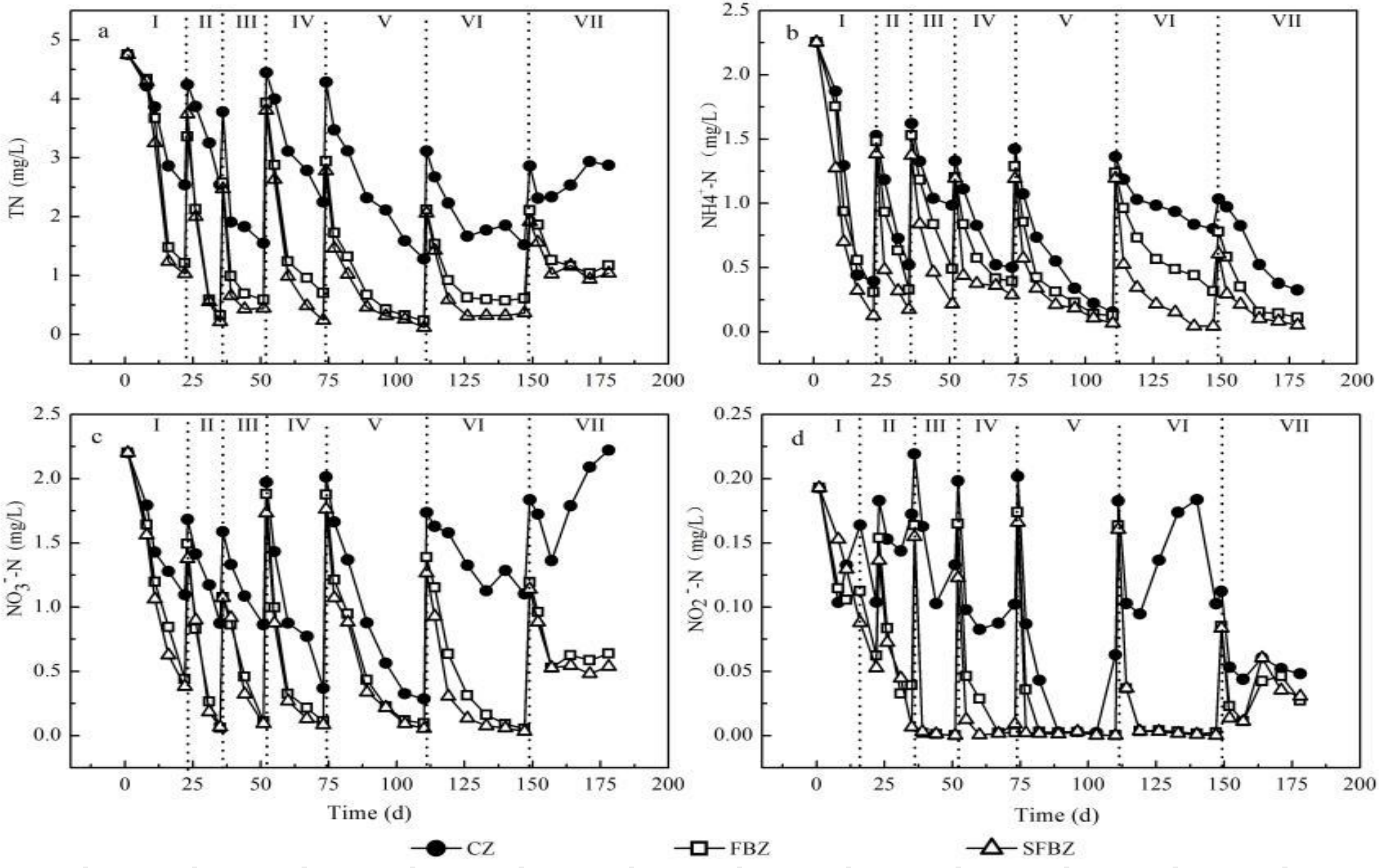
- four different plants growing in the FBZ and in the SFBZ were sampled and tested every 15 days. The tests included the conditions of the four plants, such as the weight (fresh), the dry weight, the heights and the roots length, and the nitrogen and phosphorus concentration in the tissues. The plant height and the root length were measured using a measuring tape. The fresh weight and the dry weight of plants were determined by the gravimetric method

Results

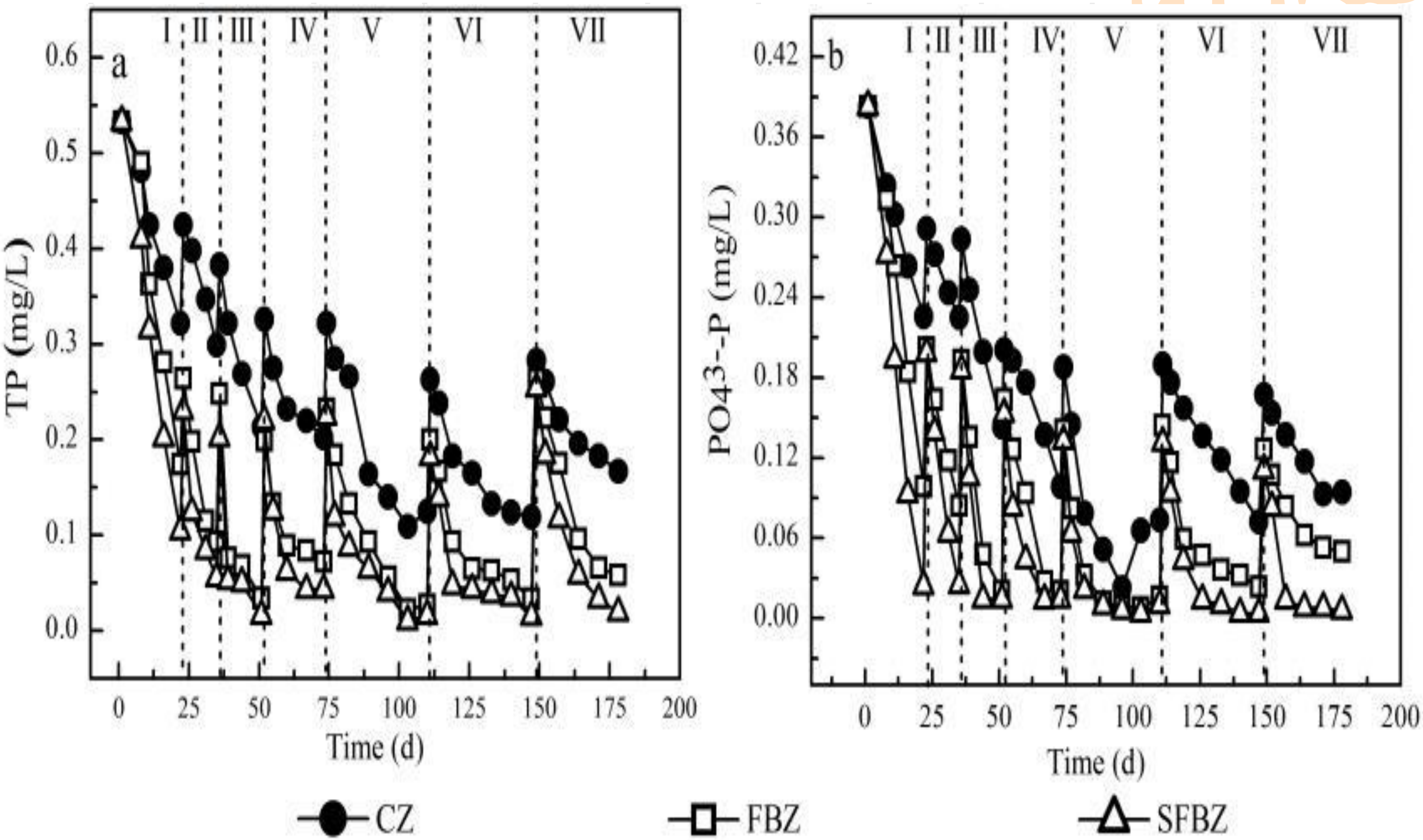
Time course of DO and turbidity in different waters



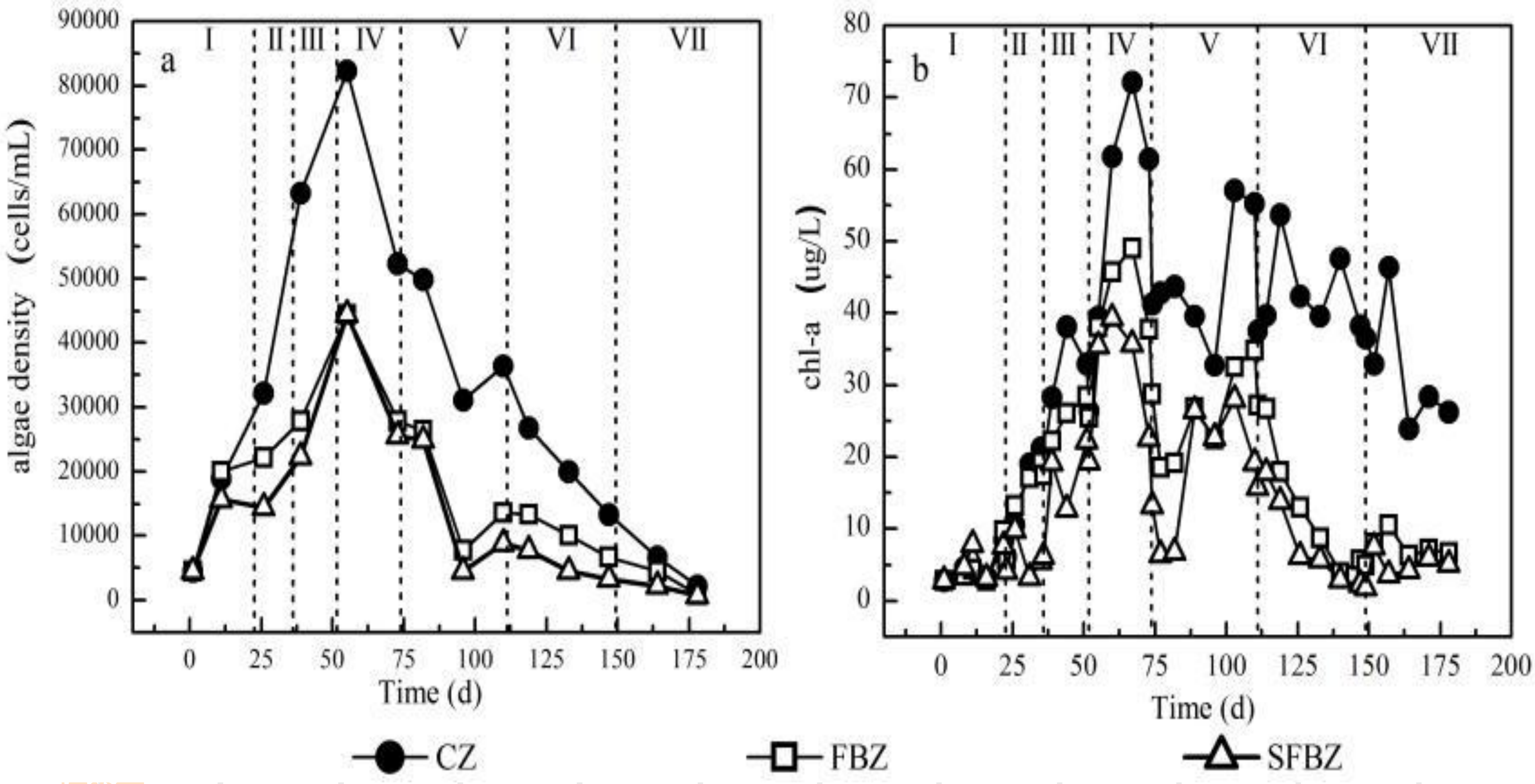
Variation of N concentrations in different zones



Variation of P concentrations in different zones



Time course of algae density and Chl-a concentration in different waters



Removal Efficiency

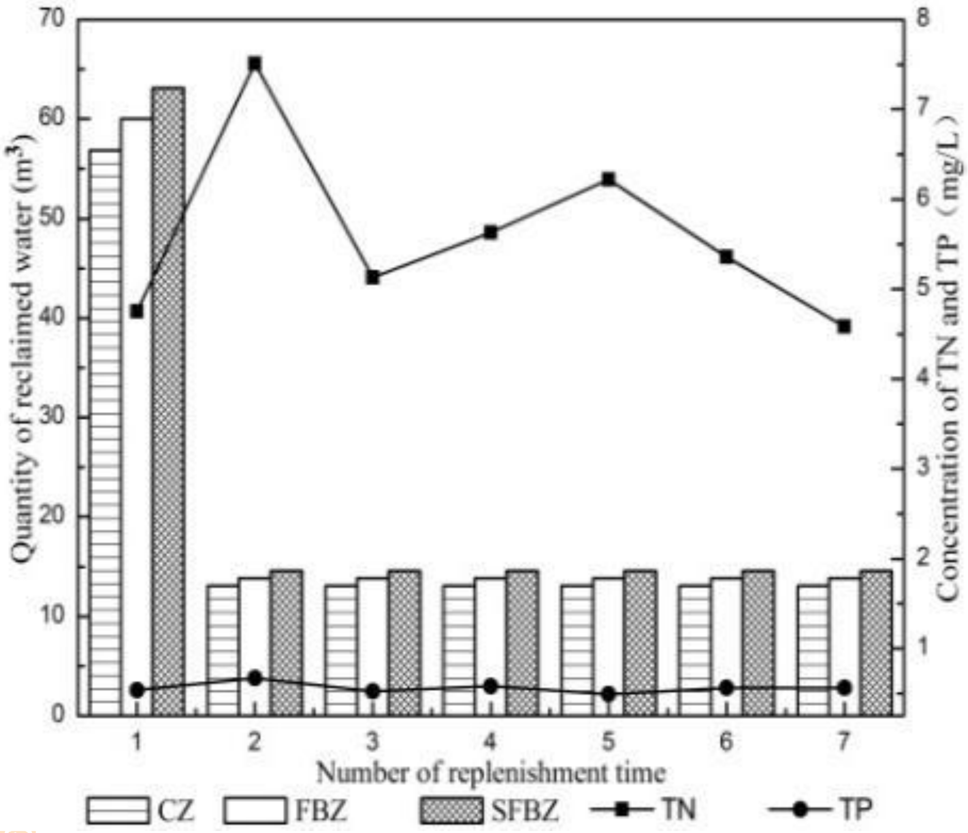
- The quality standard for reclaimed water as scenic water (GB/T18921-2002) can't ensure the quality in urban landscape water. SFB can keep the concentrations of TN and TP below1.04 and 0.06 mg/L, which can meet Class Ⅳ in Chinese Surface water Quality Standards(GB3838-2002).

AREs of each season to NH_4^+-N and PO_4^{3-}-P in CZ, FBZ and SFBZ

	NH_4^+-N			PO_4^{3-}-P		
	Summer	Autumn	Winter	Summer	Autumn	Winter
CZ	21.62%	44.72%	34.88%	51.90%	50.12%	46.62%
FBZ	42.02%	78.89%	51.51%	59.22%	63.36%	50.28%
SFBZ	61.92%	85.17%	78.72%	61.92%	79.95%	86.27%

Removal mechanism of N and P in landscape water

-Check the input load of N and P

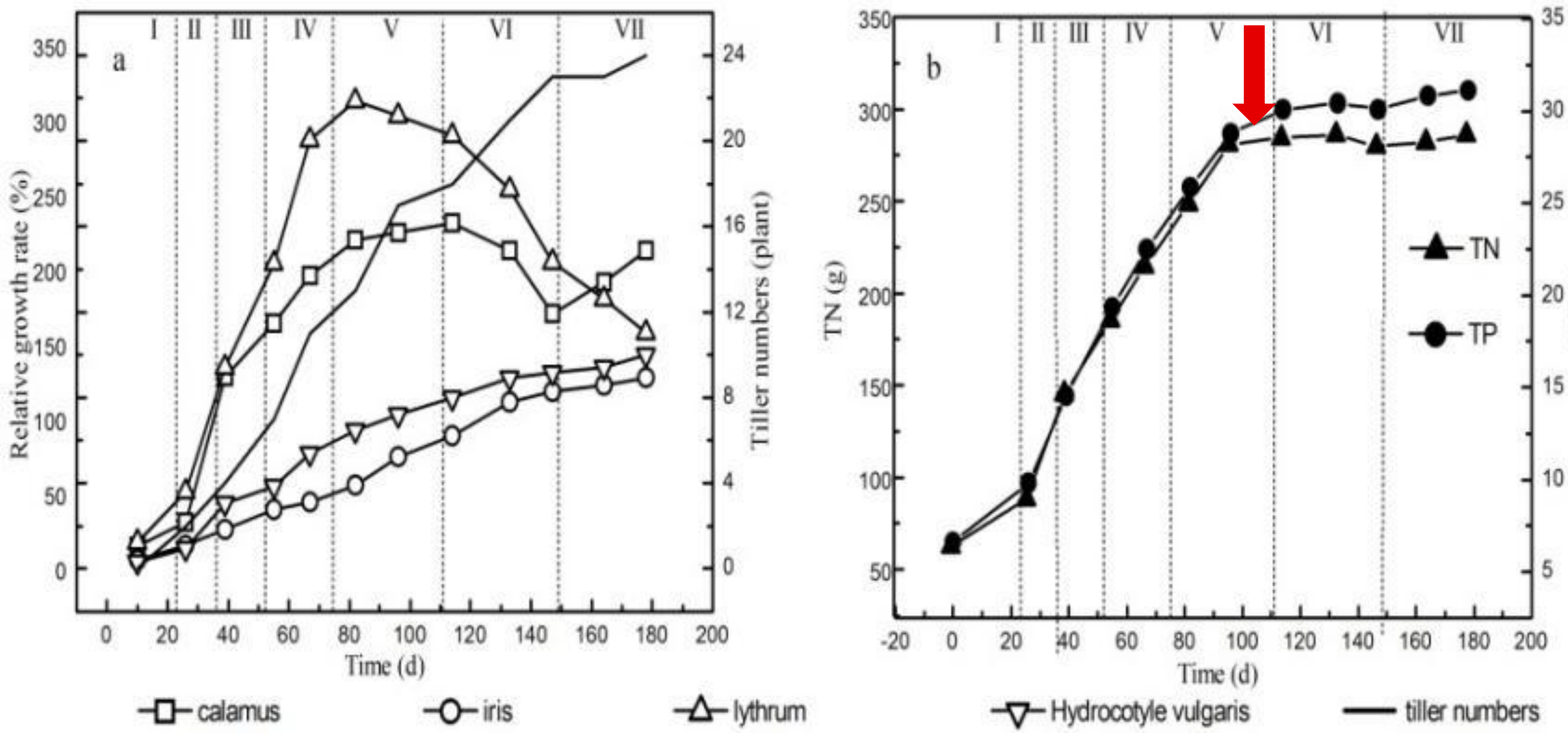


- Total input TN loads were 720.78g, 760.42g and 801.73g respectively while the total input TP loads were 83.69g, 88.30g and 93.08g respectively in CZ, FBZ and SFBZ

Content of N and P in different plant tissues

Time (d)	Mass of N and P in per Stem of the plant(g N/g P)				Mass of N and P in per Root of the plant(g N/g P)			
	Calamus	*Lythrum*	*Iris*	*Hydrocotyle vulgaris*	*Calamus*	*Lythrum*	*Iris*	*Hydrocotyle vulgaris*
0	0.66/0.03	1.93/0.06	0.41/0.02	0.16/0.02	0.22/0.02	0.62/0.10	0.59/0.11	0.29/0.05
26	1.03/0.05	2.20/0.07	0.49/0.03	0.30/0.03	0.51/0.06	0.84/0.13	0.64/0.12	0.44/0.08
39	2.37/0.14	2.83/0.09	0.70/0.04	0.55/0.05	1.18/0.10	0.95/0.15	0.79/0.14	0.65/0.12
55	3.62/0.24	3.51/0.12	0.77/0.04	0.68/0.07	1.26/0.12	1.10/0.18	0.85/0.16	0.73/0.14
67	4.27/0.29	3.96/0.13	0.89/0.05	0.87/0.09	1.53/0.14	1.25/0.20	0.97/0.18	0.90/0.16
82	4.81/0.31	4.58/0.15	1.30/0.07	1.16/0.12	1.71/0.16	1.44/0.23	1.23/0.23	1.14/0.18
96	4.94/0.32	5.10/0.16	1.65/0.08	1.54/0.15	1.88/0.18	1.58/0.26	1.44/0.27	1.44/0.21
114	4.83/0.30	5.54/0.17	1.87/0.10	1.95/0.19	1.99/0.19	1.66/0.26	1.60/0.30	2.07/0.26
133	4.43/0.27	4.92/0.16	2.10/0.11	2.38/0.23	2.08/0.20	1.50/0.25	1.80/0.32	2.70/0.29
147	4.36/0.27	4.62/0.15	2.13/0.11	2.42/0.24	2.10/0.20	1.41/0.23	1.83/0.33	2.75/0.30
164	4.76/0.29	4.57/0.15	2.15/0.12	2.43/0.24	2.13/0.21	1.33/0.22	1.86/0.34	2.84/0.31
178	4.83/0.31	4.48/0.14	2.17/0.13	2.44/0.25	2.21/0.23	1.16/0.19	1.93/0.34	2.93/0.32

Removal of nitrogen and phosphorus by plant absorption in FBZ



Result of Plant in FBZ

- High N content in *Calamus* and *Lythrum*
- Highest N content in the stem of *Calamus*
- High P content in *Iris* and *Hydrocotyle vulgaris*
- Highest P content in the root of *Iris*
- The optimal harvest time: 100-110d growth period

Nitrogen and phosphorus by filler adsorption in SFBZ

Saturated adsorption capacities of two fillers in adsorption test

	NH_4^+-N	PO_4^{3-}-P
Zeolite	0.45 mg /g	0.18 mg /g
Sponge iron	0.23mg /g	0.56mg/g

Desorption test : 2 mmol/L citric acid exerted the best desorption effect on the saturated zeolite and the sponge iron. The desorption rates of zeolite and sponge iron were 87.32% and 82.19% for NH_4^+-N, and 79.84% and 80.17% for PO_4^{3-}-P with 2 mmol/L citric acid.

Dosage: 120 kg zeolite and 150 kg sponge iron were used in SFBZ.

the total adsorption amounts of NH_4^+-N and PO_4^{3-}-P should be 63.6 g N and 11.1 g P, thereby indicating that the removal efficiencies of N and P in SFBZ were 7.93% and 11.93%, respectively, via filler adsorption.

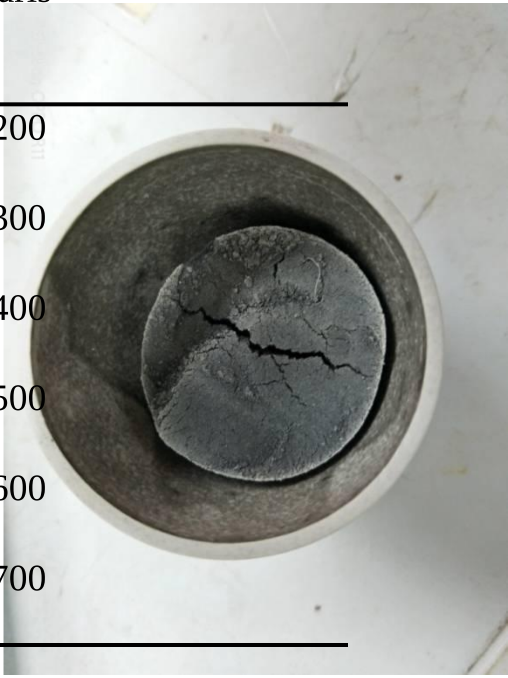
Contribution rates of each component to adsorb or absorb N and P in the experiment

Type	Residue in water		Self-purification		Plant absorption		Filler adsorption	
Nutrient	N	P	N	P	N	P	N	P
CZ	27.21%	15.19%	72.79%	84.81%	0	0	0	0
FBZ	10.86%	8.61%	59.79%	63.60%	29.35%	27.79%	0	0
SFBZ	9.64%	4.79%	54.58%	56.92%	27.85%	26.36%	7.93%	11.93%

Utilization of FB plant

Production Condition of Biochar from FB Plant

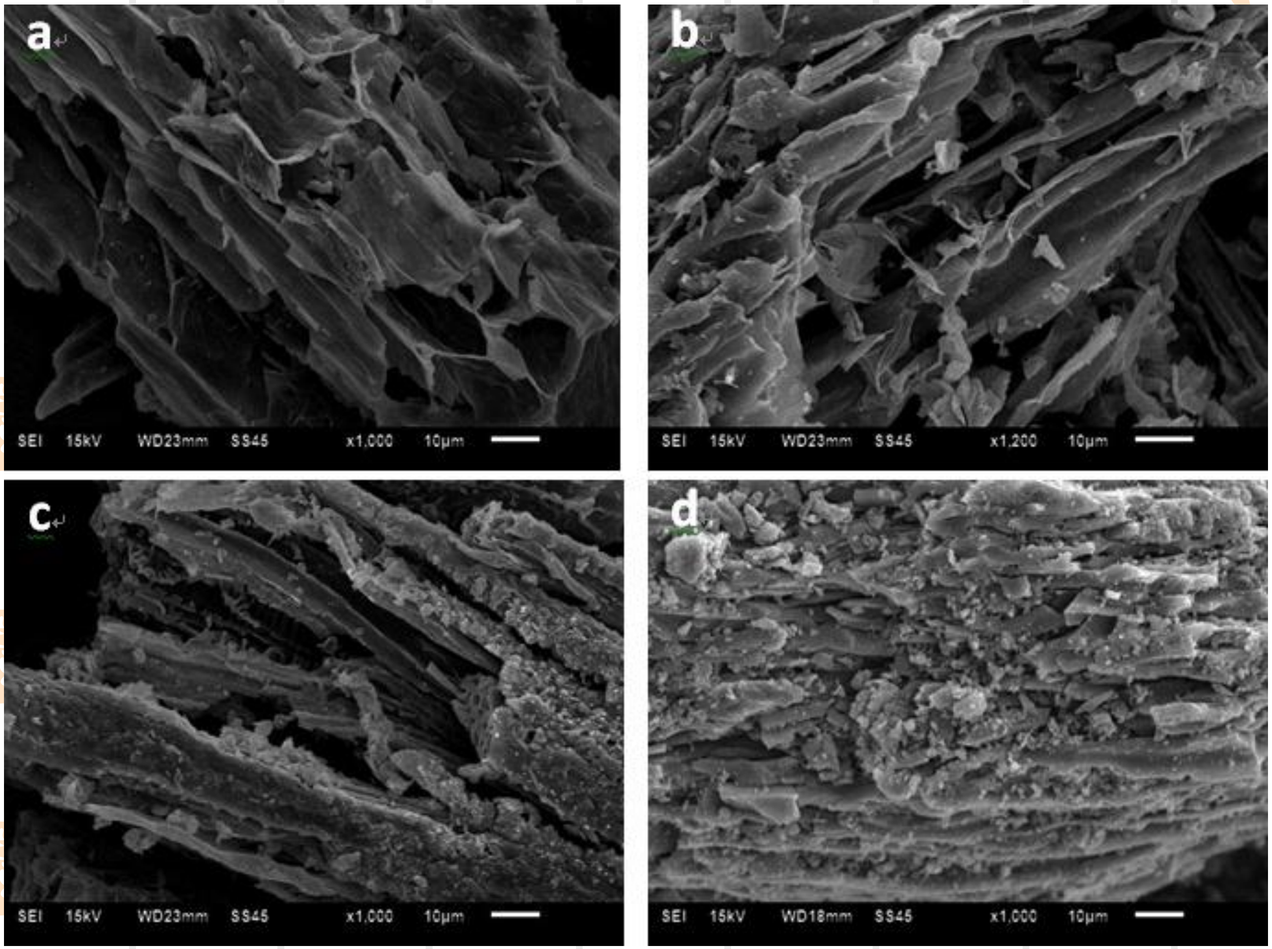
Material / T	Calamus		Lythrum		Hydrocotyle vulgaris
	Stalk	Root	Stalk	Root	
200℃	CS200	CR200	LS200	LR200	HV200
300℃	CS300	CR300	LS300	LR300	HV300
400℃	CS400	CR400	LS400	LR400	NV400
500℃	CS500	CR500	LS500	LR500	HV500
600℃	CS600	CR600	LS600	LR600	HV600
700℃	CS700	CR700	LS700	LR700	HV700



Biochar as Adsorbent for Ni^{2+} removal from water ($C_{initial}$=50mg/L)

Biochar	Removal Rate	Biochar	Removal Rate	Biochar	Removal Rate	Biochar	Removal Rate
CS200	42.10%	CR500	97.95%	LR200	63.43%	HV500	80.92%
CS300	89.84%	CR600	98.78%	LR300	73.84%	HV600	87.06%
CS400	93.07%	CR700	99.08%	LR400	86.05%	HV700	96.59%
CS500	97.99%	LS200	51.26%	LR500	97.14%	D200	51.11%
CS600	98.48%	LS300	71.83%	LR600	93.45%	D300	80.99%
CS700	98.21%	LS400	89.39%	LR700	98.75%	D400	99.41%
CR200	63.95%	LS500	98.40%	HV200	43.65%	D500	99.47%
CR300	88.43%	LS600	97.55%	HV300	67.32%	D600	99.51%
CR400	90.05%	LS700	98.73%	HV400	76.03%	D700	99.34%

SEM of the optimal biochar and AC



a. CS400； b. CR400； c. D400； d. AC

A case of Chemical-physical Method in Electroplating Wastewater Treatment

Chemical flocculation+ biochar adsorption

Efficiency of Electroplating Wastewater Treatment

	Salinity (mg/L)	NH_4^+-N (mg/L)	PO_4^{3-}-P (mg/L)	Ni (mg/L)	Cu (mg/L)	Zn (mg/L)
Raw Water	6130.00	8.62	1569.59	36.53	5.84	1.25
$Ca(OH)_2$ 5g/L	1520.00	2.65	2.38	1.50	0.33	0.00
Biochar 5+3g/L	1710.00	0.51	0.37	0.42	0.09	0.00

Conclusions

- SFB could effectively improve the water quality of urban landscape water supplied with reclaimed water, which was based on the combination function of the plants absorptions, the fillers adsorptions, and self-purification functions of the ecosystem. A suitable plant community and filler type could ensure high removal rates of nutrients in water even during low-temperature seasons.
- >26% nutrient in water was eliminate by the plant in FBZ or SFBZ
- Biochar is an alternative approach for utilization of FB plant, especially in removal of Ni^{2+}

Acknowledgments

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Thanks