International Conference, Turin, Italy

“The Future of Water Services”

Waste Water Treatment Development in China

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8 November 2013

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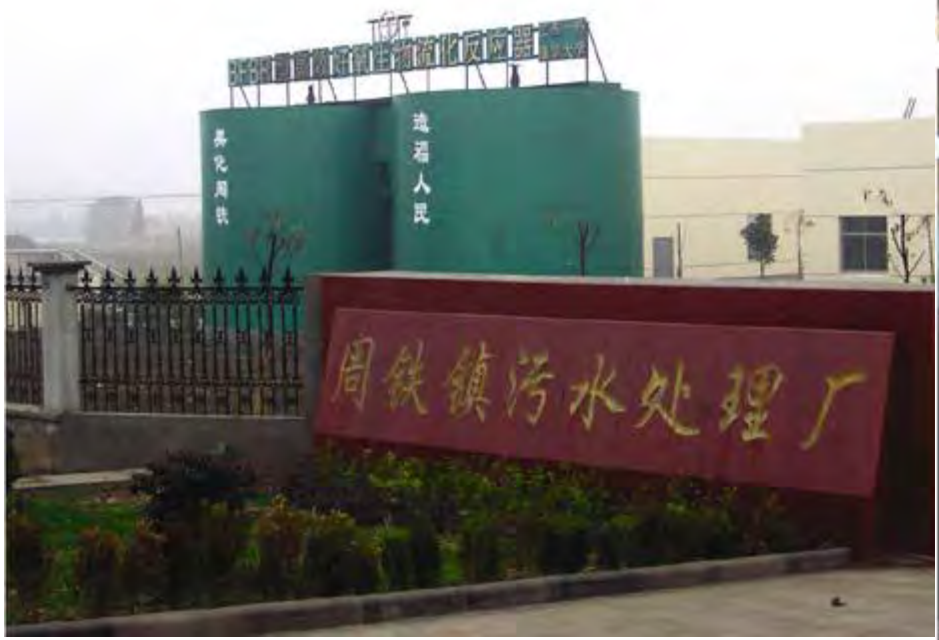
Outline

- **Wastewater treatment development in China**
  - ✓ Wastewater treatment : Chem/Phy/Bio processes
  - ✓ Wastewater treatment: natural purification processes
  - ✓ Wastewater treatment development in Shanghai
  - ✓ A case study of algae removal
  - ✓ Technology of wastewater reuse
- **Example of recent projects in the UK:**
  - ✓ Ferrate technology development for drinking water and wastewater treatment

Wastewater treatment development in China



Wastewater treatment process in China: Chem/Phy/Bio

一级处理
Primary treatment

- Bar Screen
- Grit chamber
- Primary sedimentation
- Chemical aided primary sedimentation

→

二级处理
Secondary treatment

- Conventional activated sludge
- BNR
- Biological phosphorus removal
- Biological nitrogen &phosphorus removal
- Bio-filtration

→

三级处理
Tertiary treatment

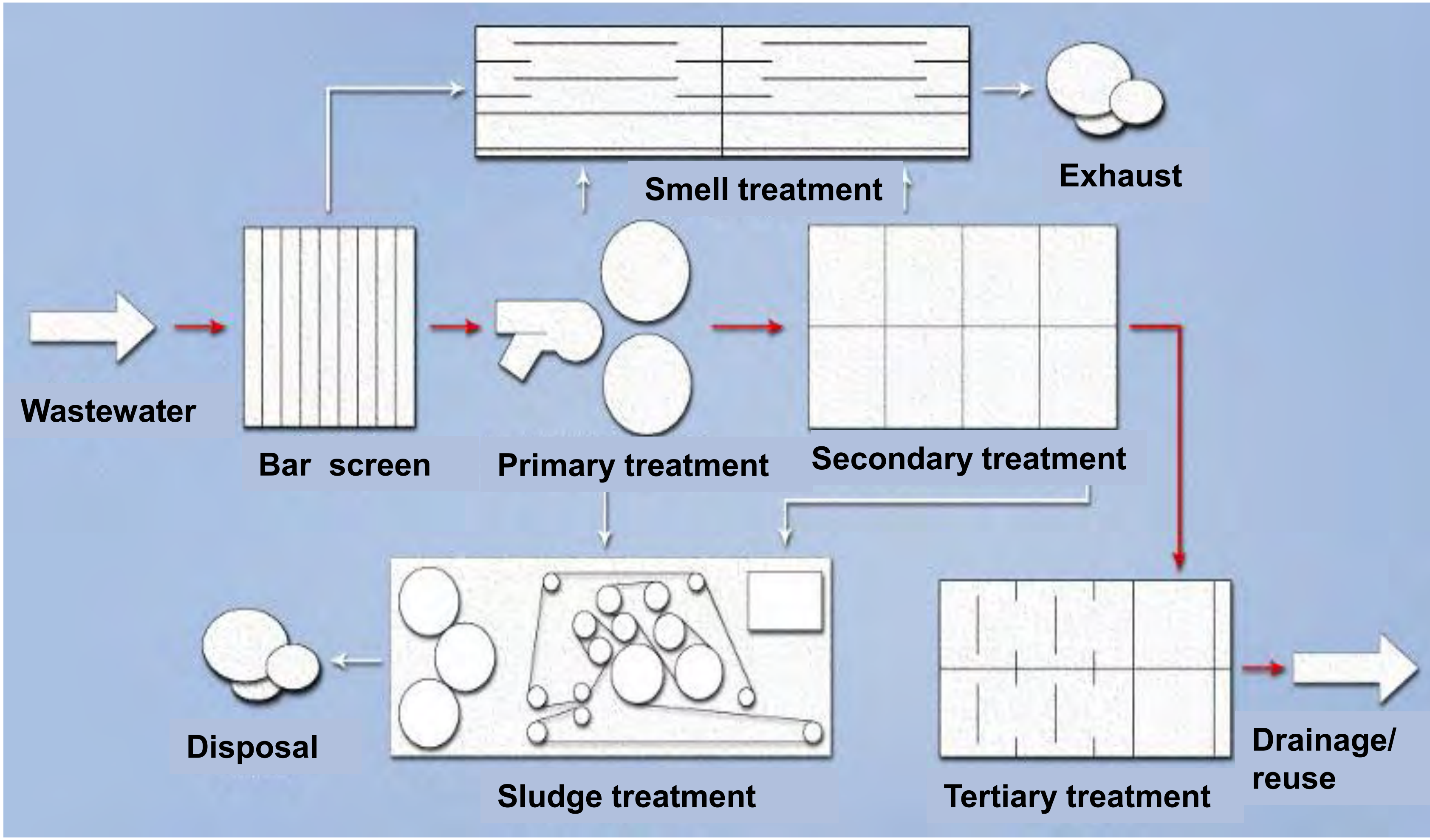
- Disinfection
- Coagulation
- Filtration
- MBR
- RO

→

Discharge or Reuse

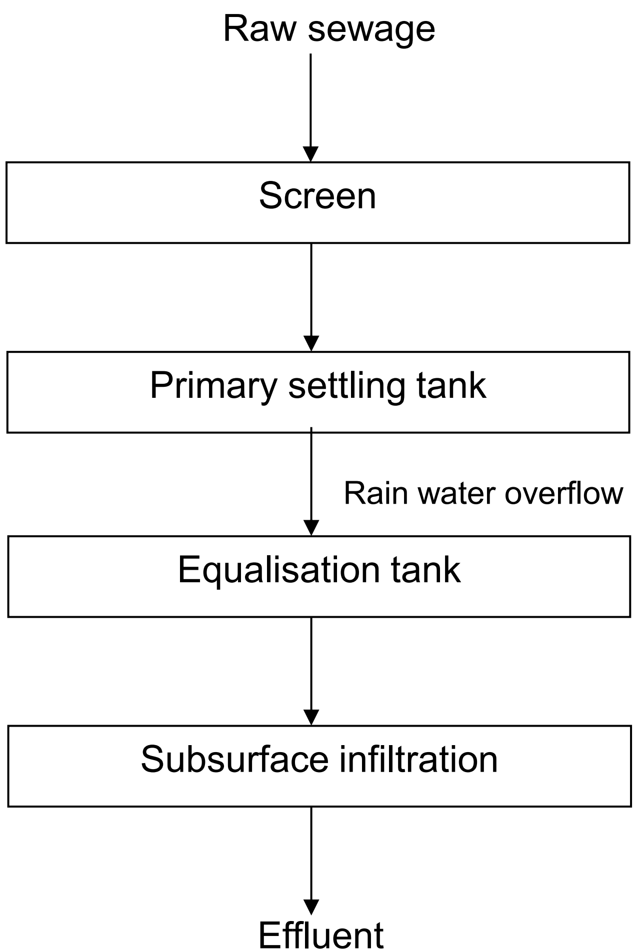
BNR: Biological Nutrient Removal
MBR: Membrane Bioreactor
RO: Reverse Osmosis

Wastewater treatment plant configuration



Wastewater treatment in China – natural purification processes

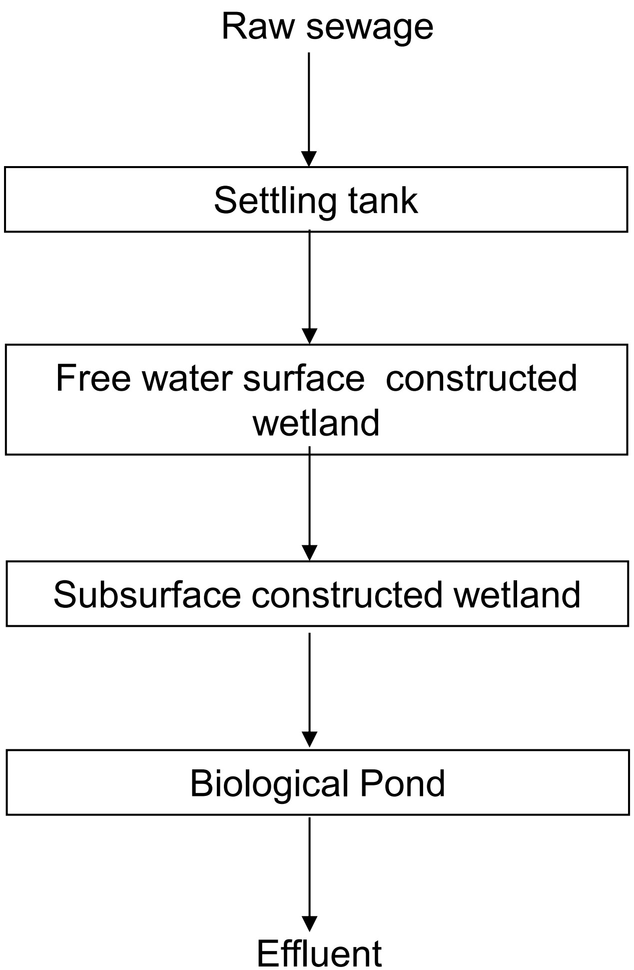
• Rapid infiltration; • Slow rate filtration; • Overland flow; • Subsurface infiltration; • Constructed wetland; • Stabilization pond



A full-scale <u>subsurface infiltration</u> system for rural sewage treatment in Dian Lake area, Yunnan Province

Wastewater treatment in China – natural purification processes

• Rapid infiltration; • Slow rate filtration; • Overland flow; • Subsurface infiltration; • Constructed wetland; • Stabilization pond



A full-scale constructed wetland treatment system combined with a biological pond for rural sewage treatment established in Dian Lake area, Yunnan Province

Benefits of wetlands wastewater treatment system

Wetland wastewater treatment system in Nan-Hui District, Shanghai

- less expensive to construct than traditional secondary and tertiary wastewater treatment systems.

- less maintenance and less expensive to operate than traditional treatment systems.

- may provide important wetland wildlife habitat, as well as human recreational opportunities such as bird watching, hiking….

- viewed as an asset by regulatory agencies in many regions and as a potentially effective method for replacing natural wetlands lost through agricultural practices, industrial and municipal development and groundwater withdrawal.

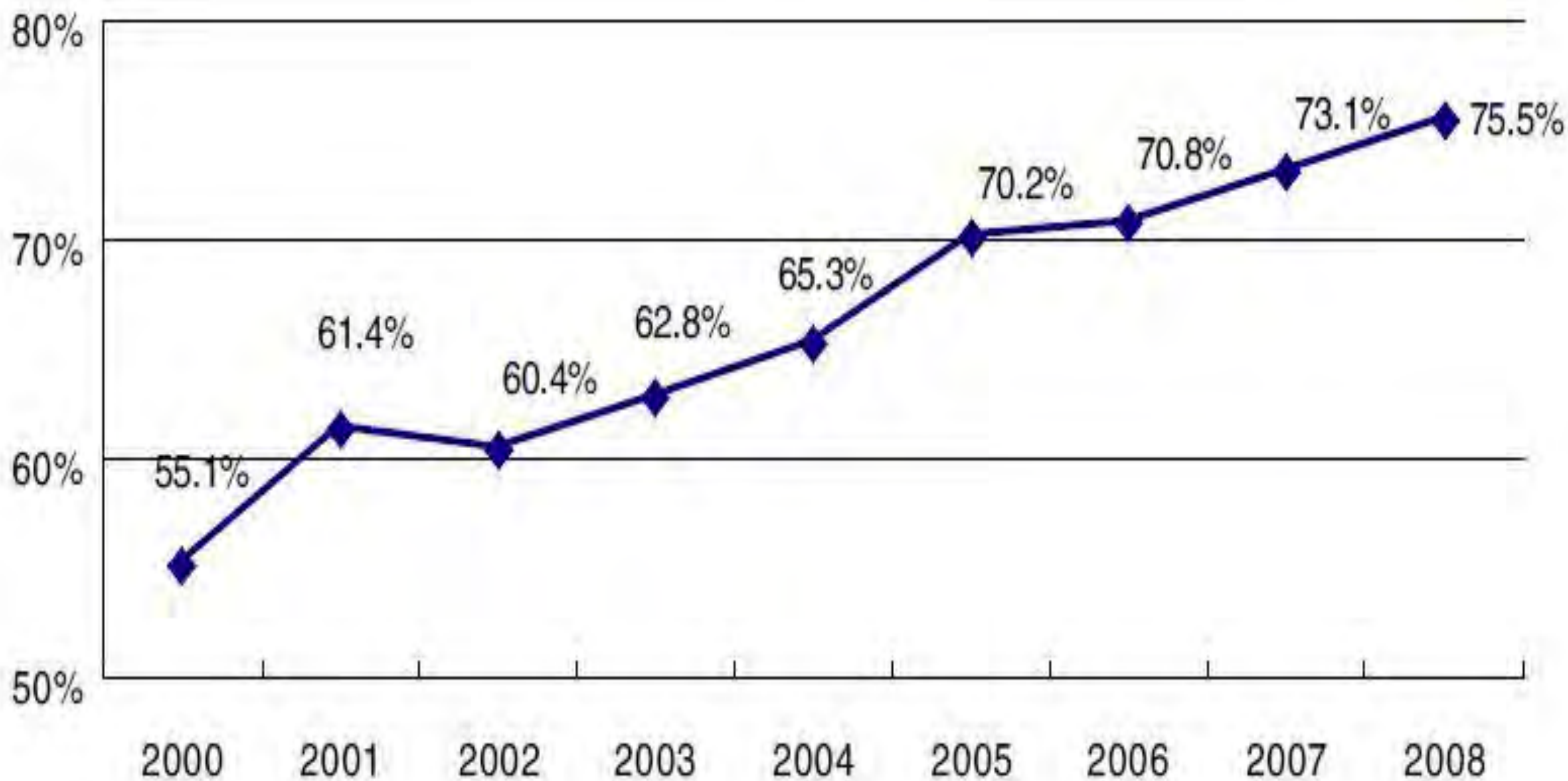
Wastewater treatment in China – natural purification processes

Performance of full-scale subsurface infiltration system and constructed wetland system combined with a biological pond

System	Subsurface infiltration			Constructed wetland combined with biological pond		
	COD	TN	TP	COD	TN	TP
Influent/(mg L^{-1})	50–450	5–50	0.5–9.5	100–700	5–65	1.4–12
Average effluent/ (mg L^{-1})	28.17	3.53	0.13	47.5	3.2	0.52
Removal %	80–90	80–90	80–98	80–90	75–90	80–95

Wastewater treatment development in Shanghai

Wastewater treatment coverage % in Shanghai, China (2000 – 2008)

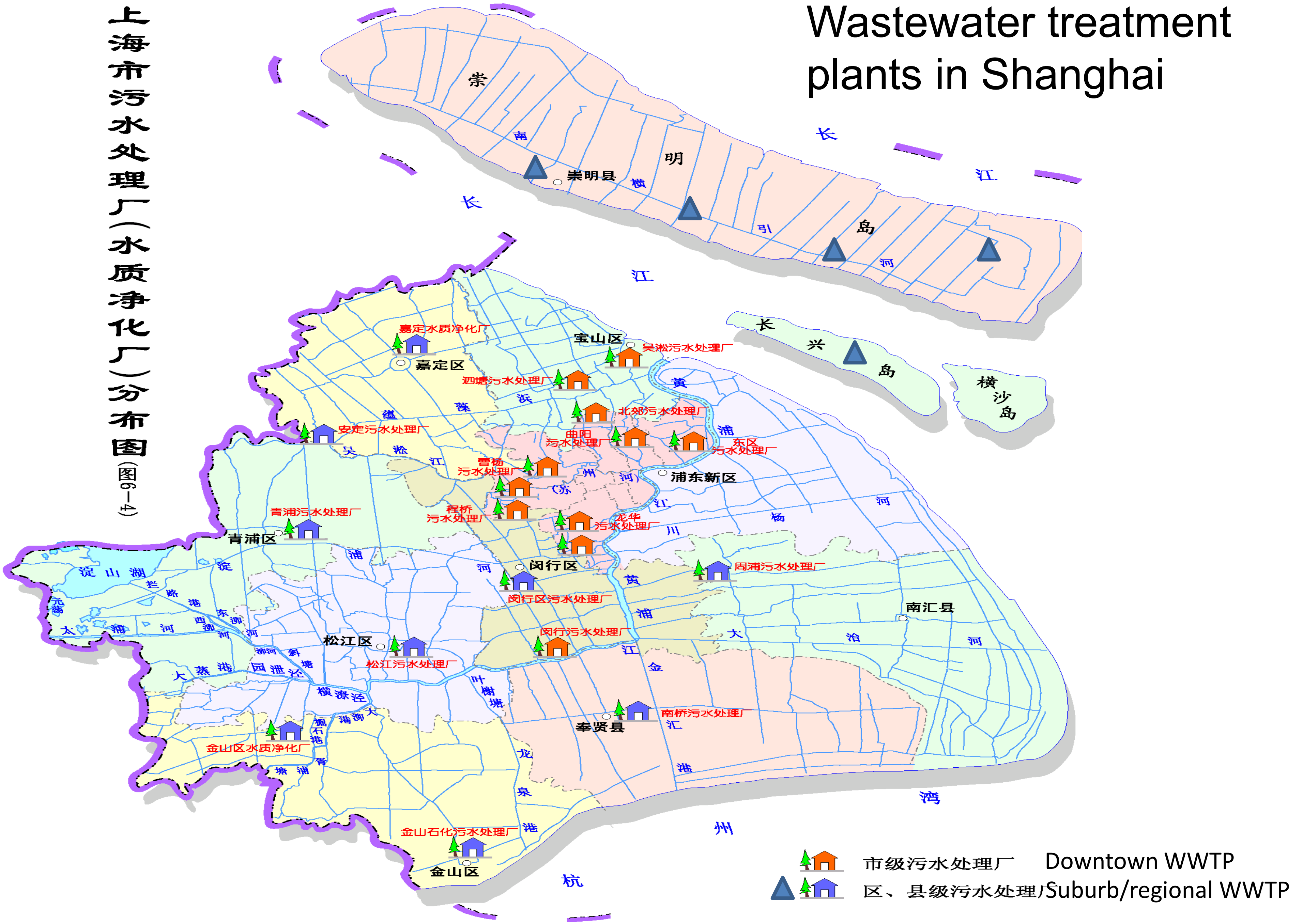


Wastewater treatment capacity of Shanghai, China (2010)

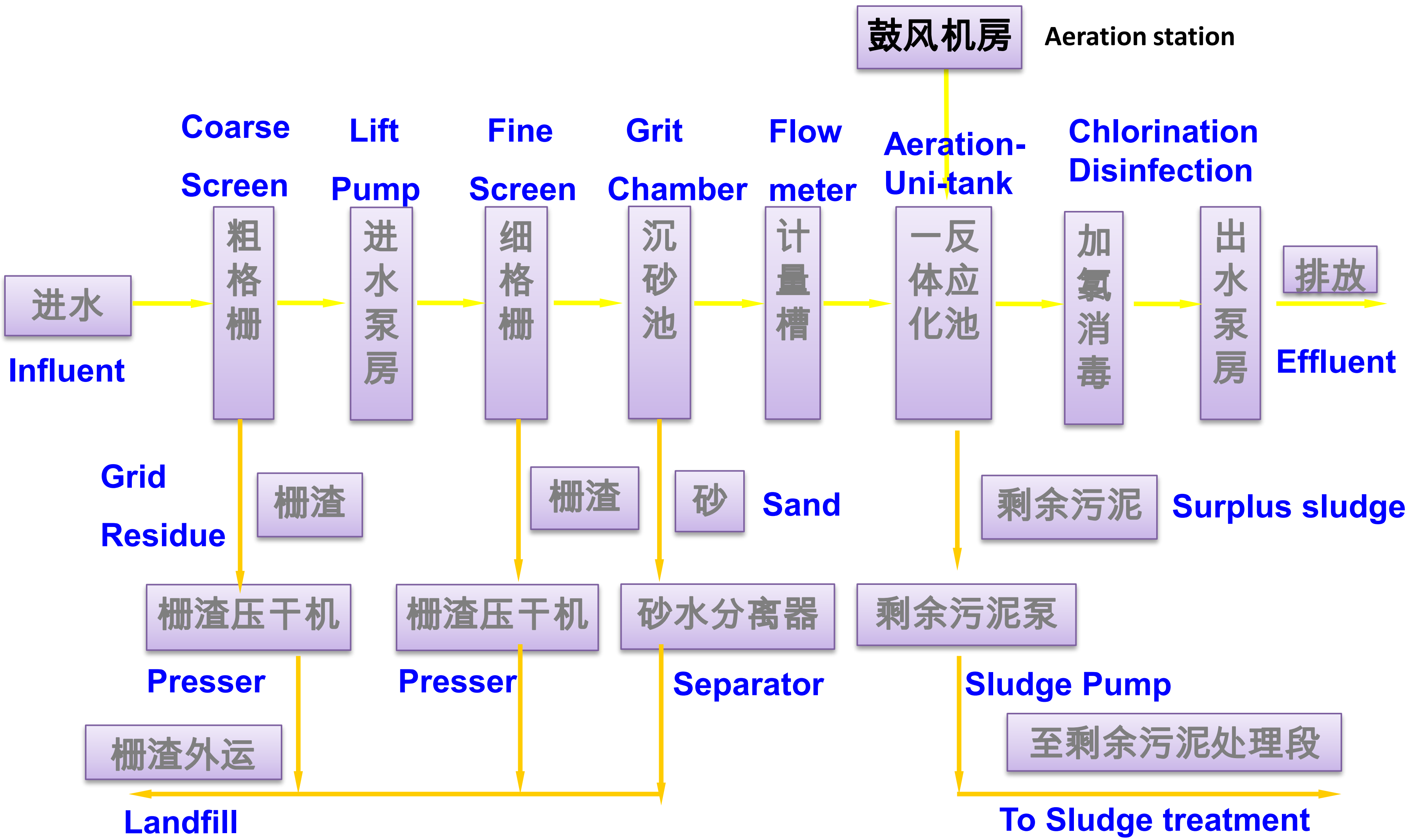
2012: Shanghai's regular population = 23.8 million and flowing population = 13.7 million

	Unit	Total	Downtown	Suburb and local town
Number of WWTP		53	14	39
Design capacity	Million M^3/day	6.84	5.07	1.77
Actual capacity	Million M^3/day	5.19	3.85	1.34
Total wastewater	Million M^3/day	6.34	4.40	1.94
Wastewater treatment capacity	%	81.86	87.5	69.07

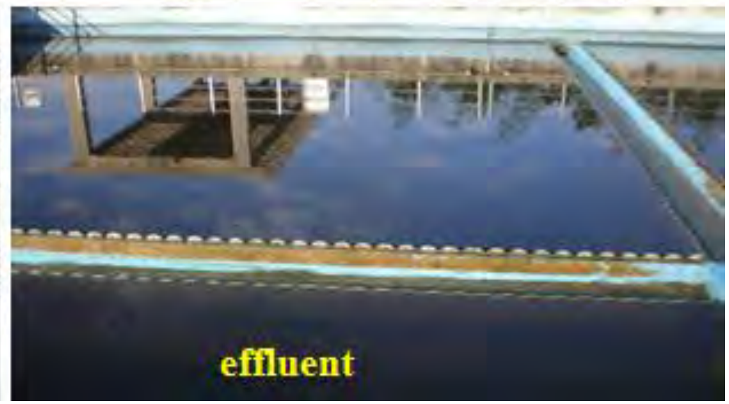
Wastewater treatment plants in Shanghai



Treatment technologies of Shidongkou WWTP, Shanghai



Shidongkou WWTP, Shanghai, China



	COD	BOD_5	SS	NH_3-N	TP
Influent (mg/L)	400	200	250	30	4.5
Effluent (mg/L)	60	20	20	8(15)	1.5

Shidongkou WWTP, Shanghai, China

Effluent:

- Discharged to Yangtze River;
- Reclaimed and reused for road flushing, firefighting, irrigation

Sludge treatment

- Thickening;
- Dewatering;
- incineration;
- Landfill

Case study: Removal of Algae from Tai Lake

Tai Lake to Shanghai: 130 km

Shanghai is located in the downstream of Yangtze River

Tai Lake is in the upstream of Huangpu River

Huangpu River and entrance of Yangtze River provide raw water for Shanghai water supply.

Tai Lake




China's famous scenic spot

Algae bloom in Tai Lake

Blue-green algae is seen on the surface of Tai Lake

Tai Lake turns green after an algae bloom

Blooming algae fills large areas of the Tai Lake

Ducks swim in the algae-rich Tai Lake

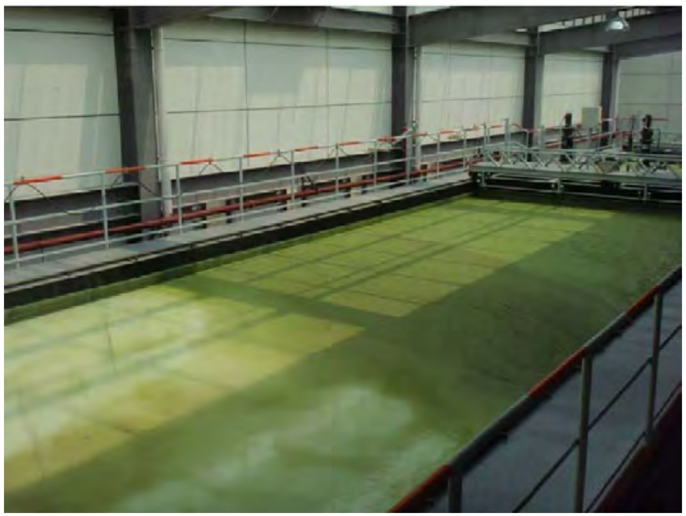
Algae Removal from Tai Lake

- Algae collection
- Algae separation

Algae Removal from Tai Lake

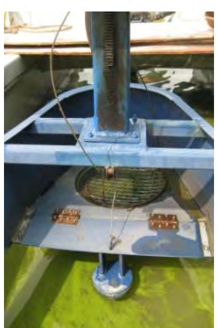


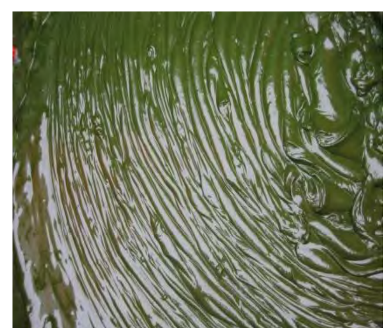




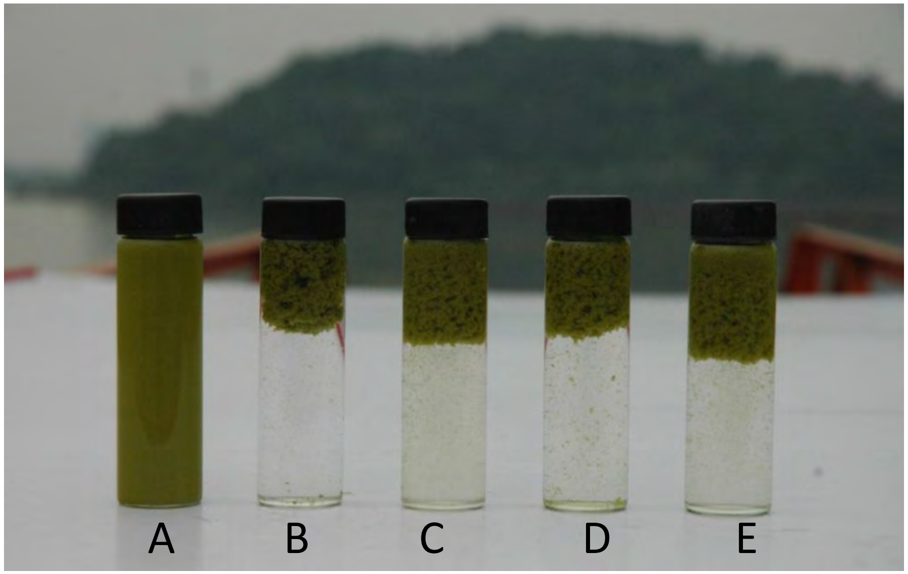

Treatment capacity:
2,000 m^3/d

Solid content:
0.5-1%

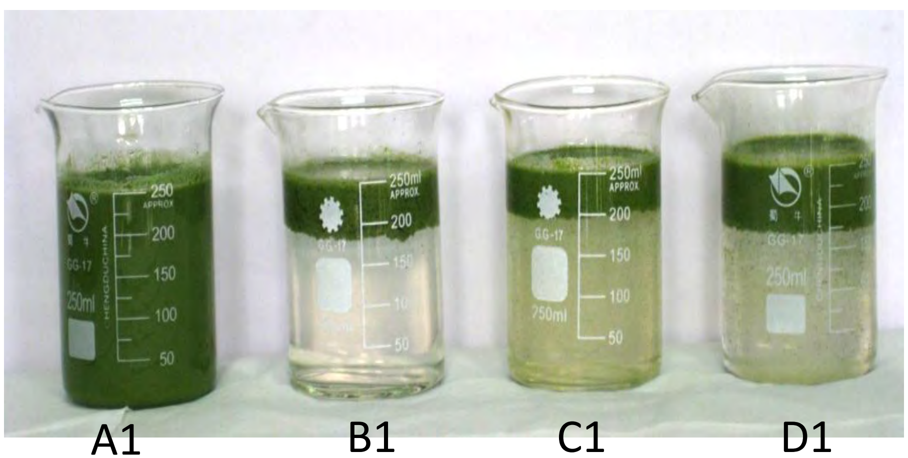


Algae Separation from Tai Lake



Coagulant:150 ppm
- A:algae slurry
- B:+absorbent modified with chitosan
- C:+poly aluminum chloride (PACl)
- D:+poly ferric sulfate
- E: +alum



- A1:algae slurry
- B1:+absorbent modified with chitosan
- C1: +poly aluminum chloride (PACl)
- D1: +alum

Energy producing and carbon sequestration

Energy producing and carbon sequestration

Elementary analysis table of algae sludge

element	C	H	N	S	P
content（%）	37.63	3.453	3.050	0.94	0.57

1 ton algae(dry) = 600 m^3 methane
+100 kg N
+10 kg P

Carbon sequestration=0.85~3.39 ton carbon/d

Algae Separation from Tai Lake

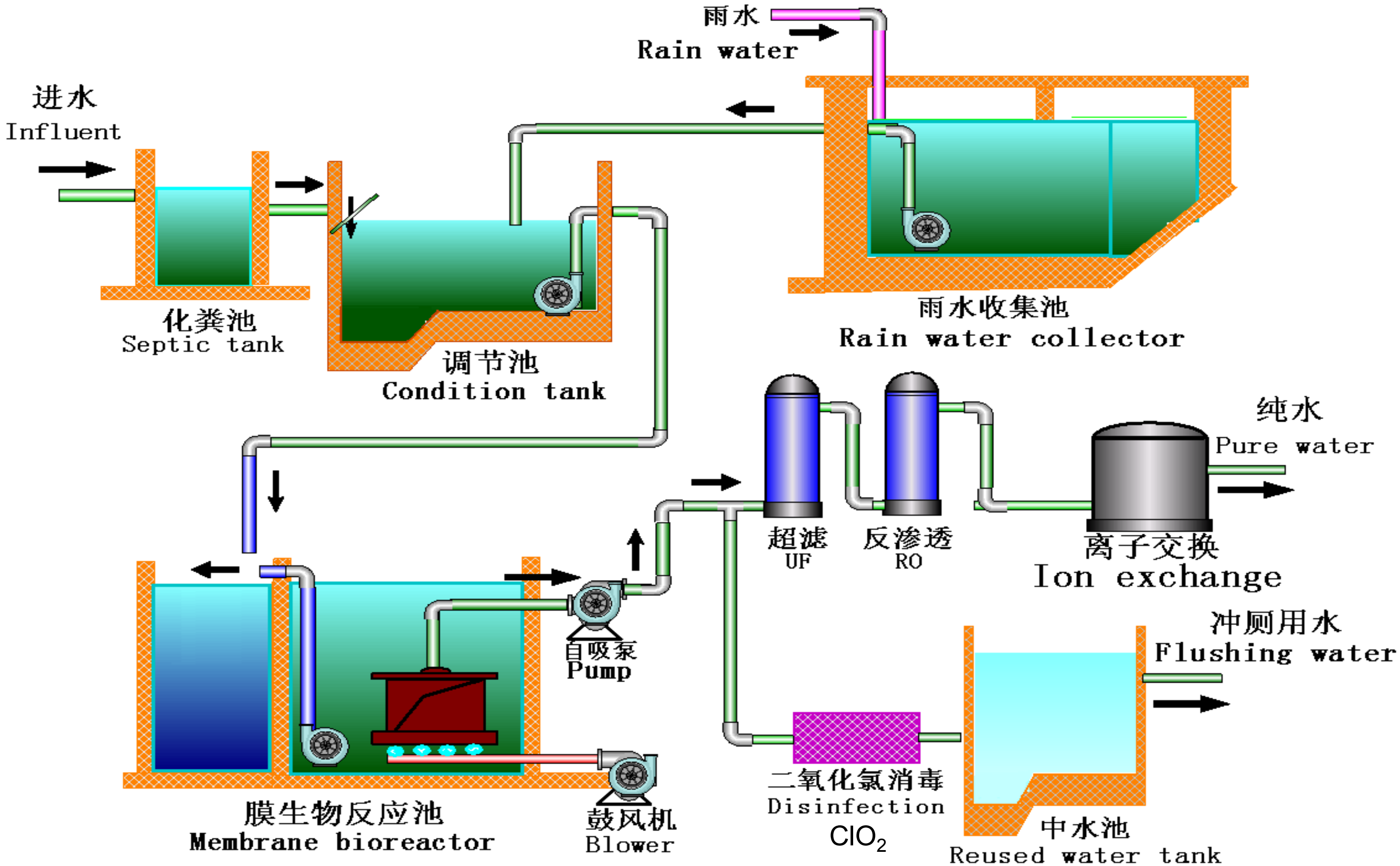
- Algae bloom is a serious problem in Tai Lake

- Algae can be separated from water by coagulation/adsorption and dewatering

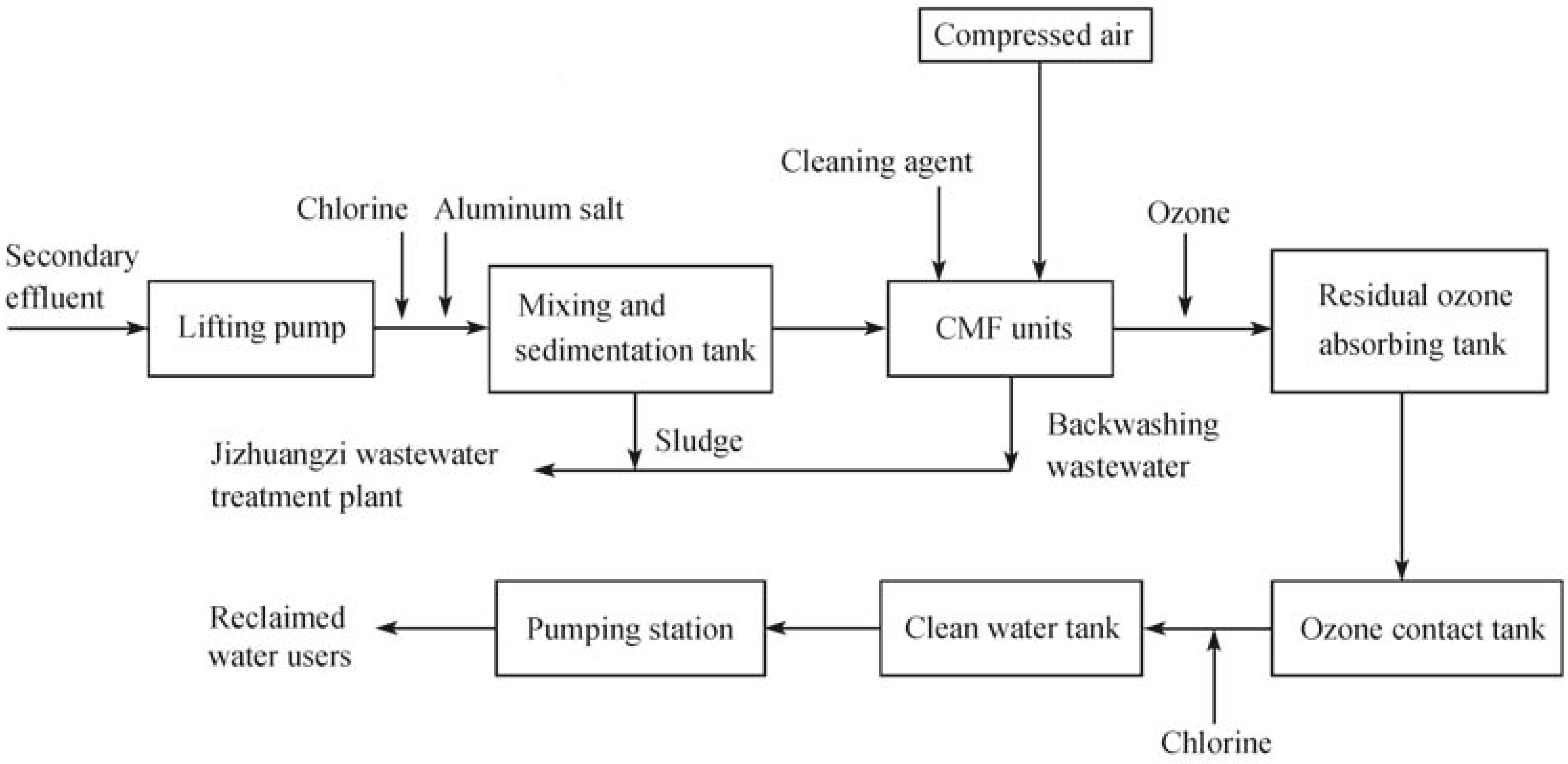
- Algae can produce energy and fertilizer

- Significant for carbon sequestration

Wastewater reuse – researches in China



Wastewater reuse in China



A combined system of continuous micro-filtration (CMF) and ozonation in a Tianjin city wastewater reclamation plant

Wastewater reuse in China

Wastewater reclamation and reuse practice in some water-short cities of China

Wastewater treatment plant	Capacity/(m^3 d^{-1})	Reclaimed water uses	Operation year
Dalian Malanhe WWTP	40 000	Municipal uses	2001
Shandong Laizhou WWTP	20 000	Municipal uses and cooling water	1996
Qingdao Haibohe WWTP	40 000	Municipal uses	2003
Beijing Gaobeidian WWTP	300 000	Municipal uses and cooling water	2003
Tianjin Jizhuangzi WWTP	50 000	Municipal uses and cooling water	2003
Tianjin TEDA WWTP	25 000	Municipal uses, cooling and process water, supply to boiler water	2002
Xi'an Beishiqiao WWTP	50 000	Municipal uses and cooling water	2003

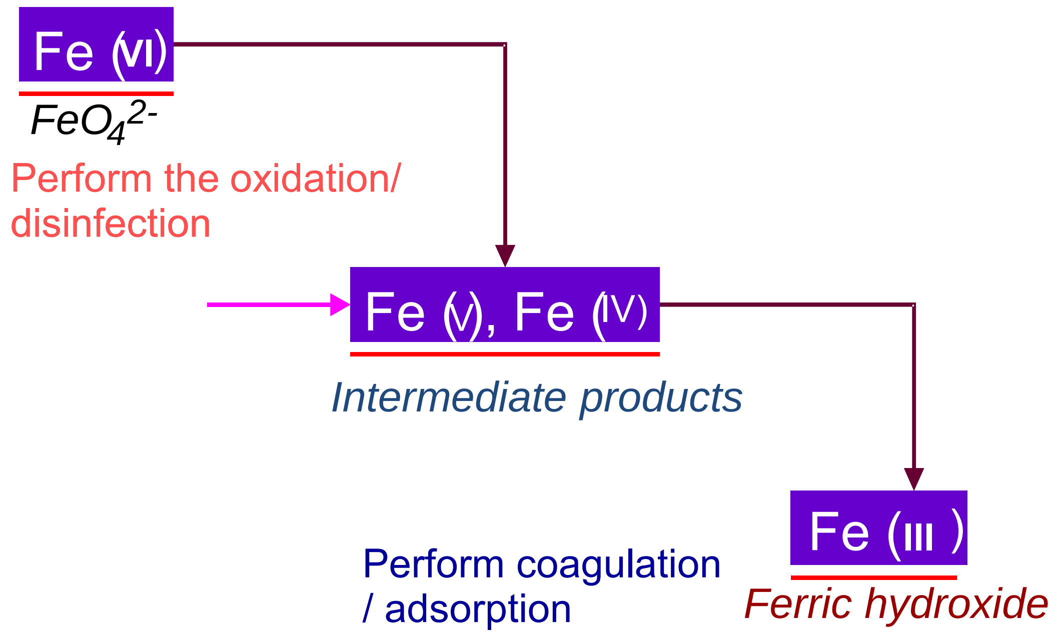
Ferrate(VI) Technology

- Possesses high red-ox potential - even greater than ozone under acidic conditions,

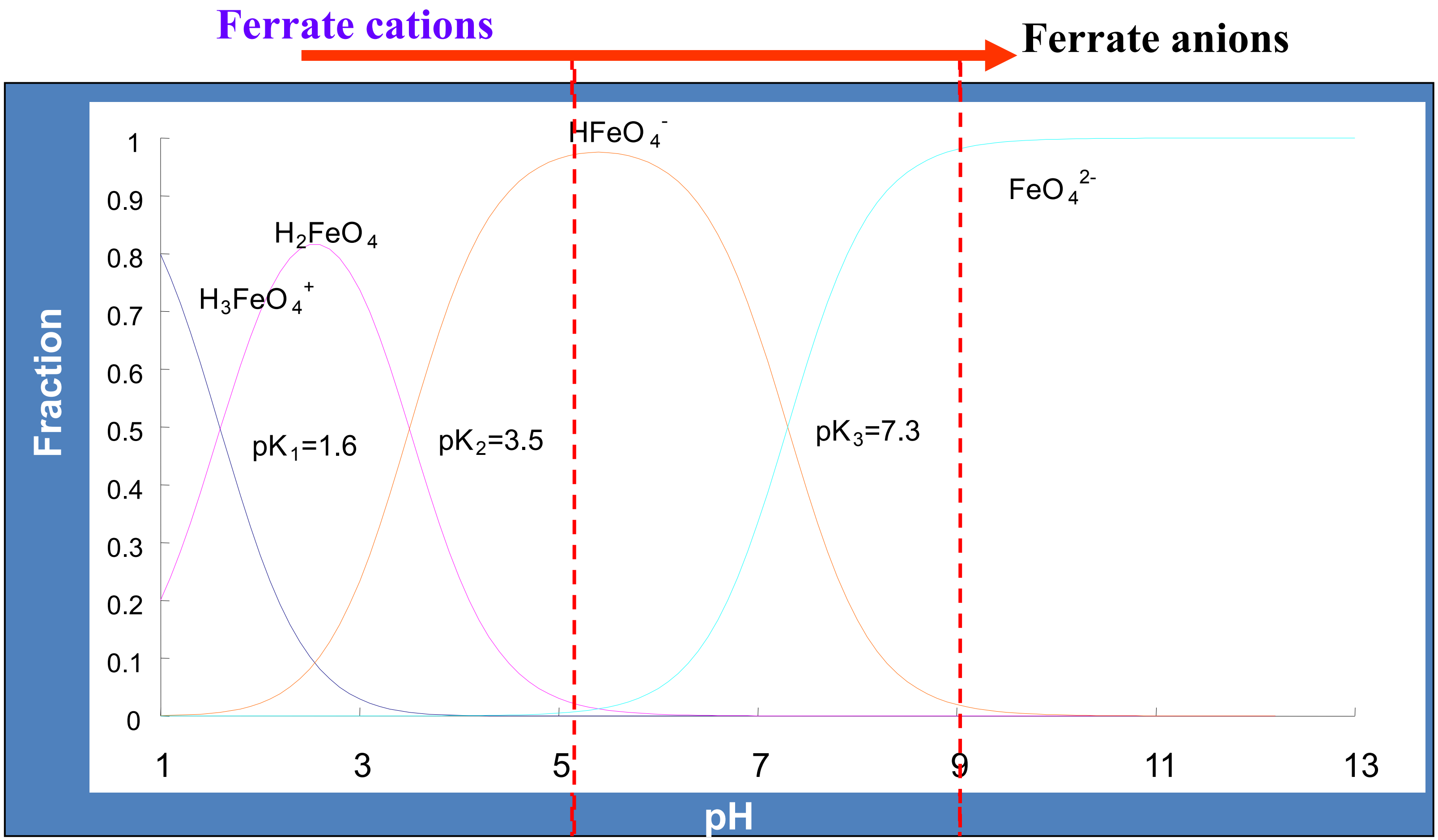
$$FeO_4^{2-} + 8H^+ + 3e \Rightarrow Fe^{3+} + 4\,H_2O$$
$$FeO_4^{2-} + 4H_2O + 3e \Rightarrow Fe(OH)_3 + 5\,OH^-$$

- Has dual-function chemical properties, i.e., oxidation and coagulation,

- It is a chemical which can be used for drinking water and sewage treatment.



Ferrate speciation in aqueous conditions

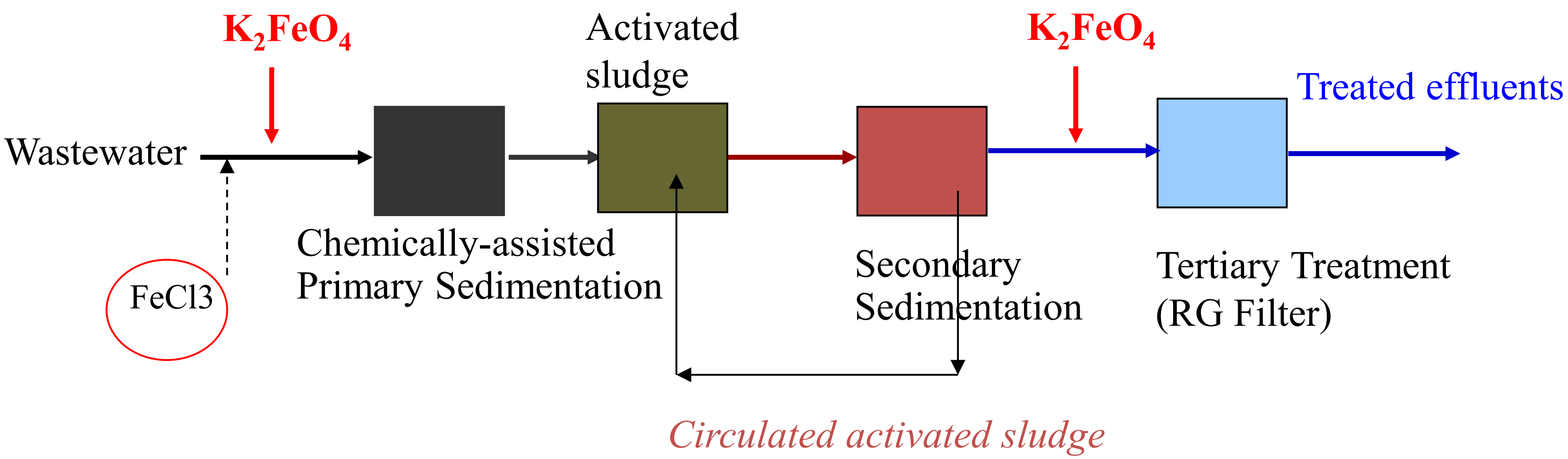


$$H_3FeO_4^+ \leftrightarrow H^+ + H_2FeO_4 \qquad pK_a = 1.6 \pm 0.2$$

$$H_2FeO_4 \leftrightarrow H^+ + HFeO_4^- \qquad pK_a = 3.5$$

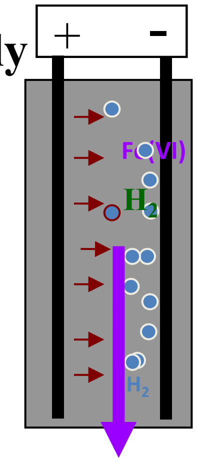
$$HFeO_4^- \leftrightarrow H^+ + FeO_4^{2-} \qquad pK_a = 7.3 \pm 0.1$$

Dosing location of Ferrate (VI) in waste water treatment



In situ generation of Ferrate (VI) in wastewater treatment

Power supply



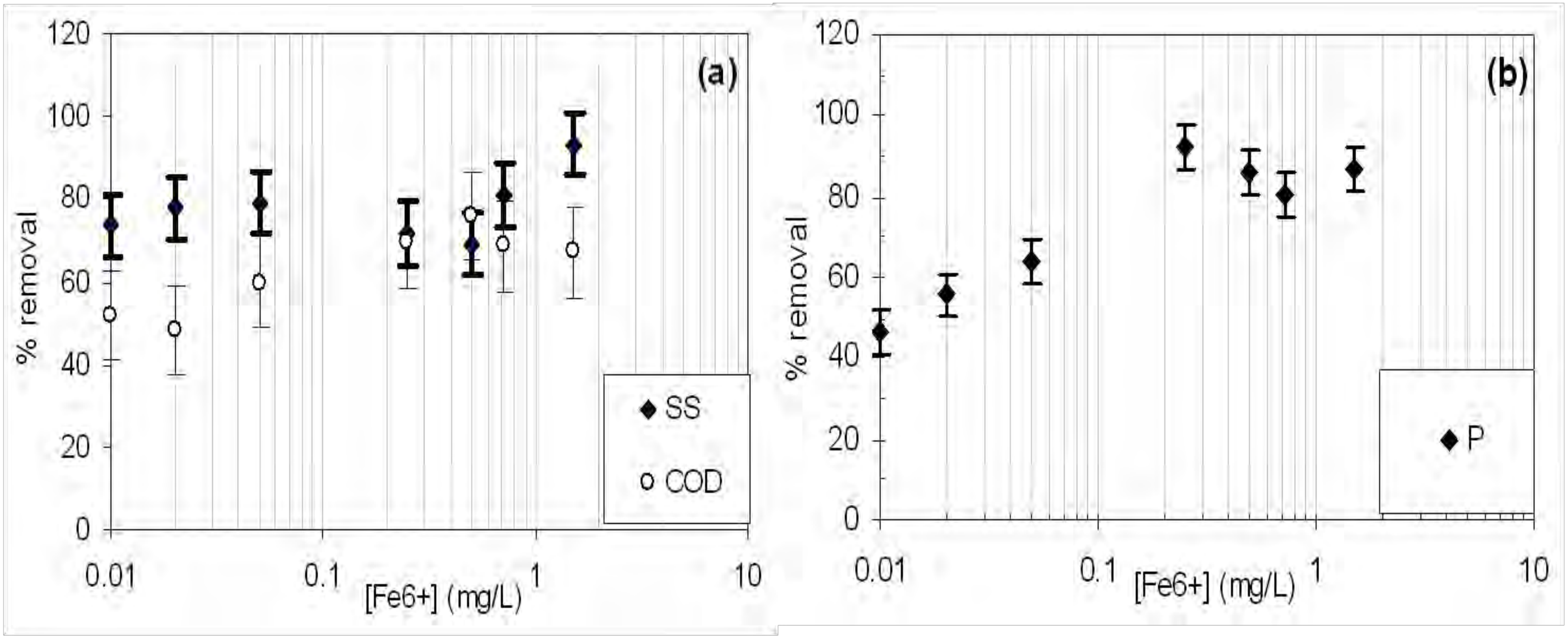
Anode reaction: $Fe + 8OH^{-} \rightarrow FeO_4^{2-} + 4H_2O + 6e^{-}$

Cathode reaction: $6H_2O \rightarrow 3H_2 + 6OH^{-} - 6e^{-}$

Overall reaction: $Fe + 2OH^{-} + 2H_2O \rightarrow \mathbf{FeO_4^{2-}} + 3H_2$

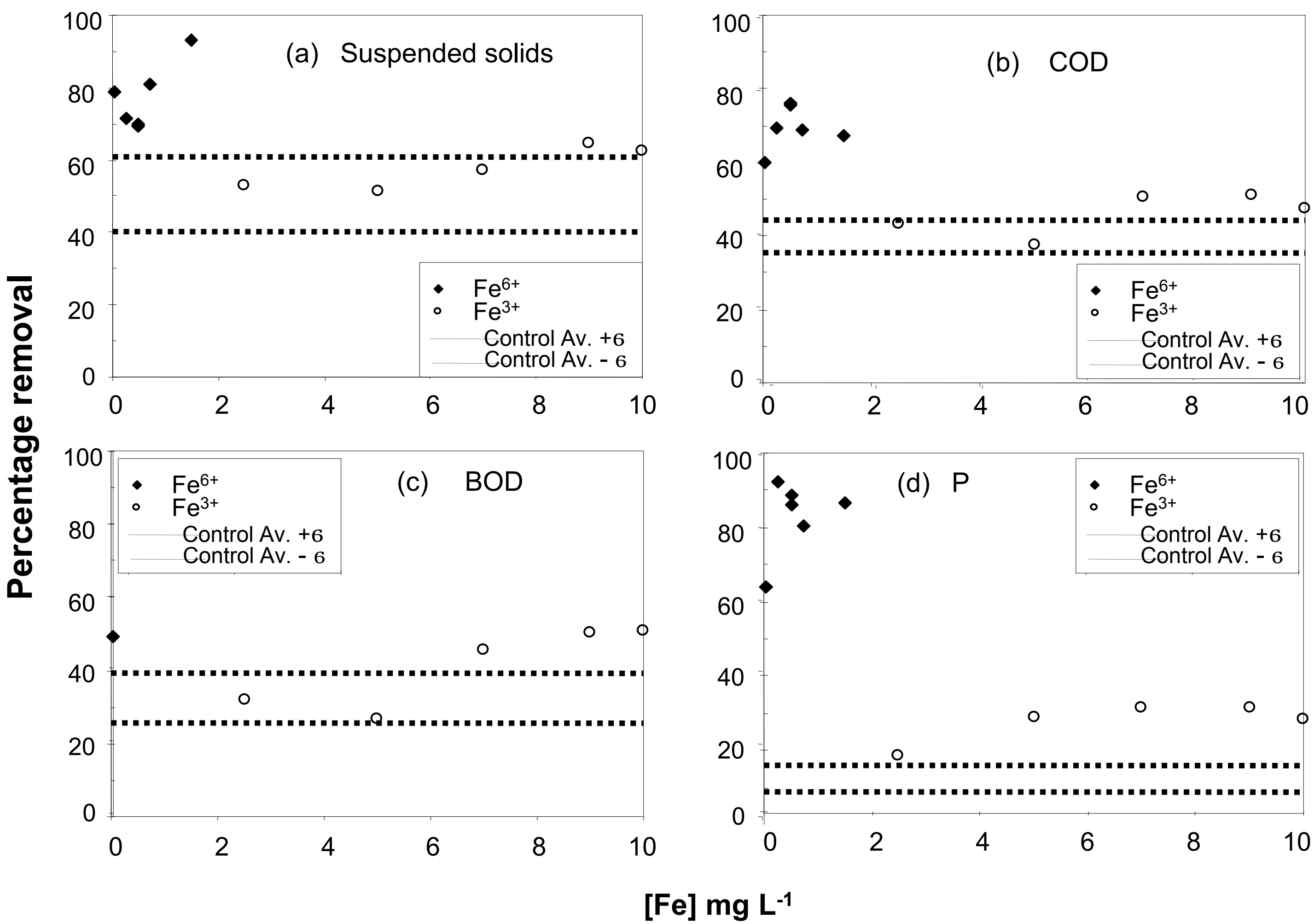
Crude Sewage → **Oxidation/coagulation by ferrate(VI)** → **Treated effluent**

Waste water treatment by ferrate(VI)

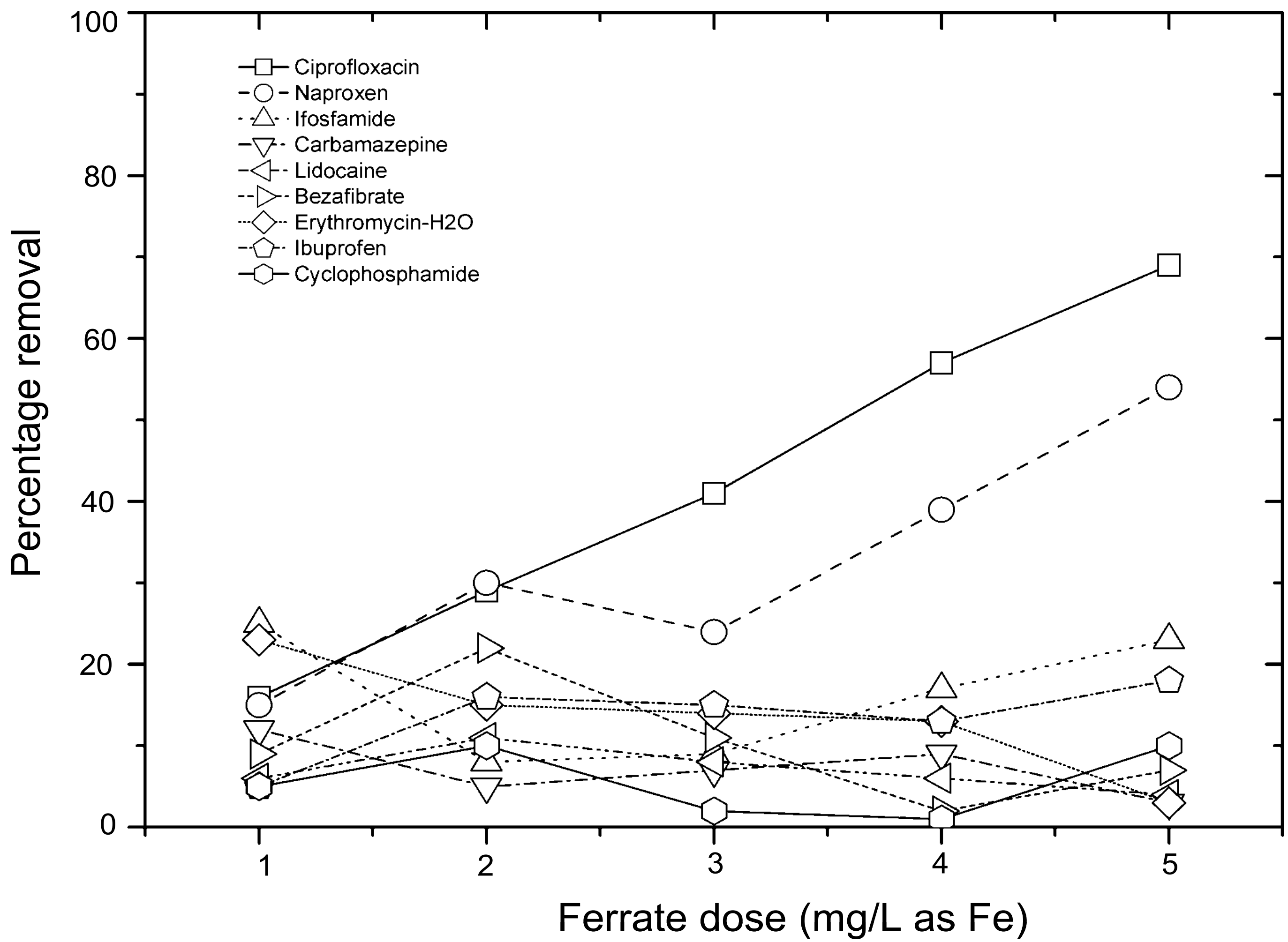


The effect of ferrate(VI) dose on
(a) % removal of suspended solids and COD; (b) % removal of total P

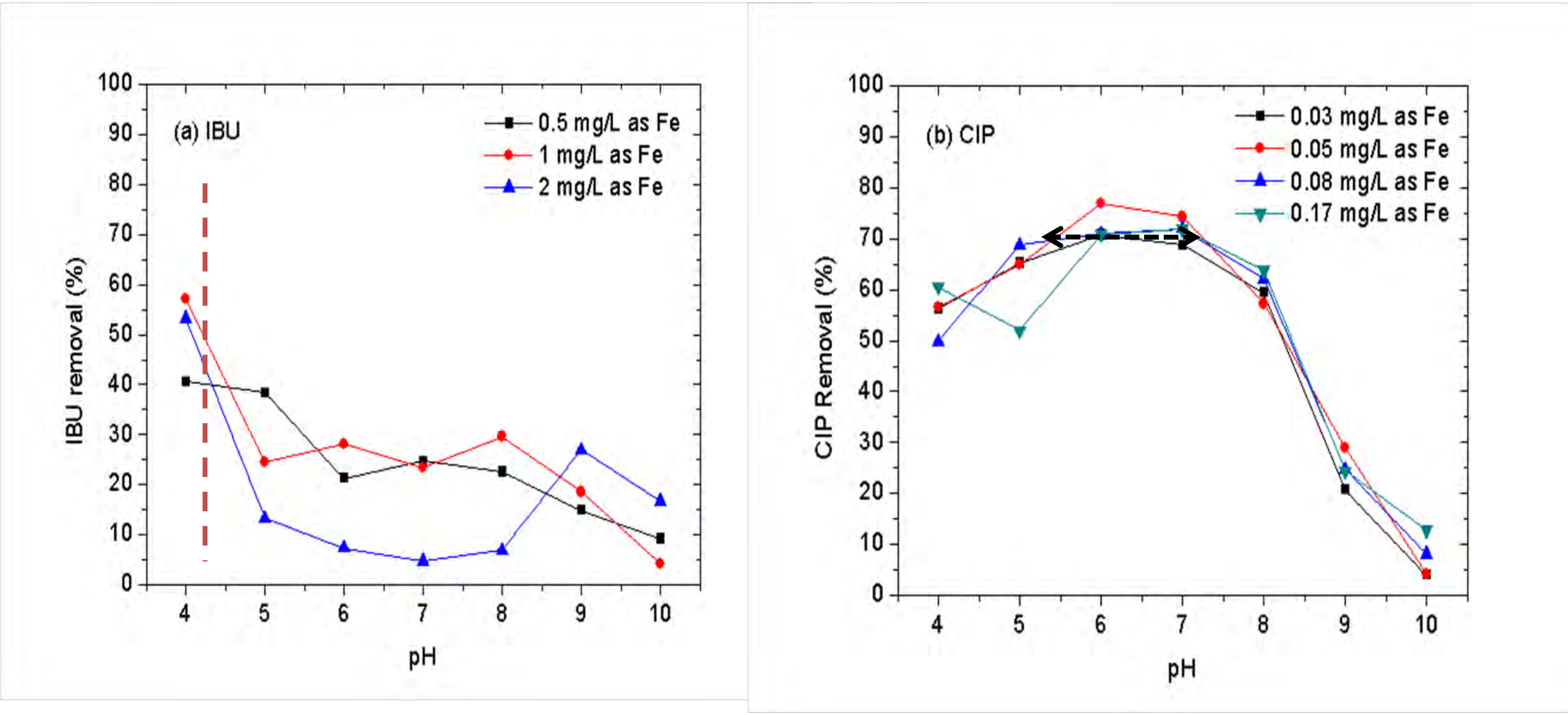
Comparison Fe(VI) with Fe^{3+} for (a) SS, (b) COD, (c) BOD and (d) P% removal



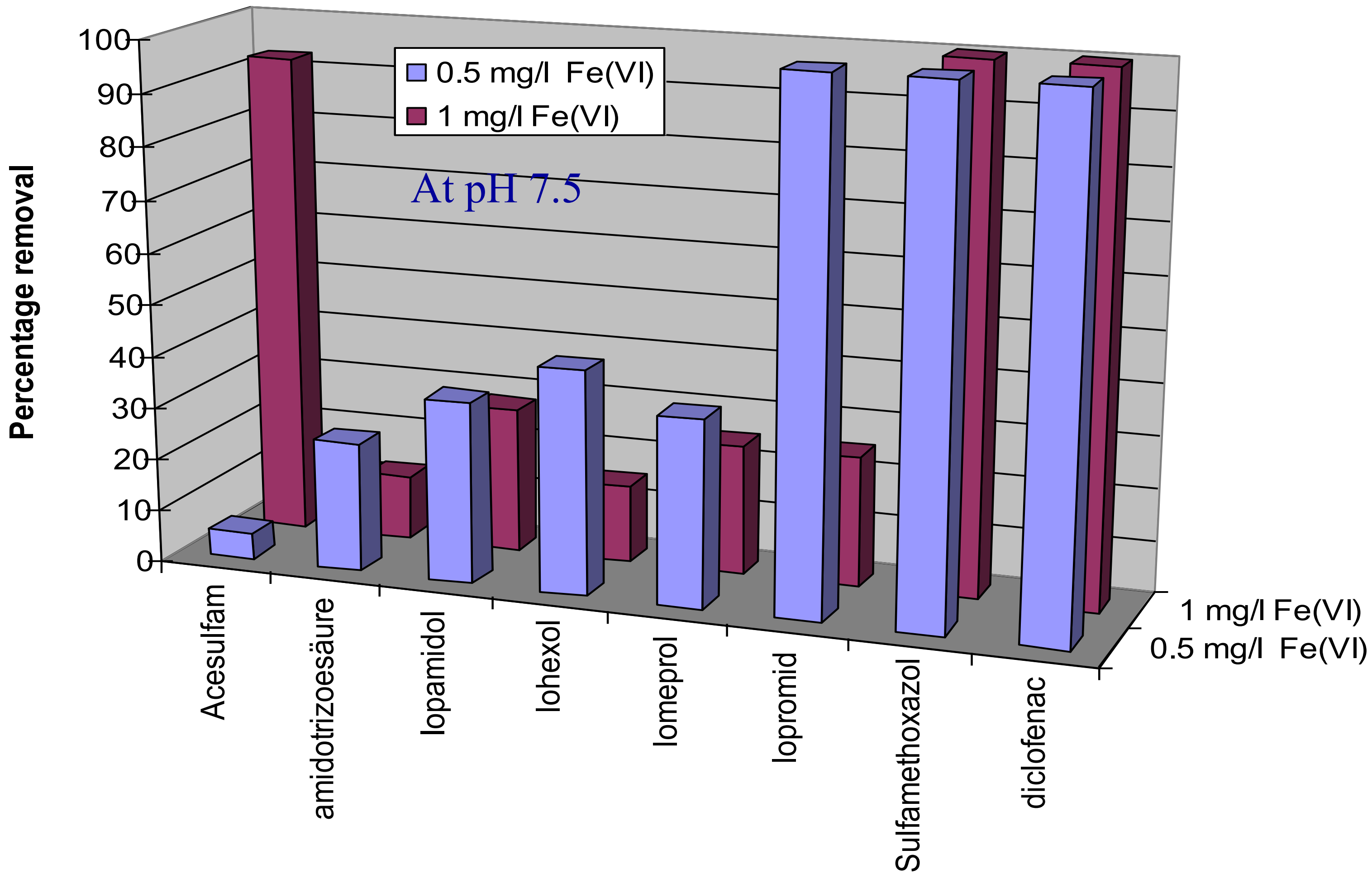
Performance of ferrate(VI) at pH6 in removing pharmaceuticals



pH dependence of pharmaceuticals' removal by ferrate: (a) Ibuprofen (IBU); (b) Ciprofloxacin (CIP)



Performance of ferrate(VI) in removing micro pollutants from surface water - ***Recent results from the site study***



Thanks for your attention