Retention Potential of an Offline Pond-Wetland Combined System on River Water's PAHs through Superficial Sedimentation

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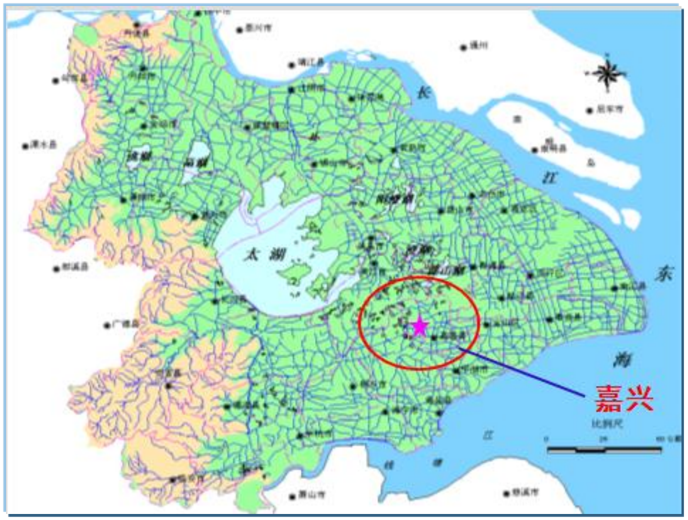
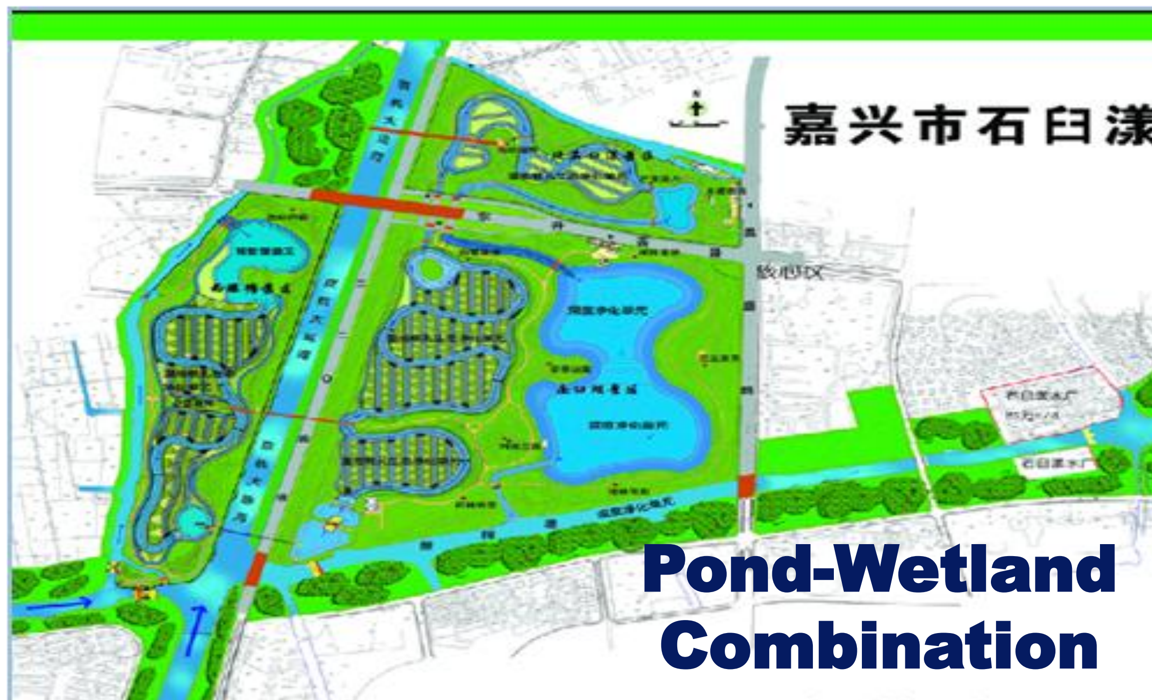
YRD Water Problem

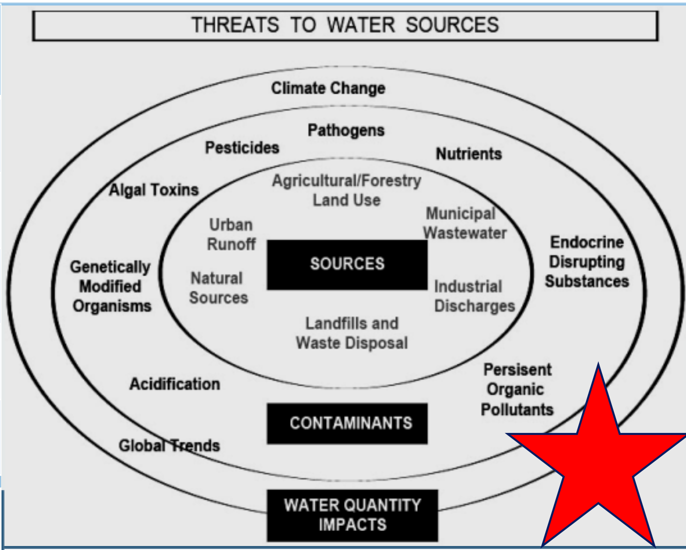


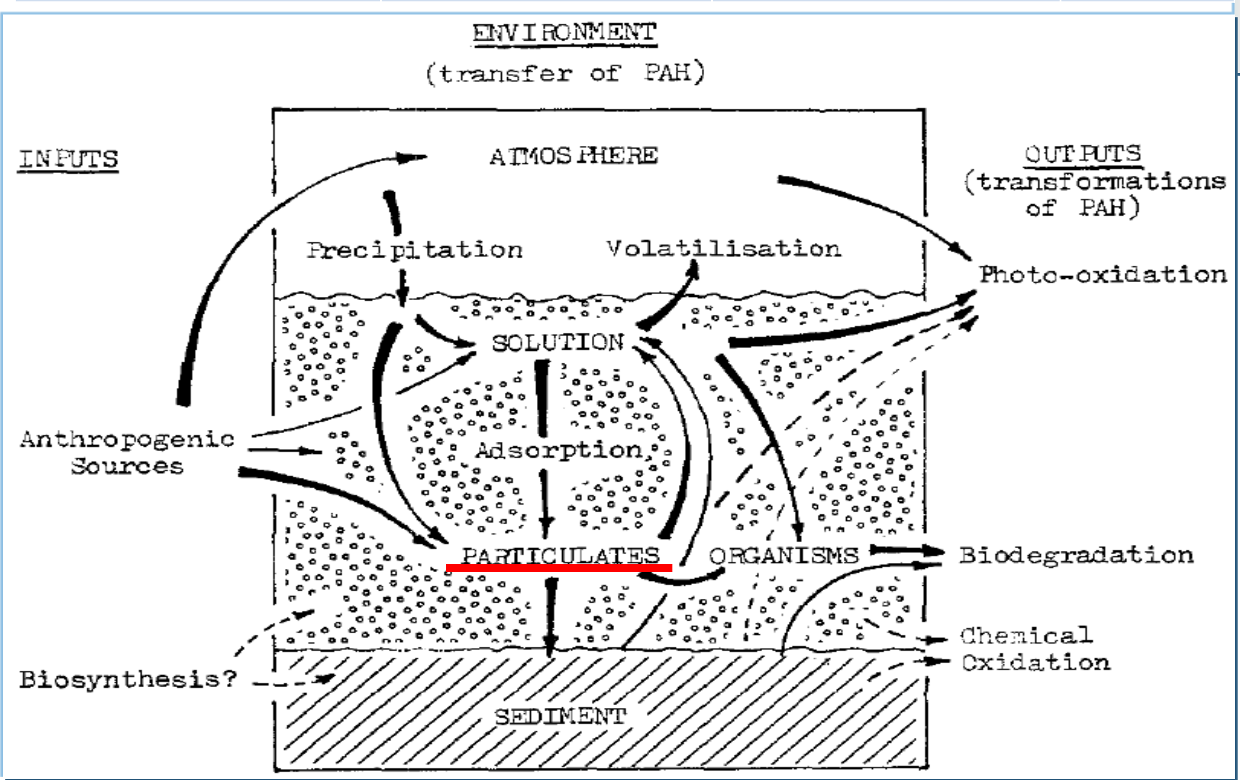
- Control all sources X
- Hi-tech in the waterworks X
- Trans-valley water diversion X
- Local solution √ – Try to control sources + Build wetlands. Maybe the best practical solution recently.



Wetland Treatment (3yrs)

Run Parameters		Performance (%)	
Area (ha)	110	TN	15.9
Supply (t/d)	20-25*10^4	TP	26.2
HRT (d)	3.43-4.13	NH_3-N	49.6
HL (cm/d)	39.2-29.2	Turbidity	31.0
WLF (cm/d)	Two 30-40	COD_{Mn}	6.0

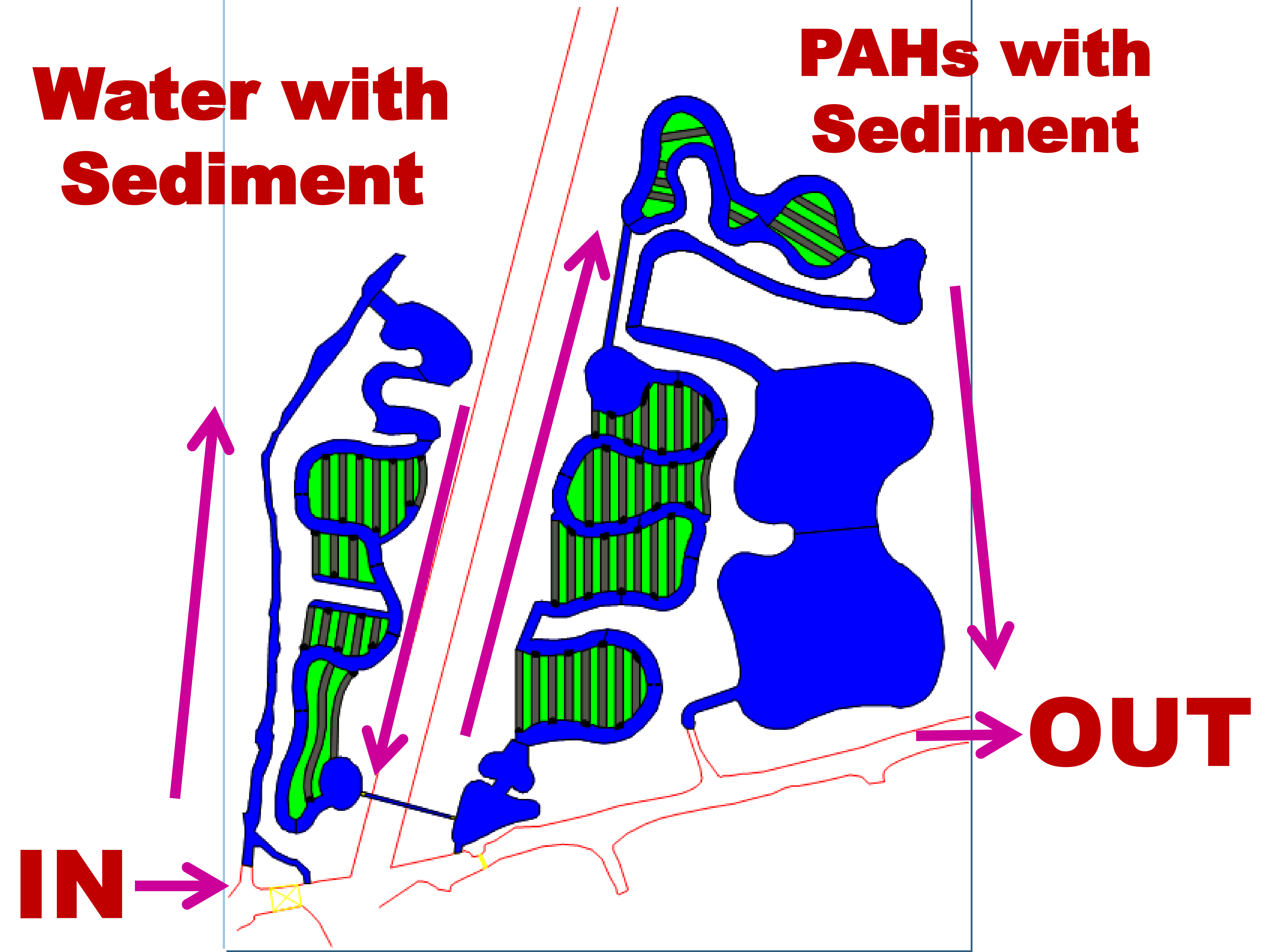




POPs? (such as PAHs) Persistent, Cumulative, Ubiquitous, High toxicity

KEY FOR HEALTH RISK

Importance of particulate adsorption is of special interest.


Water with Sediment
PAHs with Sediment
IN
OUT

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Sampling

Trial Test: June 2009

Test: June 2011

Sediment Point: 31

Sediment Profile: 4

PB/D Section: 2

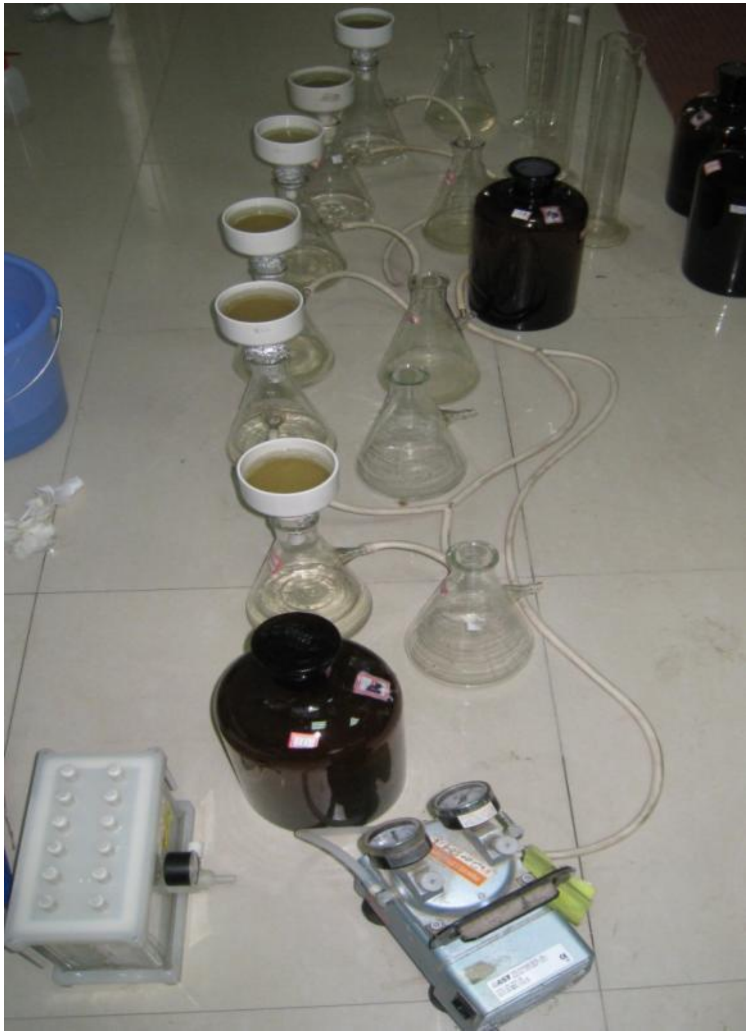
Sediment Sample: 91

Water Point: 4

Water Sample: 12

Procedures

Purify & Concentrate in Lab



Filter and Enrichment *in situ*

Calculation

$$F_i = \frac{C_i \times (1-W) \times \rho \times \Delta H_i}{T \times 10}$$

Where: F_i: sedimentary PAHs flux of *i* station (μg/(m^2·d)); C_i: average sediment PAHs content of *i* station (ng/g); *W*: average sediment water content (%); ρ: average sediment density in dry (g/cm^3); $\triangle H_i$: sediment thickness of *i* station (cm); *T:* operation days (d).

$$m_i = F_i \times S_i \times T \times 10^{-4}$$

Where: m_i: sediment PAHs mass of *i* station; F_i: sedimentary PAHs flux of *i* station (μg/(m^2·d)); S_i: area of *i* station (m^2); *T:* operation days (d).

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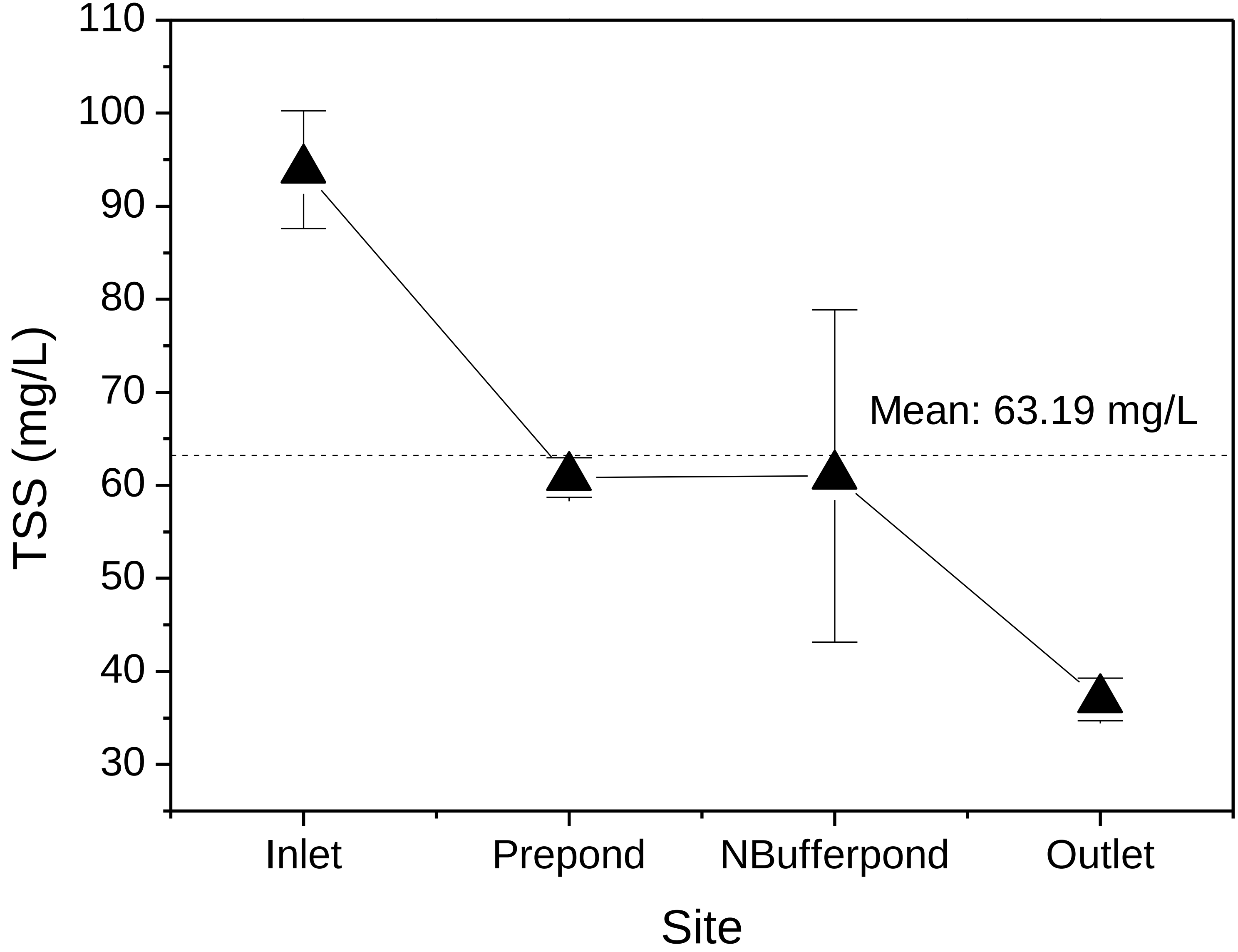
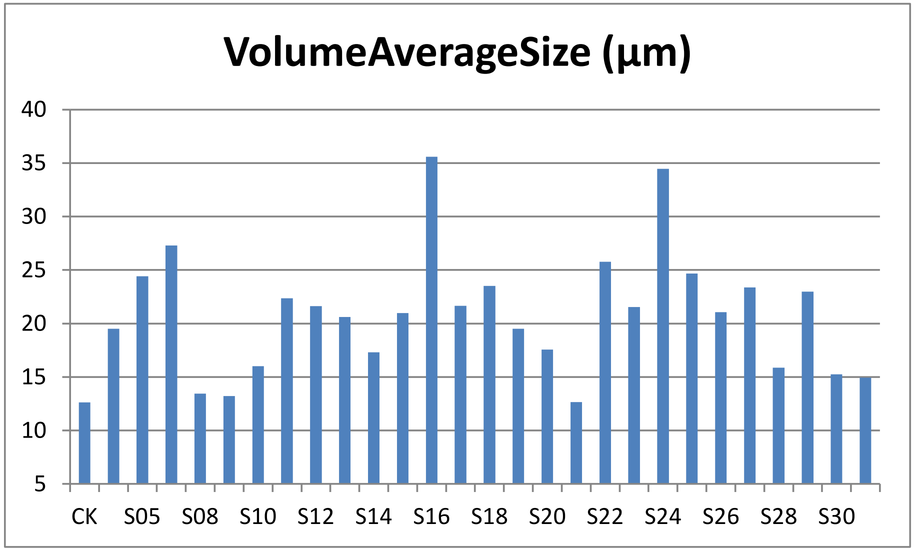
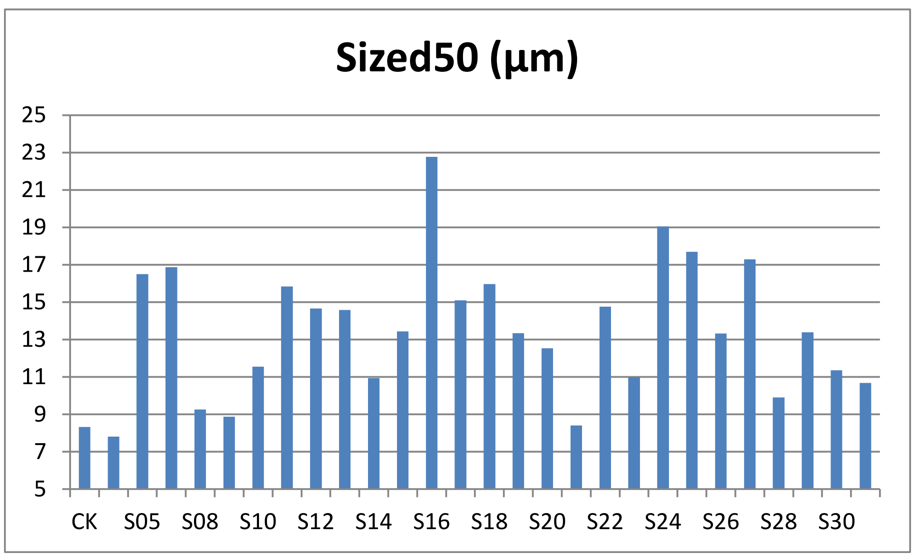
TSS in Water Phase



Sediment Size Distribution





VAS: 12.63 µm (CK)

VAS: 21.00 µm (Wetland)

Wetland/CK=1.66

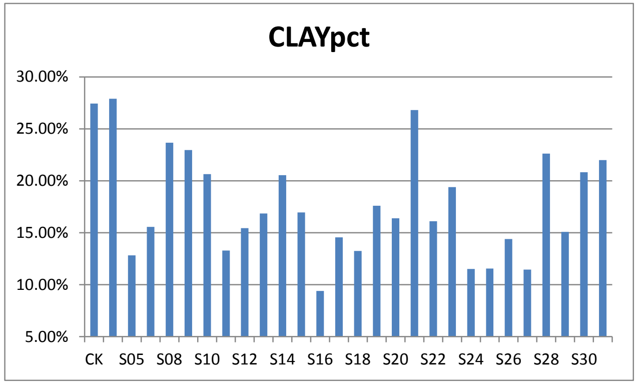
Peaks in Plant-Bed/Ditch System

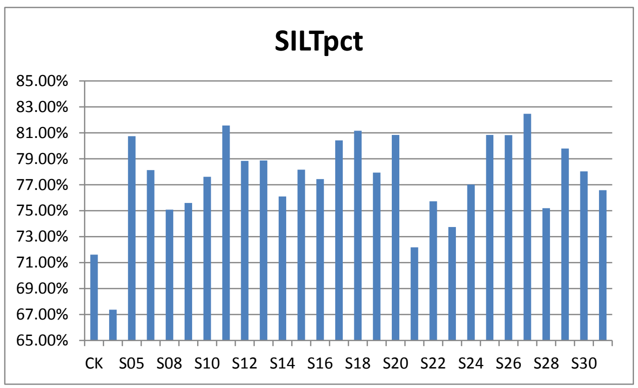
S50: 8.32 µm (CK)

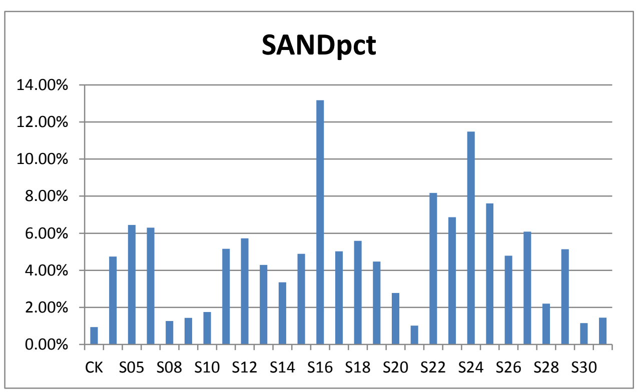
S50: 13.59 µm (Wetland)

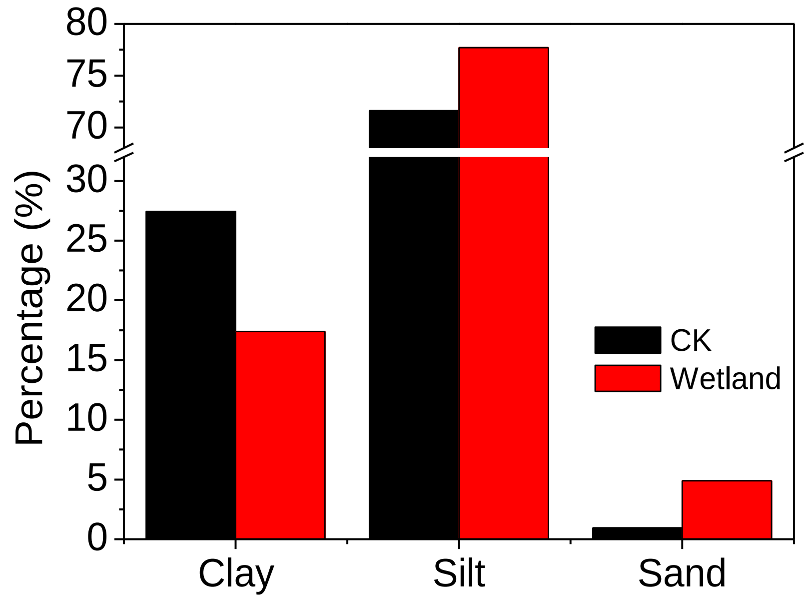
Wetland/CK=1.63

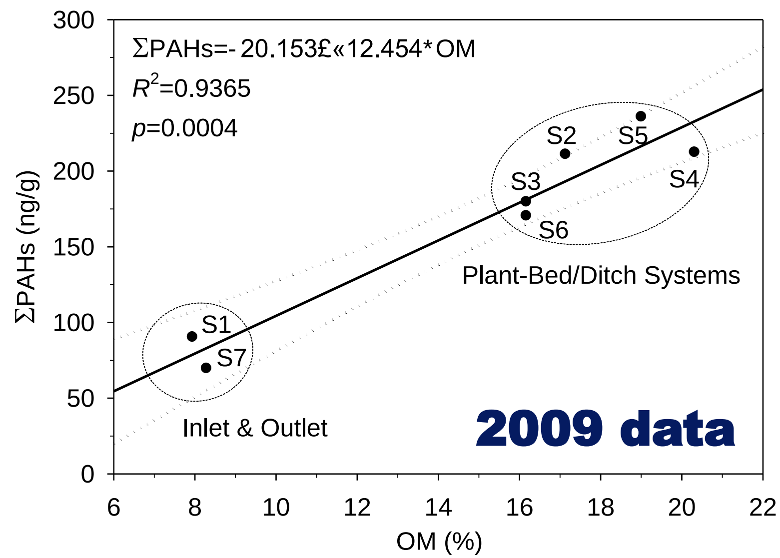
Sediment Size Fraction



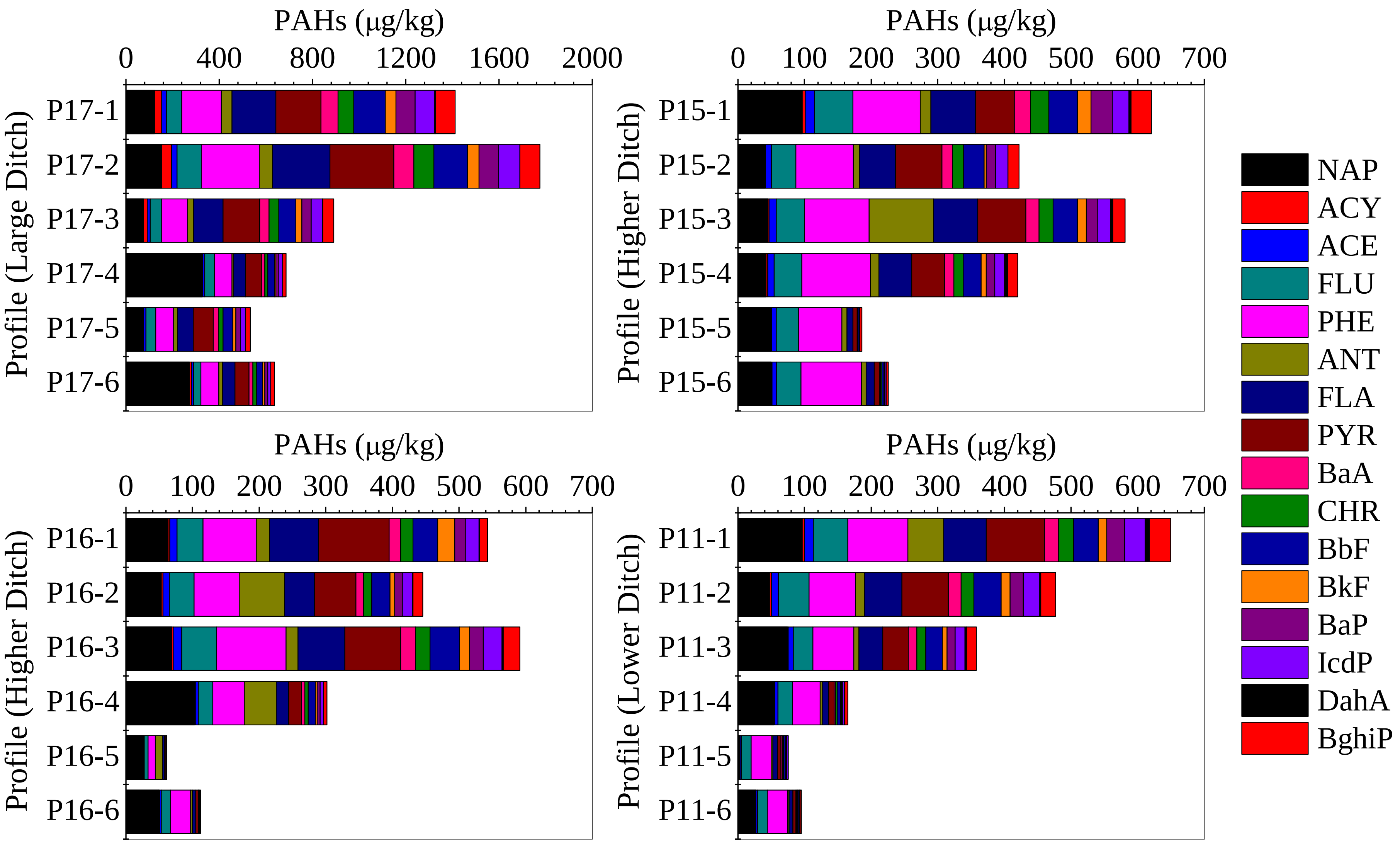




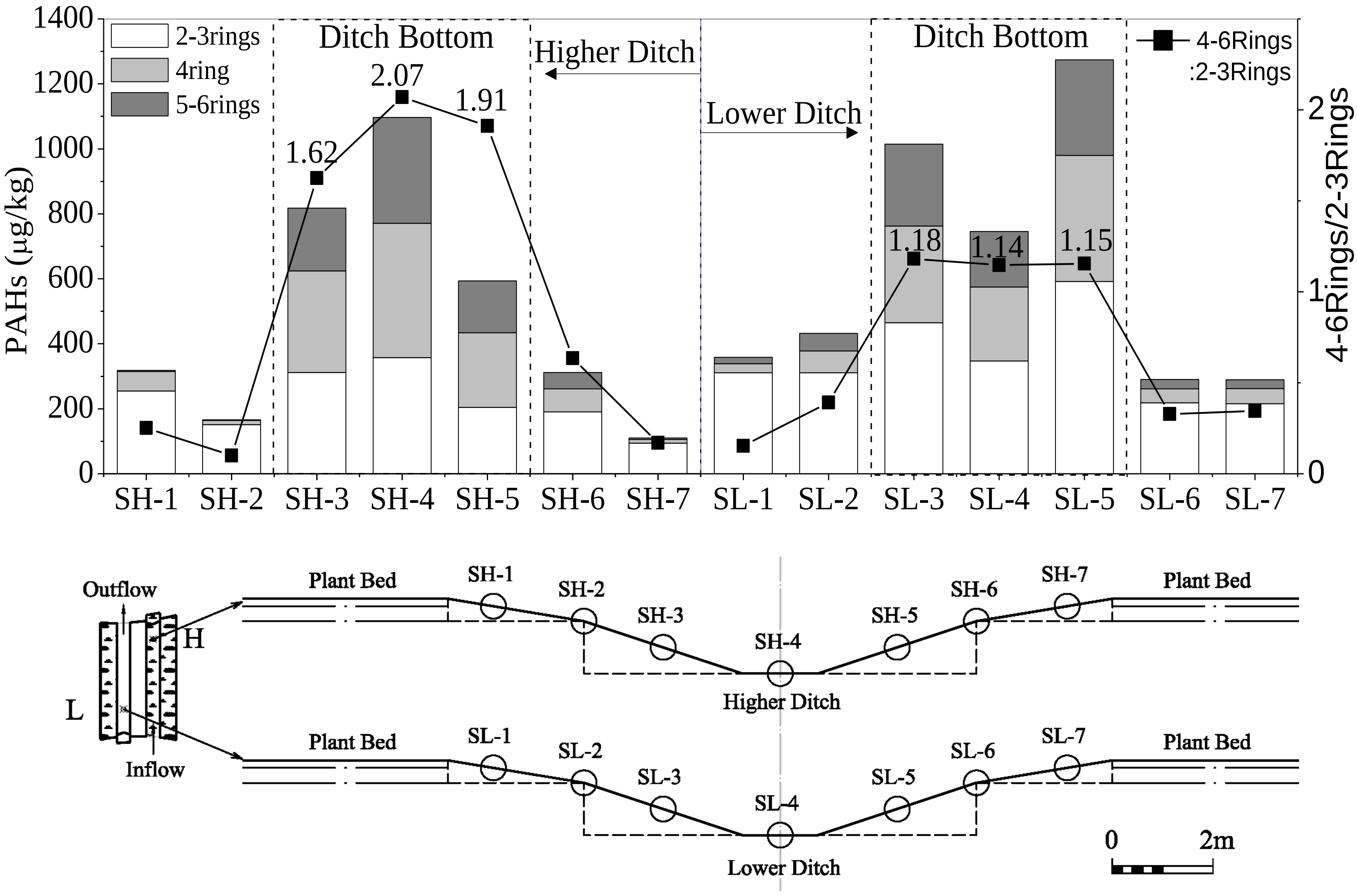




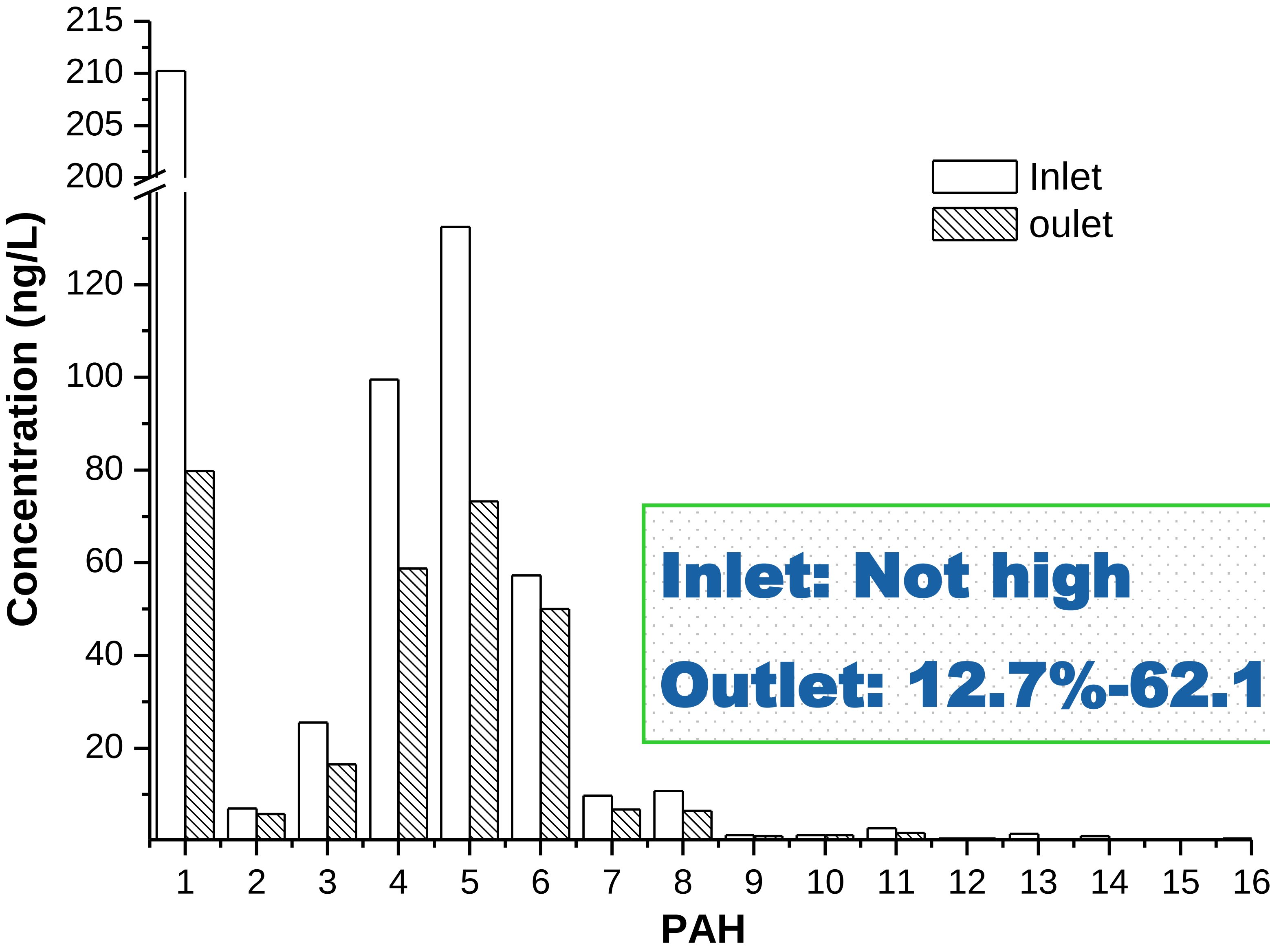
PAHs Profile in Ditch



PAHs Section along Ditch



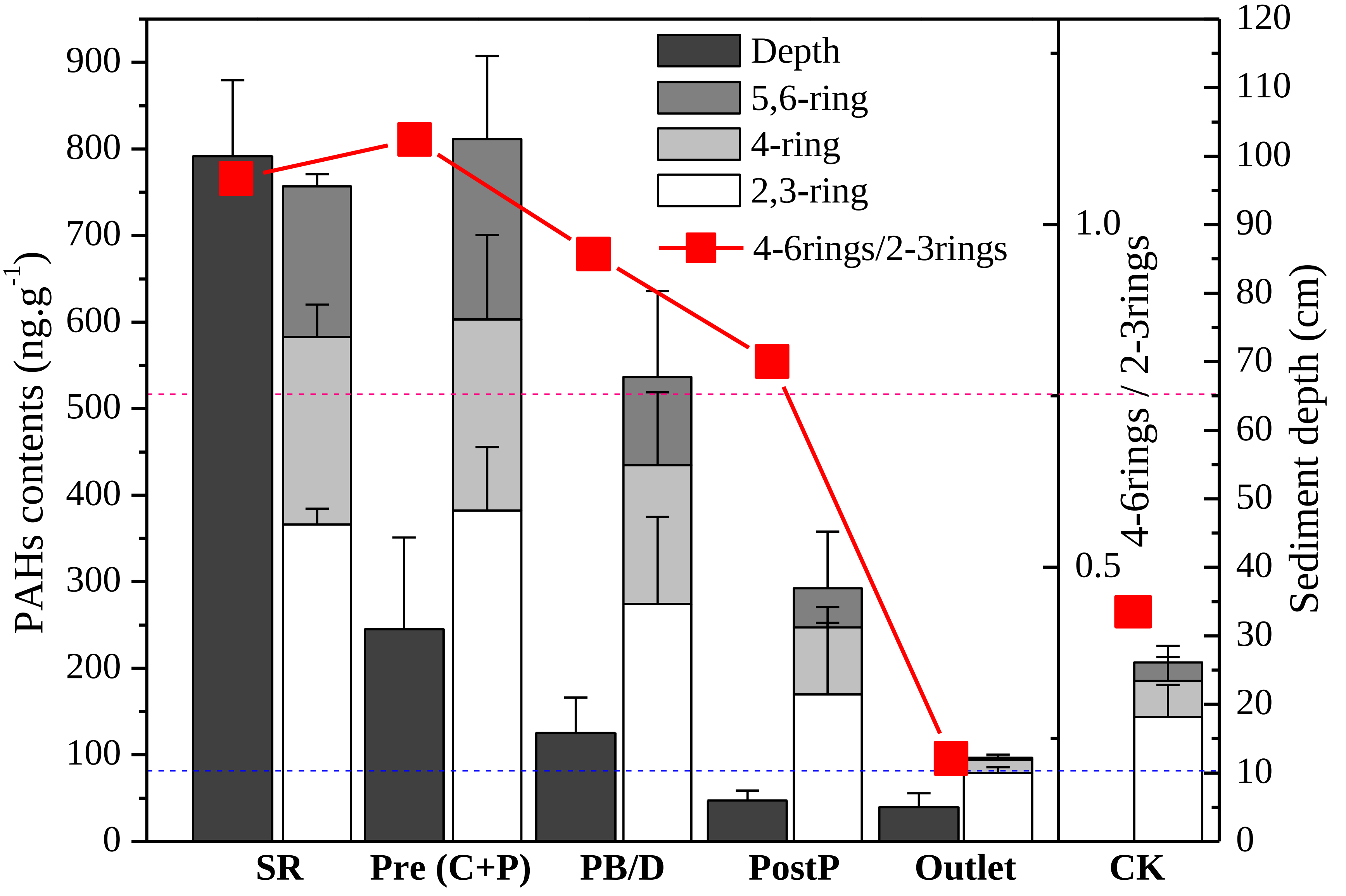
PAHs in Water Phase



Inlet: Not high

Outlet: 12.7%-62.1%

PAHs in Sediment Phase



PAHs Sedimentation Flux

PAHs Sedimentation Flux

1. **Areal flux, Pre-1/3:Post-2/3=3;**
2. **Top priority, in pre-1/3, Channel and Prepond deposit most PAHs, ready for dredging;**
3. **Structure potential, Plant-Bed/Ditch:Pond=1.27;**
4. **Average of all 74.4 μg/(m^2·d), higher than natural waters reported 0.18-3.6 μg/(m^2·d);**
5. **3 years net deposited 28.6 kg PAHs, 70 % in Prepond and Plant-Bed/Ditch, 90 % before Postpond;**
6. **Postpond flux (≈0) is lower than Prepond.**

PAHs were effectively intercepted, Pretreatment zone and Plant-bed/ditch systems are hotspots.

PAHs Removed by Wetland (2011)

Item	Prepond	Postpond	Removal (%)
Sediment depth (cm)	20-55	3-7	/
Sediment ∑PAHs (μg/kg)	657.3-1120.0	514.6-97.7	/
Sediment PAHs flux (μg/(m^2·d))	107.8-341.4	5.1-21.5	/
Water ∑PAHs (dissolved) (ng/L)	489.7±268.6	277.0±52.3	43.4
Water ∑PAHs (particulate) (ng/L)	828.7±395.6	430.8±83.3	48.0
Water ∑PAHs (total) (ng/L)	1318.4±720.3	707.8±145.8	46.3

Sedimentary PAHs Risk

PAHs	ERL	ERM	Sediment [a] Min	Sediment [a] Max	Mean ± Std	Sediment [b] Min	Sediment [b] Max	Street dust [b] Min	Street dust [b] Max
Nap	160	2100	10.6	***305.0***	78.6±7.9	19	147	***223***	***389***
Acy	44	640	0.3	***60.1***	3.5±0.4	2	9	43	***86***
Ace	16	500	***0.6***	***39.5***	12.7±1.4	2	***36***	***17***	***33***
Flu	19	540	2.7	***97.3***	50.4±3.9	8	***83***	***73***	***158***
Phe	240	1500	6.9	208.5	86.6±5.5	28	***576***	***587***	***1035***
Ant	853	1100	0.9	112.8	21.4±3.4	6	78	113	172
Fla	600	5100	2.9	218.1	53.2±8.3	81	525	353	***925***
Pyr	665	2600	3.0	233.0	59.9±10.2	102	454	271	645
BaA	261	1600	0.6	79.9	15.3±3.1	62	***318***	167	***364***
Chr	384	2800	0.7	76.6	16.2±3.3	122	***457***	195	***613***
BbF	NA	NA	0.6	140.1	33.2±7.6	153	585	224	917
BkF	NA	NA	0.1	47.4	10.0±2.5	38	234	76	315
BaP	430	1600	0.2	82.1	15.0±3.5	95	358	157	***537***
IcdP	NA	NA	ND	87.8	15.3±3.3	1	76	65	229
DahA	63	260	ND	7.7	1.2±0.4	1	***222***	***176***	***436***
BghiP	NA	NA	ND	85.5	14.5±2.9	30	245	164	491
∑PAHs	4000	44,792	96.7	1593.7	516.8±52.0	767	4402	2909	7261

[a]: Sampling from Shijiuyang constructed wetland

[b]: Sampling from Xincheng upstream network (Zhao 2008; 2009).

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Conclusions

1. **Pond-wetland treatment are effective PAHs trapper and may significantly lower PAHs risk;**
2. **Prepond and crisscrossed plant-bed/ditch system are PAHs sedimentation "hotspots";**
3. **Superficial sedimentation is a potential mechanism for PAHs retention;**
4. **Optimized design provides base for persistent and permanent removal of PAHs through constructed wetland.**

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海宁市长水塘水源生态湿地方案设计

Pond-wetland complexes suit for trapping and removing POPs from river water, thus greatly reducing POPs risk.

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Thank You!
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